Comparative study of knowledge and use of Bloom's digital taxonomy by teachers and students in virtual and conventional universities

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Abstract

Purpose – This paper intended to explore the knowledge and use of the digital verbs and tools by the students and teachers for conceptual understanding in the virtual and conventional learning environment. The study also explored the use of such digital tools for lower- and higher-order thinking.

Design/methodology/approach – A survey research method was used for the study. All the students and teachers of the faculty of education from one virtual and one conventional university were the population of this study. Teachers were selected through census sampling. Student enrollment in the faculty of education of the virtual university during Spring 2019 was 1,139 while the conventional university had 1,809 students. In total, 20% of the students from each of the two universities were sampled by using a convenient proportionate sampling technique. A questionnaire was developed by the researchers and validated by three experts before administration. The reliability of the instrument was $a = 0.934$. Mean, SD, parametric and nonparametric statistics were applied for data analysis.

Findings – The study reveals that the students of ODL are far better in using digital tools and activities that is, googling, collaborating and Skyping. They are good at understanding and application levels and are involved in higher-order thinking tasks, that is, publishing and podcasting as well. Unlike the students, the teachers of the virtual university are using digital tools of lower-order thinking. The authors infer that the students and teachers of the online universities are using these tools regularly because of the demands of the ODL environment. These findings suggest further research to explore the factors that hinder the use of higher-order thinking skills by the teachers in the online environment.

Originality/value – The study suggests the adoption of Bloom's digital taxonomy in teaching–learning processes, that is, curriculum, instructions and assessment for the millennials. The findings may motivate the online and conventional higher education institutions to adopt digital pedagogy for instructional purposes as the students of the digital age are already extensively involved with digital tools.

Keywords Bloom's digital taxonomy, Cognitive process, Higher- and lower-order thinking, Digital pedagogy, Collaborating

Paper type Research paper

1. Introduction

Since the times of Plato, Socrates and Aristotle, education is considered crucial to improve ones' life and socioeconomic status (Wedlock and Gorwe, 2017). This Greek ideology is still relevant in the current world as it was in the past, though with a little change in the modes of instruction

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and academic activities. Technology, as the driving force of educational processes, has transformed the teaching–learning landscape to a whole different level. It has also changed the ways students and teachers think, perform, interact and process information (Raymundo, 2020). There is a worldwide growing concern among educationists and policymakers on educating the digital-age students (Wedlock and Gorwe, 2017, p. 25). The introduction of online and distance learning (ODL) has created the possibility of flexible and boundaryless campuses and classrooms since the last decade (Dash, 2019). Accessibility to the digital technologies has helped teachers to disseminate education to the young generation through varied means (Literat and Glaveanu, 2018), which has, resultantly, increased the opportunities to adapt innovative and creative ways for the engagement of millennials (Nikolić and Dabić, 2016). The challenge in the ODL environment is not limited to providing technology infrastructure but also to provide mentoring and guidance to use the digital resources for interaction with teachers and peers anywhere and anytime (Xiao *et al.*, 2019).

The students are expected not only to attain the content-related basic understanding and competencies but also to display higher-order thinking and creativity (Brookhart, 2010; Collins, 2014). Applying higher-order thinking skills in the current digital world requires sufficient knowledge of the digital tools and expertise to perform those (Prensky, 2001). Teachers' expectations from the students within and outside the classroom have been classified in the form of taxonomies of learning objectives (Krathwohl, 2002). The original and revised Bloom's taxonomies describe the conventional or basic cognitive skills but not the digital skills parallel to the various levels in the hierarchy of the cognitive domain. The Bloom's digital taxonomy (BDT) has provided a framework to teach and assess the teachers' and students' understanding and usage of associated digital tools in the academic and nonacademic contexts (Crockett *et al.*, 2011).

2. Literature review

2.1 Original Bloom's taxonomy

Bloom's taxonomy is perhaps the most prominent concept in education, particularly for teaching and learning. This taxonomy has divided learning into three behavioral domains, that is, cognitive, affective and psychomotor (Bloom, 1956) with the main focus on the cognitive domain because of its possible application in primary, secondary and tertiary education. Each of the three categories is further organized into six levels from simple to complex.

According to Krathwohl (2002), Bloom devised the cognitive taxonomy to reduce teachers' burden for preparation of comprehensive examinations. The six levels of this domain arranged in a hierarchy are knowledge, comprehension, application, analysis, synthesis and evaluation. Each level has its own associated action verbs to demonstrate students' learning. Every level is considered as a prerequisite to qualify for the next level.

