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Effect of Digital Awareness on Mathematics Achievements at School to University Levels in Nepal

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Abstract: *Digital awareness is necessary for mathematics teachers to use digital technologies, including ethical, cultural, leadership, and policy awareness in this 21st century. This study aimed to examine the interrelation of digital awareness of mathematics teachers with students' achievement at schools to higher education levels in Nepal. An online survey was conducted among 399 mathematics teachers of Nepal and Mann-Whitney, Kruskal-Wallis, and multilevel linear regression were major statistical techniques used in the study. The findings indicated that most of the participants had digital devices, and the level of digital awareness was found to be high. The types of institution and teaching level were major contributing factors to determine the digital awareness, and developing and sharing cultural consequences are the main predictors of learners' achievement.*

Keywords**:** Ethical and policy awareness, cultural and leadership awareness, digital awareness, mathematics achievement, Nepal

INTRODUCTION

In a study, Bennison and Goos (2010) stated that teachers' inclination to professional development encourages them to innovate new approaches to improve student learning of mathematical concepts. In this context, teachers' use of technology in innovative ways fundamentally changes the content and learning process (Lynch 2006). For effective and innovative use of technological and other mathematics tools, teachers should have competencies of such tools (e.g., digital tools, computers) and mathematical content knowledge to utilize an integrated form of knowledge for effective teaching of subject-specific content (Campbell 2003). Therefore, teachers' technological, pedagogical and content knowledge (TPACK) impacts how proficient and skillful the teachers are in selecting digital technologies to represent, broaden, and connect mathematical activities for profound learning and higher-order thinking (Loong and Herbert 2018; Mishra and Kohler 2006). The use of technological and digital tools in education in general and mathematics education, in particular, has been increased in the Australasian region. For example, Australia has emphasized using digital tools to teach and learn mathematics at the school level (AAMT 2014). Likewise, the use of digital tools in Singapore schools has been emphasized with a "special computer ownership scheme" (UNESCO 2014, p. 18). Nepal also unveiled Digital Nepal Framework 2019 as a significant step to apply new technology and digital tools in education and other sectors (MoECIT 2019).

Teachers are considered as change agents of society (Badley 1986; Bourn 2015). Hence they should have knowledge and skills of innovations, creations, and adoption (Kovacs 2017; OECD 2016) in their discipline. Teachers also should have skills to motivate others towards correct and ethical use of technological resources. Mobile, computer, TV, radio, and the Internet are core ICT infrastructures (UN et al. 2005) at this age. Technologies are being advanced day by day. Misappropriation of digital resources may cause hostilities, aggression and violence, sexual abuse, commercial exploitation (UNICEF 2017). Hence the safe use of such technology is a necessity for all global communities.

Misuse of technology is a growing concern in all sectors, including education and teaching-learning. One of the most misuses of technology is cybercrime. There are several provisions to combat cybercrime due to the misuse of technology. Technological advances have been changed and affected every sector of human life, from food, medicine, transportation, education, research, and entertainment (Al-Saqqa et al. 2014; DoCE 2019; Elsobeihi and Abu Naser 2017; Sutton 2013). People of all ages and professions are affected more or less by modern technology, such as digital gadgets and tools. This immense transformation in life and thinking through digital technology has raised concerns about identity, safety, privacy, and digital content publicity. These concerns are genuine in the proper use of digital information at both personal and public levels. In this context, one can raise digital awareness questions in schools and higher education institutions in Nepal. Are school and university teachers and students aware of their privacy and internet security in Nepal? Do they care about digital footprints? Do teachers have an awareness of the responsible use of digital devices and online materials? This paper discusses the issues around these questions, in general, to look at the overall perception of the teachers with a focus on digital or technological tools such as mobile phones, computers, and television. More importantly, it explores how mathematics teachers' digital awareness level impacts on students' achievement or performance in mathematics from school to higher education in Nepal.

The Internet has been an essential means of digital technology and information in Nepal in recent years. There were only about 7000 Internet users by 1999 (Pradhan 1999), and this number reached nearly 30,000 in the year 2006 (Kasajoo 2006). It grew further to 19.7% of the total population in 2016 and 34% in 2017 (The World Bank 2020). Internet broadband penetration increased sharply from 2016 to 2017. It penetrated 63% of the total population in the year 2019 (MoCIT 2019). ITU report showed that 21% of individuals using the Internet in Nepal.

In contrast, that rate is 44.3% in Asia & Pacific and 48.6% in the world, a household with computer access is 14%, 38.9%, and 47.1%, and the 3G coverage population is 54.1%, 91.3%, and 87.9% in Nepal, Asia & Pacific and in the world respectively (ITU 2018). This status shows that the position of Nepal is comparatively low in comparison to others. The study is concerned with mathematics teachers from primary to university level only. This data included both broadband wired and wireless and mobile Internet usage. The growth of the Internet and smartphone penetration in the country certainly demonstrates a growing awareness of ICT use in daily life, business, communication, and education, among many other activities. However, the government lacked a firm national policy and guidelines to regulate Internet technology's proper use for various sectors until 2019, despite some policies and prior guidelines for ICT and the Internet.

