Digital Pedagogy: An effective Model for 21st Century Education

- Bed Prasad Dhakal

Abstract

Prior to COVID-19, very few teachers had introduced technology to deliver teaching learning activities. While COVID-19 created a sudden and unexpected situation, it has motivated large number of teachers to utilize digital tools in curriculum, pedagogy, and assessment. With this emerging context of technology use for 21st century education, student have already started to learn from their personal handheld devices, but teachers are navigating unparalleled challenges to manage students learning and classroom pedagogical skills using digital tools. This gap is seen between technology innovation, race of todays' learners, and pace of pedagogy governance. In this context, this paper articulates a framework for teacher to ensure effective use of Digital Pedagogy (DP) for 21st century education through designed based action research carried out to master's students of mathematics education at Central Department of Mathematics Education (CDED), TU during the academic year 2017 (Aug-Dec). The study participants were 126 third semester students taking a course "Differential Geometry". The used tools are DP model, mathematics achievement test (MAT) and semi-structure interview guideline. Based on the analysis of data, it is found that DP is effective model to adopt modern student-centered pedagogical practices, where the focus is on students' learning and emergent activity, rather than teacher's lectures and teacher-led activities.

Keywrds: Digital Pedagogy, Action Research, Mathematics Education, Nepal.

Introduction

Teaching is the core of teachers' professional practice. It is not a simple application of theoretical knowledge one studied or practical skills they learnt. As a mass phenomenon, teaching consists of always new and unique situations. In this sense, it combines art and science (Bayer, Brinkkjær, Plauborg, & Rolls, 2009). If teaching were a perfect science, we would have certain rules of thumb to behave as an ideal teacher and the process could potentially be automated to a degree that made teachers unnecessary. On the other hand, if teaching was merely an art, there would be no philosophy or theory behind the professional practice. Therefore, teaching is an ideal composition of both art and science, and always consists of greater possibility of interplay between humans and machines.

I see teaching today as very much aligned with concept of didactics (Hopmann, 2007) which constitutes three core principles: bildung, matter and meaning, and autonomy. For Hopmann, didactics is a process to unfold the capabilities of students' "I", which is not only the degree that students master, but includes if and how their educative substance opens the meaning as intended (Hopmann, 2007). In this sense, I could understand teaching as a complex phenomenon, as light of the life, that provides opportunities to a learner to be creative and potential enough to interact both with human, machine, and object and better fit themselves in the learning trajectory.

Hopman's didactic perspective of teaching is still relevant. It is compatible with 21st century education where knowledge is moving faster. In the past, if someone discovered new knowledge, it could take a generation to be known in the rest of the world. Today, it will spread within 24 hours or even in less time around the word using internet and social media like Facebook, Twitter. Therefore, teaching must address this kind of knowledge acquisition and dissemination process rather information display.

Berlinger (1986) mentioned that it is hard to define 'expert pedagogue'. However, he mentioned that professional practice of expert pedagogues pertains certain patterns. They design wide range of instructional options for versatile output according to students' level, their individual learning preference and style. We believe, teaching is ultimately for students' learning. Teachers therefore need to design and implement teaching with resources, activities, and assessments that enhance student leaning. In this line, I could understand digital pedagogy as a professional practice by the interplay between art and science (Bayer et al., 2009), where teacher effectively use digital tools for learner's engagement to perform didactics (Hopmann, 2007), using a "Bag of tricks" (Joram, 2007), and let student to achieve intended outcome in each learner's hand so that no one is left un-achieved.

Existing Challenges in Teaching

Teaching is a mass phenomenon across the group of learners from a range of prior knowledge, backgrounds, cultures, languages, and other numbers of diversities. So, there is a challenge to address such diversity to ensure "all are learnt". Some challenges in existing professional practice of teaching are described below.

Resource Constraints: Ignoring Learning Preferences and Style. Learning is an individual process. Learning occurs in different race and pace according to students' individual learning preferences and style and multiple intelligence level (Gardner, 1983). In Nepal, there are limited learning resources. These resources are text only materials (Martin Chautari, 2005; Bhattarai, 2014; Bhusal, 2011). Few teachers can select, organize, and use learning resources available online (for example resources from YouTube and other sources), and even few of them can create tailored made multiple resources themselves (for example, image, audio/video, animation, and simulation using subjected specific technology software) using digital tools.

Time/Activity constraints: Restricting Engaged and Interactive Learning. There is a proverb "Higher the engagement, higher the learning". Active participation, interaction, group work, project work, and formative evaluation are important ways of learning (Johannesen, Ogrim, Pangeni, & Dhakal, 2016). In Nepal, pedagogy is mostly dominated by teacher's lecturing. Besides lectures, few students ask questions, and everybody else just listen. So, there is a challenge in teaching to ensure everybody to participate in learning.