2.2 Revised Bloom's taxonomy

In the beginning of the 21st century, a revised version of Bloom's taxonomy with a number of significant changes was proposed by Bloom's former student Anderson along with his fellow researchers (Anderson and Krathwohl, 2001). They changed the original taxonomy in three major ways, that is, terminology, structure and emphasis. Out of the six levels, three were renamed (Nikolić and Dabić, 2016) and two of the levels were shuffled with their titles reflecting the actions or verbs instead of nouns (Wedlock and Gorwe, 2017). The six levels of the revised taxonomy are remembering, understanding, applying, analyzing, evaluating and creating (Anderson and Krathwohl, 2001). Similar to the old taxonomy, the revised one also represented a hierarchy with each level linked to the previous as a prerequisite.

2.3 Digital update of Bloom's taxonomy

ODL has revolutionized the modes of learning. It has dissolved the canvas of site-bounded teaching–learning into open, flexible and collaborating. It is evident from the literature that a new epistemology has led to paradigm shift in educational theories for future generations. These transformations have developed a new learning paradigm called "connectivism" (Siemens, 2005). Connectivism plays an important role in the development of digital pedagogies (Kop and Hill, 2008). The primary goal of these digital pedagogies is to use digital tools as educational tools to facilitate learning and provide opportunities to students to take charge of their learning process (Sneed, 2016).

Churches (2009) has promoted "Bloom's Digital Taxonomy" and explained that the digital taxonomy is not limited to the cognitive domain only, rather it provides the methods and tooling for conceptual understanding as well. He identified the digital tools and verbs associated with each level, that is, lower to higher (Munzenmaier and Rubin, 2013). The names and hierarchy of levels were retained from the Bloom's revised taxonomy.

Nikolić and Dabić (2016) describe that verbs used in digital settings differ on the basis of their practice in the academics and are termed as "digital verbs". *Editing*, *creation*, *sharing* and *interaction* are at the core of many digital activities proposed in BDT (Cardoso, 2019). BDT helps us to make choices about learning experiences by navigating through the large pool of digital tools (Lightle, 2011). However, there are two limitations of using digital verbs in the academic context. First, the classification of digital tools conferring to their appropriate level is difficult as many tools might be used for multiple actions. Second, the popularity of the tools is different and contextually diverse (Hart, 2015).

Statement of the problem: Munsenmaier and Rubin (2013) stated that BDT has facilitated teachers to design student-centered activities by shifting the focus from teachers to students. Teachers use these taxonomies as a compulsory and vital hierarchical instructional set to develop lower- and higher-order thinking skills of students. In this tech-savvy world, it is a prerequisite for every student and teacher to have the knowledge and proficiency of using digital tools for positive academic outcomes. Many online digital tools (i.e. blogs, wikis, apps and games) are accessible to teachers and students at minimal or no cost. If teachers use these digital tools correctly and embed those in lesson planning and classroom instructions, the gap between education and technology can be reduced (Wedlock and Gorwe, 2017). Currently, it is indispensable for teachers to use innovative digital tools and transform them into educational tools to enrich students' learning experiences. The online students and teachers are supposed to have better knowledge and skills to use the digital tools while the conventional teaching–learning world cannot remain isolated from the revolution created by the information communication technologies. Therefore, this research aimed to explore the knowledge and use of BDT by the students and teachers in the virtual and the conventional universities.

Objectives of the study

The objectives of the study were to:

(1) compare the knowledge and use of BDT by the teachers and students in the virtual and the conventional universities;

(2) determine the difference in the use of different levels of BDT by the students in the virtual and the conventional universities;

(3) determine the difference in the use of different levels of BDT by the teachers in the virtual and the conventional universities;

(4) explore the difference in the use of BDT used for higher- and lower-order thinking skills by the teachers and students in the virtual and the conventional universities.

Theoretical and conceptual framework of the study

BDT proposed by Churches (2009) was used as the theoretical framework for this study (Figure 1). Churches retained the levels of the revised Bloom's taxonomy. He then identified the digital verbs and actions associated with each level. For this study, researchers selected 13 different digital verbs and tools from the list proposed by Churches and categorized them

Figure 1.
Comparison of three taxonomies (Gonzalez-Major and Albright, 2008)

as lower- and higher-order thinking skills (knowledge–creativity). The list of all the digital tools with respect to categorization is given in Table 1.

Hypotheses for students' data

H1. There is no significant difference between the mean scores of students of the conventional and virtual universities regarding the overall knowledge and use of BDT.

H2. There is no significant difference between the mean scores of students of the virtual and conventional universities on remembering (bookmarking and favorting): BDT level 1.