For the first time, Nepal unveiled the 2019 Digital Nepal Framework to adopt technological advancement in all government, public, and private entities (Ministry of Communication and Information Technology [MoCIT] 2019). The vision of Digital Nepal, the framework emphasized the Internet penetration for economic growth, innovation to solve many challenges and tap into the global economy's opportunities amid the development of both neighboring countries- India and China through digital connectivity (MoCIT 2019). The framework has charted a broad vision with one nation, eight potential sectors with eighty digital initiatives to leverage disruptive technologies and the country's socio-economic transformation. One of the eight sectors in the digital framework is education as a key priority area to develop connectivity, access, and empowerment of all stakeholders. Among the eighty digital initiatives identified, the first one focuses on establishing a reliable and essential Internet service by taking the lead by developing 5G networks to leverage all other sectors, including education. The other initiatives have links with Internet connectivity in general. The education sector has eight initiatives integrated into the framework. The first initiative is to develop smart classrooms. The second initiative is to develop OLE Nepal 2.0 within this initiative. An online portal, E-Path, and E-Pustakalaya have been designed to provide access to educational resources to the students, teachers, and parents. It also supports teacher training and developing the e-infrastructure of educational institutions in Nepal (see http://www.olenepal.org/). The other initiatives are – rent-a-laptop program, EMIS 2.0, centralized admission system, biometric attendance and CCTV, and mobile learning centers (MoCIT 2019). ICT regulation scores of Singapore, Japan, and Australia were high in Asia-Pacific; however, that score is low in Nepal's context (ITU 2020).

For effective use of digital resources, every teacher should know local, national, and international ICT policies related to their fields. They should design activities and lessons with the technological tools to implement their strategies for their instructional activities. The policies also provide guidelines for the use of technology in their teaching-learning activities. Nepal has initiated several other policies to support digital technology. For example, the National ICT policy 2015, the National Broadband Policy 2015, and the Electronic Transaction Act 2008 are some policies to guide the development and use of digital technology in Nepal (MoCIT 2019). These policies and other guidelines by the government are helping to initiate digitization in public services and education. In this line, the ICT Policy 2015 aimed to increase ICT accessibility to a broader public arena through ICT infrastructure development, ICT industry promotion, e-Governance, and Human Resources Development in the field of ICT (MoCIT 2015). Likewise, the Broadband Policy 2015 aimed to extend the connectivity, public-private partnership, universal access, and minimize the digital divide and increase the access and coverage of broadband Internet service throughout the country by wireless or wired Internet connections (MoCIT 2015). The Ministry of Communication and Information Technology has promulgated Geo-Satellite Policy 2020 to connect Nepal to space for reliable and high-quality information services to reduce the dependency on other commercial Geo-Satellites communication services. This initiative is also related to digital content development and distributing those contents through the satellite networks at a faster and cheaper rate (MoCIT 2020). These are some current developments in Nepal in ICT and digital development initiatives that need a higher level of awareness and preparedness for a better future.

Ethical use of digital resources is related to individuals' moral values (Hamiti et al. 2014; Hoq, 2012). Different violence arises from the improper use of technology (Mancini and O'Reilly 2013; Martin 2010). Digital stalking, digital hate, threats of the virus, cyber terrorism, and digital spying (Mitra 2010) are major challenging issues. There are several laws of the act for computer-related crimes like the Electronic Transaction Act 2008 in Nepal, which was first introduced and implemented by the Government of Nepal. The act has a provision against the offense of relating to computers in Chapter 9 under this document. The act defined some illegal activities as cybercrime, threat, attract and abuse through the use of the Internet and provision of punishment with imprisonment not exceeding five years and with a fine not exceeding Rupees 200000 (2705 USD) based on the nature of activities (Giri 2019; GoN 2008). Hence, training and awareness programs should be given to all general public for safely using such resources (Olcott et al. 2015). Ethical and intellectual property rights-related content should be included in the curriculum (Bandara and Ellepola 2019). Hence every teacher and student should be aware of different digital resources (ISTE 2017) as software, online resources, and other e-resources (Buch et al. 2017). Digital awareness of the mathematics teacher may also support how they utilize technological tools, such as smartphones, computers, iPods, tablets, and tools available for computational and representational activities promoting mathematical thinking (English 2018). Teacher awareness and skills in using the varieties of digital tools may also support designing mathematical tasks for analyzing data and computing in a context that helps students "reinvention of mathematics by students themselves" (Langrall et al. 2011).

The digital awareness of people, at different sectors in general and students and teachers in particular, plays a significant role in the quality use of the ICT tools. Policy awareness is a fundamental and necessary skill for 21st-century teachers (UNESCO 2013). The levels of public awareness and engagement in digital technology and tools have been explored in a few studies in Nepal. For example, Regmi (2017) studied Internet connectivity and the quality of mobile phone access to the Internet at four places in Nepal – Panauti, Tangting, Changu Narayan, and Kathmandu. The studied sites were Cyber Cafes, Libraries, Schools, and University Campuses. Regmi (2017) observed the different ways to connect broadband subscriptions through dialup, wireless modem, cable modem, and ADSL. The findings of the study reported a low quality of Internet connectivity at educational institutions and public places. Although voice quality was satisfactory on the mobile phones in those places, the Internet quality on phones was not satisfactory for the users (Regmi 2017). The quality and variations of the Internet connection have not yet reached all people in Nepal due to geographical terrain and economic classes (Acharya 2016). These access issues have created a digital divide between people living in urban areas and the rural, remote areas that have affected experience and awareness toward the use of the Internet for education and other purposes (Acharya 2016). The interruption or lack of consistent internet access to Nepal's rural and remote areas is also caused by problems in power supply, bandwidth, lack of technical support, and, most importantly, lack of awareness of the people (Kasajoo 2006).