Feedback/Support Constraints: Ignoring Self-Paced Learning. Feedback and support are essential escalators for learning. There is a quote, "everybody can learn, but race and pace may differ" (Dror, 2011). This is because homogeneity among learner's characteristic rarely exists. Learner's maturity and capacities rarely correlate. Therefore, it is quite natural that some students are fast learners and others are slow learners in learning process. Therefore, teachers need to work with an equality principle, not on equity principle (Bhusal, 2011; Baral, 2016). However, most of the teacher feels easier to handle a classroom as whole, and teaching one/same topic at a time, taking same test at a time, and giving same counselling at a time. So, there is a challenge to handle students' diverse learning pace to provide appropriate and timely feedback and support in the need.

Assessment/Evaluation Constraints: Ends to End Assessment. Assessment is an integral part of learning. It occurs mostly for/in/of the learning (Harlen & James, 1997). The formative assessment is assessment for learning. Vicarious activities are assessment in learning. Summative assessment is assessment of learning. In Nepal, formative assessment is happening not as it should be (SABER, 2012). One of the reasons is people said that formative assessment is NOT happening because it is not practicable both by teacher and institutional end. The institutional composition for assessment is in linear form. It is easier to do assessment at one slot of time at the end of semester/year after finishing the syllabus (Martin Chautari, 2005). So, there is a challenge to articulate various forms of formatting assessment to address means to end for summative assessment.

Some other challenges of teachers include difficulty in finding appropriate and effective digital tools and aligning digital tools with curriculum standards. These challenges can hinder the effective integration of technology into the classroom and negatively impact student learning. Therefore, effectiveness of a designed based model for digital pedagogy on student's achievement is explored with the aim of to analyze "the effectiveness of digital pedagogy in mathematics education?"

Conceptual Framework

Digital pedagogy refers to the integration of digital media and technology into teaching and learning to emphasize the role of technology in facilitating student learning. It involves the use of digital tool and virtual learning environments to enhance students' engagement, creativity, and critical thinking skills to transform the traditional classroom into a dynamic and interactive learning environment that empowers students to take control of their own learning. With this, Digital Pedagogy (DP) is formalized as a pedagogical activity through Virtual learning Environment (VLE) with seven pedagogical principles. 1) Learning Contents and curriculum mapping 2) Learning Objectives 3) Learning Resources. 4) Learning Activities/Assignments 5) Learning Communication and Discussion 6) Learning Feedback and support 7) Learning Assessment/Evaluation. For example, Learning Contents with curriculum mapping can be aligned in a table as shown below. Assuming, 100% as learning plan, 60% content of the course can be accomplished through Face-to-Face (F2F) teaching/learning. Similarly, 15% content of the course can be accomplished through Programmed Online Learning (POL), and 25% content of the course can be accomplished through Independent Offline Learning (IOL). The plan for each curricular subtopic also synchronizes with corresponding learning outcomes, learning resources and learning activities.

Table 1: Model for curriculum mapping

Unit 1 (Subtopics)	Learning Outcomes	Learning Resources	Learning Activity	Instruction model F2F, POL, IOL
Triangle	Identify types	Cross matrix	Navigation through GGB applet	POL

Learning Objectives

Learning outcome are explicitly defined and synchronized with learning taxonomy, for example Bloom's taxonomy to address low order thinking skills (LOTs) and high order thinking skills (HOTs).

Learning Resources

Learners learn individually, according to their background knowledge, mutuality, preferences, and multiple intelligence level (Gardner, 1983). Therefore, ensuring their access in verities of resources until learning saturation comes to learner's end is resourceful teaching. For example, in this study, I have used varieties of ready-to-use resource (e.g., YouTube videos, and other text, media, and interactive format files) available online which are appropriate, essential, and contributing for learning. I have also constructed multiple media format resources using assistive technology (e.g. Camtasia studio, and other video casting tools) and discipline specific technology (e.g. GeoGebra, Mathematica, and other tools for Mathematics).

Learning Activities

It is said that "we can't teach people everything they need to know. The best we can do is position them where they can find what they need to know when they need to know it" Seymour Papert. Therefore, learning activities are designed to enable learner to use learning resources and act for next step as we expect them to do. The learning activities I used are Quiz, Assignments, Games, Peer review assignment, Project work, Case study.

Learning Interaction

Learner's communication and discussion channel are created to provide an opportunity to interact within and between learning agents (teacher, students, and learning objects) whenever needed. These channels are also expected to help learners to enhance their social presence.