H3. There is no significant difference between the mean scores of students of the virtual and conventional on understanding (googling and advance searching): BDT level 2.

H3.1. There is no significant difference between the mean scores of students of the virtual and the conventional on understanding (blog journaling): BDT level 2.

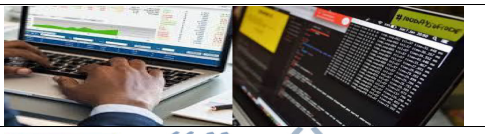
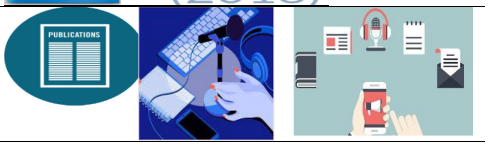
	Bloom's Digital Taxonomy (BDT) Levels	Bloom's Digital Verbs	Digital Tools
Lower Order Thinking	Remembering	Bookmarking, social & bookmarking, Favourting	
	Understanding	Googling & Advance searching, Blog Journaling	
	Applying	Content Authoring & wiki editing, Collaborating though e-tools, Skyping, Interactive whiteboard	
Higher Order Thinking	Analyzing	Data processing through computers	
	Evaluating	Validating information & Referencing	
	Creating	Podcasting, Recording videos & Digital publishing	

Table 1.
Conceptual framework of study

H4. There is no significant difference between the mean scores of students of the virtual and the conventional universities on applying (Skyping): BDT level 3.

H4.1. There is no significant difference between the mean scores of students of the virtual and the conventional universities on applying (content authoring): BDT level 3.

H4.2. There is no significant difference between the mean scores of students of the virtual and the conventional universities on applying (collaborating using e-tools): BDT level 3.

H4.3. There is no significant difference between the mean scores of students of the virtual and the conventional universities on applying (IWB): BDT level 3.

H5. There is no significant difference between the mean scores of students of the virtual and the conventional universities on analyzing (data processing): BDT level 4.

H6. There is no significant difference between the mean scores of students of the virtual and the conventional universities on evaluating (validating information and referencing): BDT level 5.

H7. There is no significant difference between the mean scores of students of the virtual and the conventional universities on creating (podcasting and digital publication): BDT level.

Hypotheses for teachers' data

H8. There is no significant difference between the median scores of teachers of the conventional and the virtual universities regarding the overall knowledge and use of BDT.

H9. There is no significant difference between the median scores of teachers of the virtual and the conventional universities on remembering (bookmarking and favorting): BDT level 1.

H10. There is no significant difference between the median scores of teachers of the virtual and the conventional on understanding (googling and advance searching): BDT level 2.

H10.1. There is no significant difference between the median scores of teachers of the virtual and the conventional on understanding (blog journaling): BDT level 2.

H11. There is no significant difference between the median scores of teachers of the virtual and the conventional universities on applying (Skyping): BDT level 3.

H11.1. There is no significant difference between the median scores of teachers of the virtual and the conventional universities on applying (content authoring): BDT level 3.

H11.2. There is no significant difference between the median scores of teachers of the virtual and the conventional universities on applying (collaborating using e-tools): BDT level 3.

H11.3. There is no significant difference between the median scores of teachers of the virtual and the conventional universities on applying (IWB): BDT level 3.

H12. There is no significant difference between the median scores of teachers of the virtual and the conventional universities on analyzing (data processing): BDT level 4.

H13. There is no significant difference between the median scores of teachers of the virtual and the conventional universities on evaluating (validating information and referencing): BDT level 5

H14. There is no significant difference between the median scores of teachers of the virtual and the conventional universities on creating (podcasting and digital publication): BDT level.

Hypotheses for lower- and higher-order thinking levels

H15. There is no significant difference between the mean scores of students of the virtual and the conventional universities for lower- and higher-order thinking of BDT.

H16. There is no significant difference between the median scores of teachers of the virtual and the conventional universities for lower- and higher-order thinking of BDT.

3. Delimitation of the study

This study is delimited to the students and teachers of the faculty of education of one virtual and one conventional university in Pakistan.

4. Methodology

This was a descriptive cross-sectional study. Survey research method was used to find out the knowledge and use of BDT (tool and verbs) by the teachers and students of the virtual and conventional universities in Lahore.

5. Population

Pakistan has 115 conventional general education universities in the public sector and only one virtual university (HEC, 2019).

The target population was all the students and teachers of the faculty of education of the selected universities, one general conventional university and one virtual university.