Digital awareness is related to having basic literacy skills in digital tools, such as smartphones, tablets, iPads, and computers. The basic skills of these devices, together with the Internet, provides students and teachers greater access to online resources for teaching-learning (Abbas, Hussain, and Rasool 2019). These skills influence students' academic performance (Amiri 2009; Lopez-Islas and Jose 2013). In the Research New Zealand report, 80% of school principals agreed that digital technologies positively impact students' achievement (Johnson, Maguire, and Wood 2017). Similarly, a US study reported that digital technology's use increased students' achievement in mathematics (Brasiel et al. 2016).

Similarly, there are views that mobile technologies have a significant impact on students' awareness and achievement through a higher level of creativity and problem-solving skills (Sung, Chang, and Liu 2016). Likewise, game-based learning has been a new trend to engage students in meaningful learning. For example, Kahoot has been one of the popular game-based learning tools that may have a positive influence on students' learning and classroom activities through enhanced thinking and awareness (Wang and Tahir 2020).

Despite the growth in the use of the Internet and digital-online tools for various purposes, there is still a lack of research that has documented the students' and teachers' digital awareness and how such awareness may affect students' achievement in mathematics (or other subjects) in Nepal. Therefore, we planned to conduct this study during the COVID-19 pandemic when all educational institutions (schools and universities) were closed for face-to-face classes. Some universities and schools were offering online and distance learning for the students. Students were using several online platforms, apps, and software for learning purposes. However, the effective use of these resources depends on their digital awareness, including ICT competence, to access various learning resources. The objective was to examine digital awareness of students' achievement in mathematics from school to university. The research question was: what is the awareness level of mathematics teachers in using digital technology? Furthermore, digital awareness affects students' achievement in mathematics from the viewpoint of teachers? In the rest of this paper, we outlined a literature review, theoretical framework, methodology, results, discussion, and conclusion.

LITERATURE REVIEW

We reviewed a few selected literatures from 2007 to 2020 on technology in teaching and learning and their impacts on students' engagement and quality of learning and performance in different subject areas. Lei and Zhao (2007) investigated to examine how students use technologies, what technology uses are popular among students, and what technology uses are useful for increasing student academic achievement. The data was collected from the seventh and eighth-grade students and teachers in highly productive technology equipped middle school in the state of Ohio in the USA in the academic year 2002-2003, employing survey and interview methods. The participants for the study were 207 for the pre-test and 231 for the post-test survey. However, 177 students participated in both the survey. The survey questionnaire to the student participants consisted of multiple-choice and four-point Likert scale items along with the question to report their GPA as academic outcomes. Besides the survey, a semi-structured interview was conducted with ten teachers and nine students to gain opinions and concerns on how students utilized technologies and for what aims. The quantitative data were analyzed using Correlation, **T-**tests, and ANOVA tests to find the association between technology uses and change in student GPA. In contrast, the interview data were coded according to the research questions of the study. The outcomes demonstrated that the amount of technology utilizes alone is not fundamental to student learning. Additionally, when the nature of innovation use is not guaranteed, additional time on PCs may cause more mischief than an advantage. Students' progress in GPA indicated that the innovation utilizes positively affected students were those identified with explicit branches of knowledge and concentrated on student development. Investigation results found that the use of innovation that had a positive effect was not well known. However, some utilization of some procedures was the least, and they were again utilized.

Barkatsas, Kasimatis, and Gialamas (2009) conducted another investigation to examine the intricate association between students' mathematics confidence, confidence with technology, attitude to learning mathematics with technology, active engagement, and behavioral engagement, achievement, gender, and year level. The study consisted of the 1068 year nine and year ten students from 27 randomly selected state co-educational schools in Metropolitan Athens, Greece. These students varied from upper-middle to low socio-economic status. The data was collected using the instrument the mathematics and technology attitudes scale (MTAS). The data were analyzed using exploratory factor analysis, correspondence analysis, cluster analysis, MANOVA, and chi-square test statistic. The results depicted that boys communicated more positive perspectives towards mathematics towards the utilization of technology in mathematics, contrasted with girls. It indicated that high mathematics accomplishment was related to significant levels of mathematics confidence, firmly positive degrees of affective engagement, and behavioral engagement. The achievement was related to increased trust in utilizing technology and an inspirational mentality to learning math with innovation. A low degree of mathematics achievement was related to lack of confidence, low affective engagement, less trust in technology, and a negative demeanor to learning mathematics.

Parishan, Jafari, and Nosrat (2011) examined the effect of technology-based learning in biology on students' academic achievement. The study used a quasi-experimental pre and post-test design. The population of the study was 5240 female students at Khomeini Shahr junior high schools. They applied cluster sampling to assign students in the control and experimental groups of 27 junior high school students selected randomly in 2009-2010. The experimental group was taught using the technology-based active learning method, and the control group was taught using the traditional lecture method. The researchers used pre and post-tests to assess the effects of two instructional approaches. The achievement data were analyzed using descriptive statistics such as mean, standard deviation, and inferential statistics the covariance analysis (ANCOVA). The results demonstrated that the students' achievement in the experimental group was higher than the control group, and the difference was significant at the 0.05 level of significance. The results of the study confirmed that there was no significant difference between the groups' performance in terms of their family characteristics (parents, number of siblings, and economic status) ($p>0.05$).