Learning Feedback and Support

Learning feedback and support are provided to help leaner when they are in the need. It is said that feedback and support count a lot if it is supplied instantly when it is needed. Therefore, assuming that, learning is an individualized process, learning race and pace may vary; feedback and support mechanism is designed accordingly. The feedback and support mechanism I used are forum announcements, course information page, FAQ page, calendar with due Dates, question board (information desk), email notification, elaborated text, audio, and video feedback files. In addition, using Moodle dashboard [overview of all the data, logs, and grade sheet], it allocates one screen for one student to assess student's activities, open every single bit of work, have an overview on progress over time and feedback was provided accordingly.

Learning Evaluation

The formative assessment is carried out based on CAS principles for summative ends. The Formative assessment I used are Lessons (15%), discussion (15%), group work (15%), peer graded work (15%), quiz (20%), assignment/presentation (20%). The formative assessment is synchronized with learning outcomes in relation summative examination framework.

For example, using Moodle, I have created series of formative assessment during the course period. It was then accumulatively resulted with students' scores in those activities and later I have produced scores for summative ends.

Methods and Materials

There are several worldviews (philosophy of inquiry or research paradigm). In this study, AR formulated DP is used for experiment using Moodle as VLE platform. This study is based on designed based action research with “I-we” form of inquiry is used. It is a collaborative approach of inquiry to engage “subjects: researcher” and “objects: participants” with an aim to enhance students learning.

This is an experimental sort of action research with constructed field in relation to the purpose. With the preconditions to carry out the research, the availability of ICT infrastructure, intensive researcher’s presence, and technological backstopping, the study participants in this research were students of Master programme in Mathematics Education at CDED in a course Differential Geometry during 2017 semester. In this semester, 167 students were enrolled in Mathematics Education courses. However, the number of students who participated both in pre-test and post-test were considered as study participants. During this study, in total of 126 students were participated in both pre-test and post-test surveys. Since a value of *n* as sample size is greater than 100, it is enough to use inferential statistics, therefore, 126 students (i.e., the matched pairs) were considered as study participants.

The model of DP was used as AR intervention tool, and that of mathematics achievement test (MAT) and semi-structure interview guideline was utilized as data collection tools. For reliability and validity, a pilot study was carried out. To ensure content and construct validity of MAT, the specification grid was validated. For reliability, Cronbach coefficient alpha was calculated, which was 0.81, this indicated 64% reliability factor, therefore accepted.

This experiment was based on intact group pre-test post-test design. One possible way to minimize problems related to having no control group is to measure the same dependent variable in one group of participants before (pretest) and after (posttest) a treatment. Using this type of research design, it is possible to measure scores before and again following a treatment, then compare the difference between pretest and posttest scores. My self-reflection as researcher and participant’s MAT responses as data were used to analyze the effectiveness of the model of Digital Pedagogy (DP).

Pre-intervention stage

In this study, DP model was main intervention to address the research questions. However, DP is not a sort of established educational pedagogy. There is no standard theory and practice strategy outlined yet to implement DP. For this purpose, AR is carried out to formulate DP as a model. Therefore, in the first phase of AR, DP is formulated through LMS intervention, and based on semi-structure interview guideline, DP Model is formulated. Also, students’ end-semester score on Math Ed 527 was collected.

Intervention Stage

After formulation of DP model, intervention was carried out for experiment. This experimental period was implemented in DG course during academic year 2017.

Post Intervention Stage

After DP intervention, LMS/VLE database were retrieved, and students’ VLE access level are computed. The post-test on MAT was administered. Students’ end-semester score on Math Ed 537 were collected.

Result and Discussion

The participants in this study were master's students of mathematics education at CDED, TU, University Campus, Kirtipur during the academic year 2017 (Aug-Dec). The study participants were third semester students taking a course "Differential Geometry". Among 126 students, 111 were boys (88%) and remaining 15 were girls (12%). In this study, student’s access in VLE was also utilized as cross-cutting variable. For this, VLE database were retrieved from Moodle log report. Retrieved databases were on grades, resource access, day access, course hits, and timestat. These five levels of data were merged and VLE access score were formulated. The distribution of participants with two variables: gender and VLE access level are given below.

Table 2: Participants of the study

	VLE Access level		
	Low	Moderate	High
Boy	39	38	34
Girl	3	4	8

Based on VLE access database score in Moodle, 126 students were divided in three cohorts. These three cohorts were coded as: High level VLE access, Moderate level VLE access, and Low-level VLE access.

Table 3: Students cohort in VLE Access

	VLE Access Level (N)			VLE Access Level (%)			
Gender	Low	Moderate	High	Low	Moderate	High	Chi
Boys	39	38	34	92	90	81	3.17
Girls	3	4	8	8	10	19	

(N=126 of 167)

To analyze the effectiveness of DP, one-way analysis of variance was applied. This analysis across VLE access level was conducted to compare pre-test result for mean difference across the groups.