6. Sampling technique

Multistage sampling technique was used to select the sample.

7. Students' sample

Frist stage: Purposive sampling technique was used to select two universities. Etikan, Musa and Alkassim (2016) stated that purposive sampling method is used to identify and select the participants who are proficient and understand the phenomenon of interest clearly. The researchers selected the only virtual or online university. For comparison, one conventional university with the highest number of students and full-time faculty was selected. During Spring Semester 2019, a total number of 1,139 students were enrolled in the faculty of education of the online university and 1,809 students were enrolled in the counterpart faculty of the conventional university.

Second stage: By using convenient proportionate sampling technique, a sample of 558 (20%) out of total 2,948 students was selected.

8. Teachers' sample

All the teachers of the faculty of education from each of these two universities were selected through census sampling (see Table 2).

8.1 Instrument of the study

After a detailed review of the literature, a questionnaire "Blooms Digital Technology Questionnaire (BDTQ)" was developed for this study. Conceptual framework (Table 1) of the study was used to identify the digital verbs and associated tools with each verb. After identification, these digital tools and verbs were categorized as per taxonomy levels, that is, *remembering to creativity*. These levels were not explicitly mentioned in the questionnaire to get the original responses from students and teachers. Only the researchers knew the level and hierarchy of the digital tools and associated verbs.

The draft BDTQ consisting of 65 statements soliciting responses on a five-point Likert scale was validated by two experts of this domain. Seven of the statements were excluded after content validation by the experts. The remaining 58 statements were distributed over ten sections of the BDT.

BDTQ was pilot tested on a sample of 75 students for reliability. The Cronbach alpha was = 0.924, which makes the instrument as highly reliable.

8.2 Data collection and analysis

Data was collected in two stages from the teachers and the students. An online questionnaire (BDTQ) using Google forms was generated and administrated through the learning management system (LMS) for the students of the virtual university. Data from the teachers of the virtual university was collected through email.

Paper-based BDTQ was administered to the students and teachers of the conventional university. On request of some of the teachers and students of the conventional university, online link of the questionnaire was also shared with them. Response rate of the questionnaires was as follows (see Table 3).

9. Data analysis

Data was analyzed by using mean, standard deviation, parametric and nonparametric statistics.

Table 2.
By mode of learning distribution of teachers and students' samples (N = 427 Students' N = 50 teachers)

	Students		Teachers	
Mode of learning	*F*	%	*F*	%
Virtual	184	43.1	18	36.0
Conventional	243	56.9	32	64.0
Total	427		50	

Table 3.
Response rate of sample

Type of university	Students' sample size	Response rate	Teachers' sample size (census)	Response rate
Conventional	361	243 (67%)	49	32 (65%)
Virtual	227	184 (82%)	19	18 (100%)
Total	588	427		50

Students' data analysis: Shapiro–Wilk test was applied to see the normality of students' data. p –value $\alpha = 0.110$ and normal histogram revealed that responses of students on BDQT were approximately normally distributed with the skewness of −0.174 (SE = 0.118) and a kurtosis of −0.073 (SE = 0.236). Thus, a parametric statistics could be applied for analysis of students' data.

Teachers' data analysis: Shapiro–Wilk test was applied to see the normality of teachers' data. The p –value $\alpha = 0.04$ and histogram showed that responses of teachers on the questionnaire were not normally distributed with the skewness of 0.632 (SE = 0.337) and a kurtosis of −0.148 (SE = 0.662) for data. Thus, a nonparametric statistics could be applied for analysis of teachers' responses.

10. Findings and discussion

This study is an empirical attempt to compare the knowledge and use of BDT by the students and the teachers in a virtual and a conventional university. Nikolić and Dabić (2016) found that the digital verbs used in academia differ on the basis of their practice in instructions and curriculum (see Table 4).

Students' responses have indicated highest mean for applying level verbs such as collaborating *through e-tools and Skyping*. It implies that students are well versed with these tools, have diverse experience and are practicing them frequently. However, for the remaining digital verbs, the average means were observed except the podcasting *and digital publishing*, which has the lowest mean value. The responses of teachers showed the highest mean for understanding level verbs, that is, *googling and advance searching*. It can be inferred that teachers' use of BDT for the rest of the levels is substantially low when compared with the students. These findings portray that the teachers spent most of the time in exploring relevant material for academic and research activities.

Hypothesis I: Statistically significant difference ($t = 2.13, p = 0.03$) was observed between the mean scores of students of the conventional and the virtual university regarding knowledge and use of BDT, which leads to rejecting the null hypothesis H1 (see Figure2) (see Table 5).