Harris, Al-Bataineh, and Al-Bataineh (2016) examined whether one to one (1:1) technology affects students' academic achievement and motivation to learn in an elementary school in Illinois. The study employed a quantitative experimental design to collect the data from 4th-grade students from two different classrooms in the same school. The school had a low-income rate of 84.3%, and most of the students were African American, and the least were Asians. The 1:1 technology was implemented in the school (experimental group) of 25 students, whereas 22 students were in the traditional classroom (control group). The data collection instruments were based on tests from the Discovery Education Assessment (Math) and the school's attendance records for each month. The results showed that performance of students who were in the 1:1 implementation achieved higher in three sets of topic tests (in groups A and B) whereas the traditional group achieved higher in the rest of the other three sets of tests (Group C), indicating a mixed result of the study. Although 1:1 technology could be a factor in student achievement and motivation to be at school, the effect was not conclusive as the control group also achieved higher in group C. Harris et al. (2016) also concluded that 1:1 technology might be the impetus required for school districts to enable their students to accomplish at more significant levels.

Al-Hariri and Al-Hattami (2017) investigated the impact of technology usage on student learning achievement in the physiology courses at five colleges of health sciences in Dammam. The data was collected using a survey questionnaire with a five-point Likert-scale. The questions were related to their use of technology and devices. The information was collected in an online survey from 219 second-year students studying physiology courses in five colleges of different health science disciplines at the University of Dammam. The descriptive statistics and Pearson correlation coefficient were used to find the frequency and relationship between technology and academic achievement in physiology courses. The results revealed a significant correlation between the use of technology and student achievements in their respective classes. The researchers found that the most-used devices were laptops (50%), and the least used devices were desktop computers (only 0.5%). Al-Hariri and Al-Hattami (2017) further stated that technology plays a significant role in promoting learning through many practical instructional approaches, such as self-directed, independent, and collaborative learning. They found that most students preferred using laptops instead of traditional desktop computers for their projects, assignments, and other academic activities.

Salvo, Shelton, and Welch (2019) examined factors that added to the effective fulfillment of online courses for African American male college understudies. The study employed a phenomenological approach. The researchers collected qualitative information from ten purposively selected male undergraduate students. They had finished an online college course from an accredited public university in the southern region of the United States. The information was collected utilizing a semi-structured interview with the participants regarding their academic achievement techniques and learning encounters. The results demonstrated several factors for motivation for online courses. For example, economic, educational, continuity, and unbiased environment, to name a few. The participants preferred self-teaching in some subjects that did not require face-to-face interaction with the teachers. In other courses, such as mathematics, they preferred face-to-face instead of online classes. The participants also viewed that they could have their voices without biasedness because everyone could participate in the discussion. There was no fear or anxiety in the online class because they could participate in the interaction. They liked to learn at their own pace and without time-pressure.

Zgheib and Dabbagh (2020) conducted a study to investigate how experienced faculty utilize web-based social networking to help learn exercises in their courses. The study focused on analyzing the sorts of social media learning activities (SMLAs), their plan, the intellectual procedures they support, and the kinds of information that understudies take part in while finishing SMLAs. The study employed a qualitative approach with quantitative results using multiple case-study designs. The researchers conducted various interviews with six faculty members who implemented Second Life based virtual class activities in their courses. The events were held in the sessions for two years in a public higher education institution in the mid-Atlantic region of the US. The study also gathered information from the observation of 115 students' course-related social media posts. The data analysis was based on Bower et al.'s conceptual framework for Web 2.0 learning design, Bloom's **Taxonomy of Cognitive Domain,** and Krathwohl's **(2002) Knowledge Dimensions.** The outcomes demonstrated that internet-based second life could bolster student learning and advance various intellectual procedures. The findings additionally uncovered that accomplished personnel could select appropriate Second Life instruments depending on their innovation highlights or their ubiquity in the field of study. They suggested coordinating a few media sources in the plan of a solitary SMLA. Zgheib and Dabbagh (2020) proposed that accomplished faculty who utilized the Second Life, explicitly wikis and sites, used them as Learning Management Systems.

The abovementioned studies outlined the impact of digital technology on student achievement, mathematics confidence, positive attitude, and social engagement in learning through web-based tools. Government policies have emphasized the use of technology and digital tools for teaching and learning mathematics (e.g., MoCIT 2019). The position statements of professional organizations, such as the National Council of Teachers of Mathematics (NCTM 2011), The Australian Association of Mathematics Teachers (AAMT 2014), and Joint Mathematical Council of the United Kingdom (JMC 2011) also suggested the use of digital tools in the classrooms.

Methodology

Design

A cross-sectional survey design was adopted in this study. The data were collected from the mathematics teachers of all levels of schools to the universities in Nepal. An online survey questionnaire was designed by using Google Form. The survey link was communicated and shared through social media, teacher training webinars, workshops, professional development webinars, and mathematics teachers' organizations in Nepal during the COVID-19 pandemic from May to July 2020. During the period, 399 mathematics teachers responded to the online survey from the seven provinces.

Variables

The outcome variables in the study were-- ethical awareness, policy awareness, cultural awareness, and leadership awareness under digital awareness and average scores of students in mathematics taught by the teachers in the last tests. All the items in the questionnaire were associated with the digital awareness of the respondents. The questionnaire had a five-point scale form of very true of me, true of me, neutral, not true of me, and not at all true of me. Additionally, marks of mathematics were calculated by the average of internal assignment or term examination marks and an average score of the final examination. Besides, a description of all items associated with all digital awareness has been presented in **Fig. 1**.