Table 4: VLE Access level and Student's pre-test score (score on Math Ed 527)

Source	Sum of Squares	df	Mean Square	F
Between Groups	0.36	2	0.18	0.85
Within Groups	25.3	123	0.02	
Total	25.66	125		

This analysis of variance given in Table 4 showed that there is no significance difference between the pre-test mean score across VLE access level group of students, $F(2,122) = 0.85$, $p > 0.05$. It indicated that three groups of students according to VLE access level have similar achievement in pre-test.

Table 5: VLE access Level and Student's MAT score

	Sum of Squares	df	Mean Square	F
Between Groups	165.06	2	82.53	9.88
Within Groups	1027.74	123	8.36	
Total	1192.80	125		

(N=126 of 167)

After, DP intervention, the analysis of variance test was examined to test the students MAT score mean differences across VLE access level group of students. The test given in Table 5 showed that the difference in mean achievement of students in three VLE access level group was significant, F(2,125) = 9.88, p <0.05. Therefore, it is indicated that DP intervention has made significant difference on students MAT score.

To better ensure the effectiveness of VLE intervention, students' end semester final score on Math Ed 537 was taken as a post-test result.

Table 6: VLE access Level and Student's Post-test score (score on Math Ed 537)

Source	Sum of Squares	df	Mean Square	F
Between Groups	2.14	2	1.07	3.46
Within Groups	37.17	123	0.31	
Total	39.31	125		

(N=126 of 167)

This analysis of variance showed that there is significance difference between the post-test mean score across VLE access level, F (2,125) = 3.46, p<0.05. It indicated that three groups of students according to VLE access level have different achievement in the post-test. Therefore, it is concluded that DP intervention is effective to enhance student's mathematics learning.

In this study, digital pedagogy has created new opportunities for students learning by addressing the limitations of conventional F2F approach of teaching learning such as (i) limited amount of learning materials by different media formats learning resources (ii) limited and restricted amount of F2F hours and activities between teacher and students by supplementing varieties of digital activities any-time any-where, (iii) F2F communication, if not then by voice to voice and real time phone call, by using text messaging, online text, audio and video chatting, email, communication, and discussion forum for feedback and support in learning anytime anywhere, (iv) one slot at end assessment by using human and machine integrated continuous and collaborative formative assessment for summative ends.

The effectiveness of digital pedagogy has been a topic of interest among educators, researchers, and policymakers. In recent years, many studies have been conducted to examine the effectiveness of digital pedagogy in various educational settings. One study conducted by Anitha and Vijaya Kumar (2021) investigated the effectiveness of digital pedagogy on student learning outcomes. The study was conducted in a higher education setting, and the researchers used a quasi-experimental design to compare the learning outcomes of students who received traditional instruction with those who received digital instruction. The study found that students who received digital instruction had better learning outcomes than those who received traditional instruction.

Similarly, a meta-analysis conducted by Means et al. (2014) examined the effectiveness of digital learning in K-12 education. The meta-analysis included 99 studies and found that digital learning was more effective than traditional classroom instruction. The study also found that digital learning had a positive impact on student engagement and motivation. Another study conducted by Huang et al. (2020) investigated the effectiveness of a blended learning approach that combined digital and traditional instruction in a secondary school setting. The study found that the blended learning approach was more effective than traditional instruction alone in improving student learning outcomes.

In conclusion, this study also provide evidence that digital pedagogy can be an effective approach to teaching and learning. However, it is important to note that the effectiveness of digital pedagogy may vary depending on the educational setting, the type of technology used, and the instructional design. The research also indicated that, overall purpose of digital pedagogy is making learning space accessible anytime anywhere using digital tools (Oblinger & Oblinger, 2005). With this inclination, this study also found that digital pedagogy is helpful to enhance teaching and learning hour beyond F2F and school/campus boundaries, which is also discussed in a article by Rosen & Nelson (2008) in the form of anytime anywhere learning opportunity.

Conclusion

The aim of the study was to analyze the effectiveness of a model for DP students learning in higher mathematics education. It is found that the model is effective. So, it is concluded that, as a pedagogue, it is necessary to use DP, no matter what age, generation, learning level a teacher is tutoring. For this purpose, DP is recommended to utilize with seven pedagogical principles: learning contents with curriculum mapping: learning objectives: learning resources: learning activities /assignments: learning communication and discussion: learning feedback and support: learning assessment/ evaluation. It is also concluded that, DP can lead to increased student learning achievement with expected contribution to motivation, better outcomes, and improved learning experiences.

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