One of the major reasons for the aforementioned significant difference between the knowledge of the students of the two modes of teaching–learning might be that the virtual university students are already studying in ODL environment and using more digital tools as requirement of their academic activities. Moreover, they have more experience of online medium and have profound knowledge and practice to use the digital resources as compared

		Students ($N = 427$)			Teachers ($N = 50$)		
Levels of Bloom's digital taxonomy	AR*	Range	Mean	SD	Range	Mean	SD
Remembering (bookmarking)	4–20	16	12.07	3.19	14	12.70	3.13
Understanding (advance searching)	4–20	16	15.34	3.48	12	14.08	2.92
Understanding (blog journaling)	5–25	20	12.03	5.27	20	13.84	4.14
Applying (content authoring)	5–25	20	12.56	4.46	17	15.70	4.39
Applying (collaborating using e-tools)	5–25	20	23.77	6.92	15	17.14	3.21
Applying (Skyping)	8–40	32	16.45	4.31	40	25.78	6.60
Applying (IWB)	8–40	32	22.65	7.02	32	23.68	7.12
Analyzing (data processing)	7–35	28	22.0	7.11	25	21.80	5.38
Evaluation (validating information)	6–30	24	19.56	5.17	17	19.64	3.58
Creativity(podcasting and digital publication)	7–35	28	18.83	7. 31	23	20.94	5.47

Note(s): *Actual range/theoretical range of instrument

Table 4. Range, mean and SD of different levels of Bloom's digital taxonomy for students and teachers

to the students of the conventional university. These findings are also aligned with the literature. Thota and Negreiros (2015) said that explosion of digital medium has transformed the nature of learners and ODL students are using more digital tools, that is, e-books, online videos, blogs, and these mediums have opened new avenues for multisensory learning and exploration for students.

Similarly, learning in the ODL context expects students to absorb information at advanced pace because they are already familiar and experiencing these technologies on daily basis (Prensky, 2001). Considine, Horton and Moorman (2009) (quoted by Wedlock and Gorwe, 2017) asserted that public institutes place restrictions on the use of Internet at the premises of universities, and this restriction fails to bridge the gap between the digital tools and classroom instructions for conventional university students. On the other hand, these millennials are using these digital tools outside the classrooms for their personal uses, and it helped them in making connections through different mediums.

11. Hypotheses II–VII

Table 6 shows that the "*t*" values for the difference between the knowledge and use of digital verbs by the students of the virtual and the conventional university is statistically significant only at three of the levels of BDT.

Table 6 revealed that "*p*-values" are 0.004, 0.000 and 0.05 for googling and advance searching, Skyping and validating information and references. Thus, it is concluded that knowledge and use of digital verbs by the students of the two types of universities are significantly different at understanding, applying and evaluating levels. Thus, we rejected the H3, H4 and H6 and accepted the hypotheses H2, H3.1, H4.1, H4.2, H4.3, H5 and H7 (see Figure 3).

Better knowledge and more use of the digital tools associated with each level by the virtual university students can be attributed to their daily requirement and practice. Sylvia (2014) points out clearly that the "Millennials" born during early 2000s are already familiar and grownup with these digital tools. Students of both the modes are not only enjoying social media but are also active on different platforms. They are collaborating extensively and productive as they are posting pictures, videos and vlogs and so on.

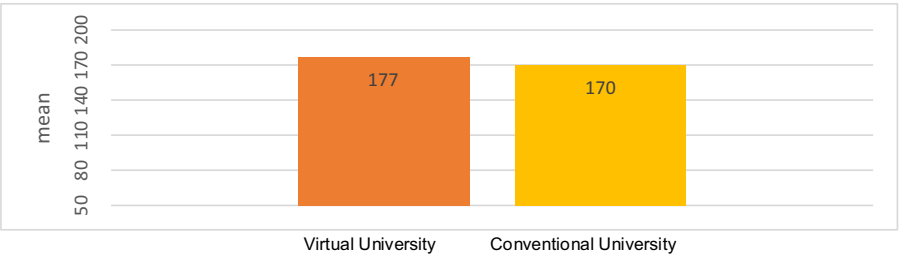


Figure 2.
Means of students' knowledge and use of BDT

Students' $N = 427$
Independent sample *t*-test

Mode of learning	Mean	SD	Df	*t*	Sig
Virtual	177	28.6	425	2.13	0.03
Conventional	170	33.1			