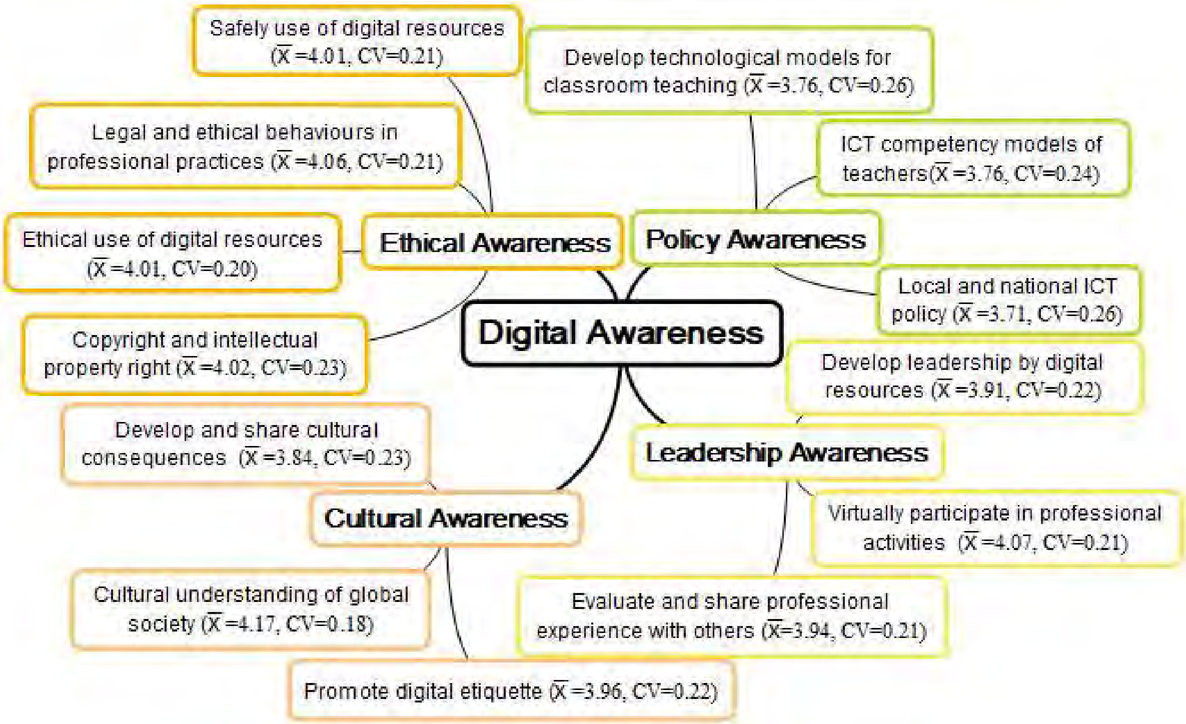

Fig. 1 Conceptual framework of digital awareness

There are twelve confounding variables-- gender, experience, age, qualification, academic background, type of institutions, job type, teaching level, laptop, computer and TV, and ICT training as the teachers' characteristics. The variable of having a mobile was excluded because all of the teachers (100%) under the study had mobile phones. The proportion of participants by gender was female 9.5% and male 90.5%. Participants' distribution based on experience was 41.1% having less than ten years of teaching, and 58.9% had more than ten years of teaching experience. By age, 26.8% were 15-29 years, 59.2% were 30-44 years, and 14% were 45 to 60. Among the participants, 25.8% had an Intermediate or a Bachelor's degree, and 74.2% had a Master or higher degree (M.Phil. /Ph. D.). Based on the academic discipline, 67.7% were from the education field, 10.8% were from humanities/management (10.8%), and 21.6% were from the science background. Types of institutions have three categories as governmental (55.9%), private (28.1%), and public (16%). Job type had two categories as permanent (53.9%) and temporary (46.1%) based on institution and government rule. The teaching level had three categories as basic (grades 1-8) level (21.8%), secondary (grades 9-12) level (67.2%), and university level (11%) as per the rule of the government of Nepal. The participants having laptops were 81%, desktop computers 68.9%, and TV 49.9%. About 42.9% had no training, and 57.1% of the participants had some training in ICT or computer.

Research Instrument

A self-constructed online tool named "Digital Awareness Measurement Scale" was used for data collection. The instrument consisted of 13 Likert-scale type items with five-point ratings-- 'not at all true of me,' not true of me,' neutral,' 'true of me,' and 'Very true of me.' Cronbach's Alpha reliability score of the tool was 0.94, which was very high. The instrument was shared with two survey design experts and two teachers to get feedback on clarity, suitability, and ease of understanding the items to establish content validity.

Analysis

The participants' responses were retrieved from the Google Form and imported to the IBM SPSS 26 for statistical analysis. The ratings in the items were coded from 1 = 'not at all true' to 5= 'always true,' respectively, to quantify the data. The mean scores of each item were calculated from the ratings, and composite scores were calculated from the groups of items within the four categories-- digital, ethical, cultural, and policy awareness. The composite values were the data into scale form. The assumption normality of these categories was tested by Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) tests. The test result showed significant results for all categorical variables at a 95% confidence interval. Hence non-parametric statistics like Mann-Whitney and Kruskal-Wallis tests were used to test the significance of digital awareness results with respect to all socio-demographic characteristics (Cohen et al. 2007). Pearson correlation was used to measure the relationship between digital awareness and mathematics achievement scores. Additionally, a multiple binary regression was used to estimate the effect of digital awareness and achievement in mathematics.

Results

Table 1 shows that all mathematics teachers have at least one digital device. All the 399 participants have a mobile device (100%), which is the basic need of the 21st-century community. The majority of the participants have a laptop (81%), half of them have TV (50.1%), and only around one-third have computers (31.1%). The majority of the teachers are using digital devices (61.7%-90.4%) less than 3 hours/day, and around half (46.8%) to four-fifth (79.3%) of them are using such resources for more than five years.