Note(s): *$p < 0.05$

Table 5.
By mode of learning comparison of students' knowledge and use of BDT

BDT levels and digital verbs	University	*N*	Mean	SD	df	*t*	Sig
Remembering (bookmarking)	Virtual	184	11.82	3.36	425	−1.438	0.15
	Conventional	243	12.26	3.05			
Understanding (googling and advance searching)	Virtual	184	15.89	3.19	415.6	2.873	0.004
	Conventional	243	14.93	3.63			
Understanding (blog journaling)	Virtual	184	11.83	5.34	425	−0.660	0.51
	Conventional	243	12.17	5.22			
Applying (Skyping)	Virtual	184	17.46	4.47	425	4.116	0.000
	Conventional	243	15.76	4.03			
Applying (content authoring)	Virtual	184	12.12	4.65	425	−1.756	0.08
	Conventional	243	12.89	4.29			
Applying (collaborating using e-tools)	Virtual	184	24.15	6.80	425	1.004	0.31
	Conventional	243	23.47	7.00			
Applying (IWB)	Virtual	184	22.46	7.50	425	−0.478	0.63
	Conventional	243	22.79	6.65			
Analyzing (data processing)	Virtual	184	21.94	5.98	425	−0.131	0.80
	Conventional	243	22.03	7.87			
Evaluating (validating information and referencing)	Virtual	184	20.12	5.61	358.02	1.938	0.05
	Conventional	243	19.13	4.78			
Creativity (podcasting and digital publication)	Virtual	184	18.29	7.36	425	−1.306	0.19
	Conventional	243	19.23	7.25			

Note(s): *$p < 0.05$

Table 6.
By mode of learning comparison of students' knowledge and use for different levels of BDT ($N = 427$)

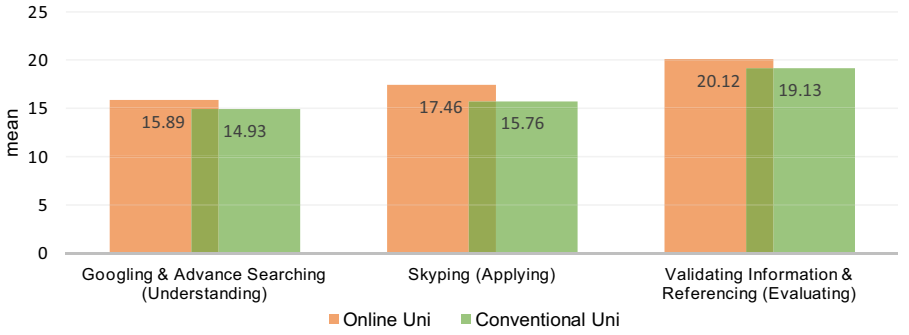


Figure 3.
Means of students' knowledge and use of different levels of BDT with significant difference

Moreover, millennials are now demanding variety in teaching–learning strategies and educational services offered by the higher education institutes (Koeller, 2012). Thus, innovative strategies and instructional practices are needed to be integrated in curriculum and practiced in classroom rigorously to keep students' attention on learning (Wedlock and Growe, 2017). Incorporating digital tools and using them intelligently in educational setting may offer opportunities for a variety of benefits to the learners. Twenty-first century's literates will be those who will be proficient in using digital tools as pedagogical tools (Mullen and Wedwick (2008).

12. Hypothesis VIII

Significant value of the Mann–Whitney *U* test in Table 7 leads to rejecting the null hypothesis H8. The teachers of the virtual university were found significantly more knowledgeable about BDT as compared with those of conventional university (see Figure 4).

13. Hypotheses IX–XIV

Knowledge and use of digital verbs and tools by the teachers of the two universities are significantly different at four levels as shown in Table 8.

Table shows that "*p*-value" 0.02, 0.04, 0.00 and 0.01 are for digital verbs *bookmarking, googling and advance searching*, *Skyping* and *data processing through computers*. Thus, it is

Table 7.
By mode of learning comparison of teachers' knowledge and use of BDT

Mode of learning	Teachers $N = 50$ Mann–Whitney U test Mean rank	Median	Mann–Whitney U	Sig
Virtual	31.92	188.5	172.5	0.02
Conventional	21.89	176.0		