Table 1 Availability and using the status of digital resources (n=399)

Devices	Yes (%)	Hours of using digital devices				Years of using digital devices		
		<3 hours	3-6 hours	≥6 hours	Missing value	Before 5 years	≥ 5 years	Missing value
Mobile	399(100)	234(61.7)	105(27.7)	40(10.6)	20	117(30.2)	271(69.8)	11
Laptop	323(81.0)	201(62.6)	90(28.0)	30(9.3)	78	160(53.2)	141(46.8)	98
Computer	124(31.1)	129(85.3)	22(13.5)	2(1.2)	236	73(40.1)	109(59.9)	217
TV	200(50.1)	170(90.4)	17(9.0)	1(0.5)	211	46(20.7)	176(79.3)	177

The coefficient of variation (CV) predicts the items' accuracy, and the items having comparatively less CV seems to be better. Hence, along with the thirteen items under digital awareness, cultural understanding of global society has the lowest CV (0.18). Therefore, this item is more robust than others. The level of items has been determined in three categories based on the mean score of the items as high (3.67-5), medium (2.34-3.66), and low (below 2.34) (Fig. 1).

However, that level found to be medium among female (Mean=3.57), 45-60 years age grouped (Mean=3.65), humanities/management streamed background (Mean=3.64), basic (class 1-8) level (Mean=3.59) and university (Mean=3.49), not having a laptop (Mean=3.57) and did not participate any training (Mean=3.62) mathematics teachers in policy awareness and based on all remaining socio-demographic variables that level found to be high. Additionally, the result is statistically significant based on types of institution, teaching level, and those having laptops in ethical awareness in favor of private and secondary school teachers and those having laptops, respectively. Types of institutions and job types have a significant result on leadership awareness in support of private and temporary school teachers with their counterparts. Teaching level and status of taking ICT training have significant results on policy awareness in favor of secondary and trained mathematics teachers, respectively (Table 2).

Table 2 Status of digital awareness with respect to different socio-demographic characteristics (n=399)

Socio-demographic characteristics	Number of Respondents (%)	Ethical awareness		Cultural awareness		Leadership awareness		Policy awareness	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Gender	p-value	0.09		0.28		0.10		0.10	
Female	38(9.5)	3.91	.67	3.93	.51	3.88	.49	3.57	.76
Male	361(90.5)	4.06	.70	4.00	.72	3.99	.75	3.76	.87
Experience	p-value	0.59		0.58		0.43		0.38	
<10 years	164(41.1)	4.08	.72	4.00	.76	4.00	.76	3.76	.92
≥10 years	235(58.9)	4.04	.68	3.98	.67	3.96	.72	3.73	.82
Age	p-value	0.32		0.76		0.55		0.59	
15-29 years	107(26.8)	4.04	.66	3.98	.78	4.02	.68	3.78	.92
30-44 years	236(59.1)	4.07	.70	4.00	.69	3.97	.76	3.75	.84
45-60 years	56(14.0)	3.93	.74	3.96	.66	3.91	.69	3.65	.85
Qualification		0.63		0.89		0.51		0.49	
Intermediate/ Bachelor	103(25.8)	4.02	.68	3.96	.79	4.03	.68	3.77	.90
Master/ MPhil/Ph. D.	296(74.2)	4.05	.70	4.00	.68	3.96	.75	3.73	.85
Academic background	p-value	0.91		0.75		0.82		0.75	
Education	270(67.7)	4.06	.66	4.00	.70	3.98	.72	3.78	.79
Humanities/management	43(10.8)	3.96	.87	3.95	.73	3.85	.89	3.64	1.05
Science	86(21.6)	4.02	.72	3.97	.74	4.02	.67	3.68	.98
Type of institutions	p-value	0.01*		0.17		0.01*		0.09	
Governmental	223(55.9)	3.94	.76	3.93	.73	3.92	.76	3.67	.87
Public	64(16.0)	4.09	.59	3.99	.65	3.87	.70	3.71	.77
Private	112(28.1)	4.22	.56	4.11	.68	4.15	.67	3.90	.89

Job Type	p-value	0.10		0.7		0.03*		0.17	
Permanent	215(53.9)	4.00	.66	3.94	.63	3.92	.68	3.70	.76
Temporary	184(46.1)	4.09	.73	4.05	.78	4.04	.79	3.79	.97
Teaching level	p-value	0.03*		0.19		0.10		0.01*	
Basic (class 1-8)	87(21.8)	3.88	.70	3.88	.72	3.87	.70	3.59	.86
Secondary (class 9-12)	268(67.2)	4.09	.70	4.03	.70	4.03	.73	3.83	.84
University	44(11.0)	4.06	.62	3.94	.69	3.84	.78	3.49	.93
Having laptop	p-value	0.01*		0.29		0.21		0.13	
No	76(19.0)	3.88	.75	3.88	0.84	3.88	0.78	3.57	1.02
Yes	323(81.0)	4.08	.68	4.02	0.67	4.00	0.72	3.78	0.82
Having computer	p-value	0.25		0.93		0.73		0.42	
No	124(31.1)	4.02	.69	3.98	.73	3.97	.73	3.76	.86
Yes	275(68.9)	4.10	.70	4.01	.67	3.98	.75	3.70	.86
Having TV	p-value	0.68		0.69		0.42		0.46	
No	200(50.1)	4.04	.68	3.99	.73	3.94	.75	3.76	.89
Yes	199(49.9)	4.05	.71	3.99	.69	4.01	.72	3.73	.84
ICT training	p-value	0.12		0.26		0.09		0.05*	
No	171(42.9)	3.99	.73	3.94	.75	3.90	.78	3.62	.95
Yes	228(57.1)	4.09	.67	4.03	.67	4.03	.70	3.83	.77

**p-value* $\leq$ 0.05 (i.e. Significant)

Since all the variables as ethical, cultural, leadership, and policy awareness and achievement, are parametric data; hence, the Pearson-product moment correlation was implemented for relationship. In Table 3, the significant correlation existed among all digital awareness related variables and mathematics achievements at 99% confidence level except as policy awareness with marks of mathematics; however, the relation is significant at a 95% level of confidence in this variable. The correlations are high among cultural and ethical awareness (r=0.77), leadership awareness with ethical and cultural awareness (r=0.7). The moderate correlation found in policy awareness with ethical (r=0.65), cultural (r=0.66), and leadership (r=0.68) awareness. However, the relation is low in achievement with culture and leadership, and negligible correlation existed in achievement with ethical and policy awareness (Burns & Dobson 1980, p. 247).

Table 3 Relationship between digital awareness with the average achievement of mathematics (n=399)

	Ethical Awareness	Cultural Awareness	Leadership Awareness	Policy Awareness	Achievement
Ethical Awareness	1.00				
Cultural Awareness	$.77^{**}$	1.00			
Leadership Awareness	$.70^{**}$	$.70^{**}$	1.00		
Policy Awareness	$.65^{**}$	$.66^{**}$	$.68^{**}$	1.00	
Achievement	$.19^{**}$	$.22^{**}$	$.20^{**}$	$.12^{*}$	1.00

**. Correlation was significant at p= 0.01 level (2-tailed)
*. Correlation was significant at p= 0.05 level (2-tailed).

Hierarchical multiple regression was used to assess four digital awareness-related variables' ability to predict the mathematics achievement score after controlling four dimensions of digital awareness variables. Preliminary analysis ware conducted to ensure the assumption of normality linearly, multicollinearity, and homoscedasticity. The overall models explain 4% to 7% of the variance in the first to fourth models, which indicates that the model is poorly fit (Cohen et al., 2007, p. 538). The outputs generated from this analysis are in Model 1 to Model 4 based on digital awareness categories. Model 1 consists of ethical awareness-related items as independent variables and mathematics achievement as the dependent variable. The leadership awareness and policy awareness related items were added for Model 2 to Model 4, respectively. The model explains 4% of the variance in Model 1, which contained only ethical awareness-related items. After entry of ethical and cultural awareness related items in Model 2, the total variance was explained by 6%, F (7, 391) =3.29, p<0. By loading ethical, cultural, and leadership related items, the Model 3 generated, and the model explained by 7% variance, F(10,388)=2.7, p<0.05. The final model (Model 4) was calculated by adding all awareness related items, and models explain by 7% of the variance, F (13, 385) = 2.30, p< 0.05. The statically significant measure was calculated in develop and share cultural consequence under cultural awareness in Model 2 (beta=0.14, p<0.05, VIF=1.96), Model 3 (beta=0.15, p<0.05, VIF=2.16) and Model 4 (beta=0.16, p<0.05, VIF=2.20) with reference to Table 4.

Table 4 Multilevel binary regression on achievement with respect to digital awareness (n=399)

Items with categories	Model 1		Model 2		Model 3		Model 4	
	Beta	VIF	Beta	VIF	Beta	VIF	Beta	VIF
Ethical Awareness								
Safely use of digital resources	0.08	1.55	0.06	1.61	0.02	1.78	0.04	1.82
Ethical use of digital resources	0.01	2.17	-0.03	2.37	-0.01	2.44	0.00	2.47
Copyright, intellectual property	0.06	1.97	0.05	2.00	0.05	2.03	0.06	2.06
Legal and ethical behavior in professional practices	0.08	1.82	-0.01	2.53	-0.03	2.67	-0.03	2.69
Cultural Awareness								
Cultural understanding of global society			-0.01	2.04	-0.03	2.07	-0.03	2.08
Develop and share cultural consequences			0.14*	1.96	0.15*	2.16	0.16*	2.20
Promote digital etiquette			0.09	2.38	0.10	2.64	0.13	2.80
Leadership awareness								
Develop leadership by digital resources					-0.10	2.67	-0.09	2.77
Virtually participate in professional activities					0.05	2.04	0.06	2.06
Evaluate and share professional experiences with others					0.10	2.15	0.13	2.25
Policy awareness								
Local and national level ICT policies							-0.03	3.21
ICT competency models of teachers							-0.10	3.34

Develop digital technological models for classroom teaching				0.00	2.45
R^2	0.04	0.06	0.07	0.07	
ANOVA	3.76*	3.29*	2.70*	2.30*	