Note(s): *$p < 0.05$

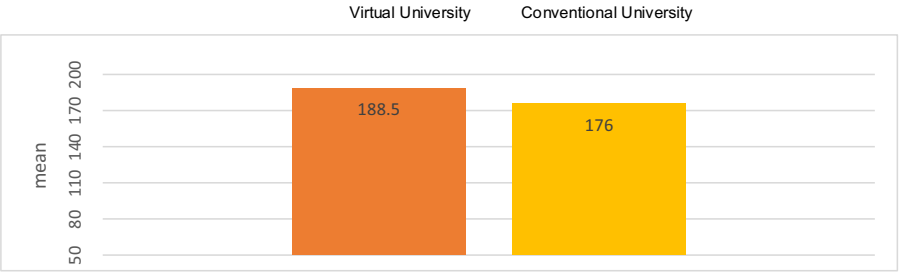


Figure 4.
Medians of teachers' knowledge and use of BDT

Table 8.
By mode of learning comparison of teachers' knowledge and use for different levels of BDT ($N = 50$)

BDT levels and digital verbs	University	N	Mean rank	Sum of ranks	Median	Mann–Whitney U	Sig. (2-tailed)
Remembering (bookmarking and favorting)	Virtual	18	36.06	613.0	14.50	134.0	0.02
	Conventional	32	20.69	662.0	12.0		
Googling and advance searching (understanding)	Virtual	18	31.00	558.0	15.50	189.0	0.04
	Conventional	32	22.41	717.0	13.0		
Understanding (blog journaling)	Virtual	18	21.39	385.0	12.0	214.0	0.13
	Conventional	32	27.81	890.0	15.0		
Skyping (applying)	Virtual	18	32.86`	591.5	28.0	155.5	. 00
	Conventional	32	21.36	683.5	23.5		
Applying (content authoring)	Virtual	18	28.33	510.0	18.0	237.0	0.30
	Conventional	32	23.91	765.0	15.0		
Applying (collaborating using e-tools)	Virtual	18	25.17	453.0	18.0	453.0	0.90
	Conventional	32	25.69	822.0	17.5		
Applying (IWB)	Virtual	18	27.06	487.0	24.0	788.0	0.57
	Conventional	32	24.63	788.0	23.5		
Analyzing (data processing)	Virtual	18	32.28	518.0	23.5	166.0	0.01
	Conventional	32	21.69	694.0	20.0		
Evaluating (validating information and referencing)	Virtual	18	27.75	499.0	20.0	775.5	0.41
	Conventional	32	24.23	775.0	19.0		
Creativity (podcasting and digital publication	Virtual	18	23.83	429.0	19.5	429.0	0.54
	Conventional	32	26.44	846.0	21.0		

Note(s): *$p < 0.05$

concluded the knowledge and use of digital verbs by the teachers of the virtual and that of the conventional university are significantly different at *remembering, understanding, applying and analyzing* levels. Thus, we rejected the H9, H10 and H11 and H12 and accepted the hypotheses H10.1, H11.1 H11.2, H11.3, H13, H14.

Teachers of the virtual university attained higher median than the teachers of the conventional university at four out of the six levels (Figure 5). They have better skills of bookmarking, advance searching, Skyping and data processing through computers. This also supports the notion of Cardoso (2019) that only awareness and right use of digital tools by teachers can play supportive role in the development of tech-savvy generation. He stressed that incorporating technology effectively into the curriculum and also in instructional practice may help the educationists and teachers to reduce time and cost of educational activities in conventional setting as well.

It is also appreciating that higher education institutes are responding to the needs of learners by fostering technological and pedagogical adaptation in the courses and instructions. Thota and Negreiros (2015) termed digital verbs as processes, that is, networking and publishing and matched them with digital tools, that is, blogs, wikis and so on to develop instructions for students.

14. Hypothesis XV

Table 9 shows that the difference between the mean scores of the students of the two types of universities is statistically significant at higher-order thinking levels of BDT.

It is interesting to note that the students of the virtual university are more involved in higher-order thinking activities as compared with those of the conventional university. This finding is supported by Lenhart *et al.* (2005) saying that the role of millennials is not limited as being the consumers of Internet content, but they are creator of content as well particularly in open and distance environment. Considine, Horton, and Moorman (2009) said that content creation is not

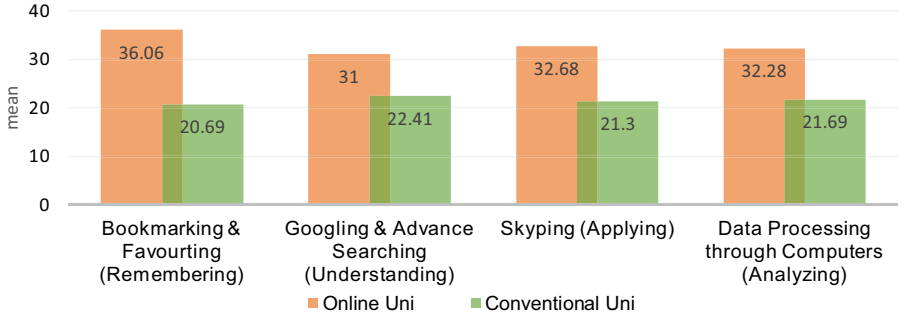


Figure 5.
Medians of teachers' knowledge and use of different levels of BDT with significant difference