**p-value* ≤ 0.05 (i.e. Significant)

DISCUSSION

Leadership awareness may play a significant role in developing teachers' digital competency and awareness. It involves developing leadership in schools and higher education institutions to help teachers learn and develop their digital capability to apply in the classroom to create a digital-friendly classroom environment (Ottestad 2013). The goal of developing and achieving mathematics teachers' digital leadership and awareness of such leadership to foster a digitally rich classroom practice is possible through cooperative and distributed leadership development (Ottestad 2013). Digital technologies can support students' access high-quality mathematics, learning, teachers' awareness of the potential of using digital tools in promoting student engagement and professional development of teachers with an emphasis on equity (AAMT 2014). On the other hand, technological advancement in education and digital tools in the classroom has raised concerns about the teachers' ethical dilemma. Overexposure of students to the digital contents may distract them from the central aspects of conceptual knowledge and development of reasoning coherently, and even it may lead them beyond the social values. There is a danger of malware and viruses on the Internet that may damage persons and institutions' reputations. Also, there is a chance that some websites may publish inaccurate and misleading information that may affect both students and teachers (Northwest Missouri State University 2018). Therefore, digital awareness and technological innovation in education should be assessed in the light of social values and ethics (O'Brien 2020). In this context, it has been recommended that educational institutions and teachers should apply digital tools for "expressive and analytical purposes" in classroom teaching and learning of mathematics and beyond (Joint Mathematical Council of the United Kingdom [JMC] 2011, p. 5). For such development of technological digital tools and their appropriate uses in the classes should be guided by the policy at the school level to the national level. Students and teachers should be aware of the "changing norms of Internet usage …and consequences of their online actions" (Buchanan 2019, p. 2). The technology principal of NCTM (2000) standards, Common Core State Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers 2010), UNESCO (2028), and Department for Education (2019) have provided some policy guidelines about the use of the digital technology in the classrooms. The National Curriculum Framework for School Education in Nepal (MoECIT 2019) does include some provision of technological integration in the classrooms. Still, it does not provide a detailed policy guideline to the teachers and education leaders. It is high time to develop a direction and policy for the ethical use of digital tools in the classroom and outside by the teachers of all grade levels and higher education (Maggiolini 2014). The current study explored digital awareness and its impact on mathematics achievement within the framework of four digital awareness dimensions—ethics, policy, culture, and leadership.

All mathematics teachers have at least one digital device; however, for most of them, the laptop was found to positively affect their ICT application and digital awareness. Around two-fifths of the teachers are using mobile and laptops for more than 3 hours per day, and more than half of them are using such devices for the last five years. This indicates that most of the mathematics teachers are digitally literate and able to use the resources for their different activities. The level of digital awareness was found to be high in all measured items and categories. One of the reasons for the high digital knowledge might be because the information was collected during the COVID-19 pandemic. The teachers learned about several digital tools and online resources during this period, which might have affected their digital awareness level. The mathematics teachers and their professional organizations conducted several technological skill enhancement programs through Zoom, Google Meet, Teams, Facebook groups, etc. However, that level was found to be medium among females 45-60 years of age. The digital awareness level was medium level among the humanities/management background and teaching at the basic (class 1-8) level. Digital awareness of teachers and students has implications from an "anthropological cultural point of view" (Combi 2016, p. 3). This awareness helps teachers and students play a positive role and develop their identity in the local, national and global arena by expanding shared knowledge, views, ideas, perceptions, and experiences using digital tools (Combi 2016). Technology and digital tools may support in enhancing students and teachers' awareness of their cultural norms, values, and practices through greater access to the online resources related to cultural diversity, characteristics, and offerings with direct or indirect engagement through linking the cultural heritages in teaching-learning (Perez, Cabrera-Umpierrez, Arrendondo, Jiang, Floch, and Beltran 2016).

Additionally, the result is statistically significant based on types of institution, teaching level, and those having laptops in ethical awareness in favor of private and secondary school teachers and those having laptops, respectively. Types of institutions and job types have a significant result on leadership awareness in support of private and temporary school teachers with their counterparts. Teaching level and status of taking ICT training have significant results on policy awareness in favor of secondary and trained mathematics teachers, respectively. A strong significant relation was found between all digital awareness categories with the achievement of mathematics. However, that relation was found to be low and negligible, which indicates that digital awareness is not highly contributing to the performance of the students. However, multiple linear regression showed that the cultural consequence under cultural awareness was the primary predictor of student achievement in mathematics. However, the coefficient of determination or the goodness of fit of the regression model is week as R^2 values are too low. Then, the predictability of the four models is weak. That means the teachers' digital awareness cannot accurately predict mathematics performance in terms of ethical awareness, leadership awareness, and policy awareness. The beta values are significant in models 2, 3, and 4 for one construct - develop and share cultural consequences within ethical awareness. These results indicated that the digital awareness of the teachers did not contribute to students' performance. One of the reasons for this unpredictability of students' mathematics achievement from teachers' digital awareness might be that digital awareness of teachers is a psychological state of teachers in terms of their preparedness to use the tools in teaching mathematics and their level of confidence in using the tools which not necessarily translated into the quality of students' mathematics learning.

CONCLUSION

Most of the Nepali mathematics teachers are digitally literate and have at least one digital resource or device. The digital awareness level on ethical, cultural, leadership, and policy was found to be high. Types of the institution, teaching level, and having laptops are contributing factors for ethical awareness, institution, and job types are contributing factors of leadership awareness, and job type and ICT training are contributing factors on policy awareness. The relation was found to be low and negligible on mathematics achievement with digital awareness; nevertheless, cultural consequences were found to be a predictor of mathematics achievement. However, this study's result was limited to 399 mathematics teachers' digital awareness in the context of Nepal, where there was limited use of digital tools in education before the COVID-19 pandemic. Enhanced use of digital prompted only due to schools, and higher education institutions closed their face-to-face classes due to the nationwide lockdown. The study results cannot be generalized to another context due to the difference in awareness levels and applications of teaching-learning tools. Hence, further investigation can be conducted among other subjects, students, and other social units, based on the country's diversity and large sample size. The finding of this research may inform the policymakers, teachers, researchers, and students to be safe using digital resources in this age. Additionally, the related stakeholders have to launch and implement some novel programs for digital awareness for teachers, students, and parents for the ethical use of digital tools for better learning and teaching.

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