Variable	Mode of learning	Mean	Students' $N = 427$ Independent sample t-test SD	df	t	Sig
Lower-order thinking	Virtual	115.52	19.18	425	0.123	0.12
	Conventional	112.28	22.94			
Higher-order thinking	Virtual	61.1	13.3	395.24	0.013	0.01
	Conventional	57.82	13.4			

Table 9.
By mode of learning comparison of students' mean scores for lower- and higher-order thinking levels

limited to posting photographs on webpages and writing for online journals, but it includes the creativity in the forms of posting stories, videos, blogs and podcasting.

Furthermore, students have accounts with YouTube, Flicker, TikTok and Picasa, which allow them to have graphic awareness and manage collaborations with peers and teachers simultaneously (Downes, 2010). Thota and Negreiros (2015) also described that when each student was assigned a topic to design lesson plan by using digital tools and verbs, their responses were overwhelmed and they participated actively in this project. They further explained that these project-based assignments involving innovation and creativity promote higher-order thinking among students.

15. Hypothesis XVI

Mann–Whitney *U* test revealed that teachers of the virtual university were found using lower-order thinking skills more as compared with those of the conventional university (Table 10).

Teachers of the online mode extensively use verbs and tools related to lower-order thinking skills in their day-to day activities. This is because in ODL environment, teachers are using digital innovations such as Zoom, Skype, Google classrooms and Adobe connect to interact with students on daily basis. Some tools also act as medium of communication to facilitate learning process and maximize productivity between peers and teachers. Wedlock and Growe (2017) said that some of the digital tools mentioned in the classification of BDT and their applications with appropriate action verbs may provide instructional differentiation for teachers. The tools, that is, iPad, Kindle, Myspace, Bebo, MindMesiter, Bubbl, Classroom blogmiester, Edublogs, Flicker and so on can be used to achieve the desired learning outcomes of higher-order thinking levels as well.

Furthermore, usage of each digital verb and its associated tool is entirely dependent on the experience, careful planning and clarity of learning outcomes. Thus, in ODL environment students and teachers learn to collaborate, exercise their freedom and creativity by showing greater level of engagement in assigned tasks. Teachers' role is limited to facilitate learning and mentoring of the digital learners (Prensky, 2001). However, teachers must not assume that if students are comfortably socializing, they will use it for business or academic-related collaboration. They still need mentoring to apply digital pedagogy to cope with the challenges of digital world (Downes, 2010).

16. Conclusion and implications

The current learners (kindergarten–college) are the first generation to grow up in digital world with a variety of digital tools. They have spent their entire life in the surroundings of computers, Internet, social networks and toys of digital world. Therefore, it is vital for the teachers to know that the students would not be using these digital tools for professional and academic purposes as they use them primarily for social and collaborating purposes (Sylvia, 2014). Hence, it is

Table 10.
By mode of learning comparison of teachers' median scores for lower- and higher-order thinking levels

		Teachers' $N = 50$ Mann–Whitney *U* test			
Variable	Mode of learning	Mean rank	Median	Mann–Whitney *U*	Sig
Lower-order thinking	Virtual	31.67	128.0	177.0	0.02
	Conventional	22.03	119.0		
Higher-order thinking	Virtual	29.0	62.50	225.0	0.20
	Conventional	23.53	60.50		

teachers' responsibility to design instructions based on digital pedagogy to involve students for academic activities.

This study concludes that students and teachers of ODL are proficient in advance searching, using e-tools for collaboration and data processing on computers in online mode. However, teachers in ODL are using digital verbs and tools related to lower-order thinking levels. Therefore, they must reflect upon the importance and strategies to use higher-order thinking skill for ODL learners.

Empirical evidence of this study implies that it is expected from teachers to help students (millennials) by incorporating BDT for academic activities and to personalize learning experiences for millennials. These technologies are everywhere around us and students are getting exposed to a plethora of information, yet they lack the ability to incorporate those in academics. Therefore, it is recommended to use digital tools in conjunction with the traditional pedagogies to make learning experiences more meaningful and constructive. Furthermore, teachers are needed to be professionally trained about the philosophy of digital pedagogy and strategies to incorporate BDT comprehensively in all phases of their teaching–learning.

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