DIGITAL TECHNOLOGIES FOR TEACHING MATHEMATICS AND SCIENCES IN SECONDARY SCHOOLS: PRE-SERVICE TEACHERS' PERSPECTIVES

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Abstract

This study is a preliminary investigation of the pre-service teachers' perceptions about using digital technologies for teaching and learning in computer studies, mathematics and science subjects in secondary schools in Botswana. The aim was to better understand pre-service teachers' usage of digital technologies during their teaching practice period, and assess their preparedness for integrating digital technologies in their future teaching. Mixed methods, including interviews, observations of class sessions, a questionnaire and document analysis methods were used for data collection during the teaching practice session of 2014. The results reveal widespread use of digital technologies among the pre-service teachers at both junior and senior secondary school levels. Findings indicated the existence of various perceived cognitive affordances, physical affordances and learner-centred approach affordances of the use of digital technologies in teaching. The findings contribute to the literature by validating the Technology Acceptance Model (TAM) factors of 'usefulness' and 'ease of use' of digital technologies in the Botswana context, and the relationship between the affordances and TAM constructs.

1.0 Introduction

Over the past decade, there has been heightened interest in the availability of digital technologies; and how globalisation has dictated much of the changes in curricula of different nations, especially those in the developing world. Botswana has responded to the pressures of globalisation in a number of ways (Tabulawa, 2007; 2009). The rural electrification drive, *Ntelesa 1* and *2* (Botswana Government, n.d) distributed telephone communication to remote parts of the country, satellite connectivity and the *Sesigo* project (Leoisa and Suping, 2014); a partnership between the Bill and Melinda Gates Foundation and the Botswana Government that furnished public libraries with Internet facilities in rural areas have provided the needed infrastructure. Botswana's use of the Internet has been growing rapidly as worldwide usage of digital technologies related to information and communication technologies increases (Global Information Technology Report, 2014). The question arises as to whether the teachers are taking advantage of the digital media resources in the teaching of computer studies, mathematics and science subjects in schools in Botswana.

As per 2012 data, 96% of the country has mobile network coverage, and mobile Internet subscriptions are 74.9% (Global Information Technology Report, 2014). Internet access in schools is 3.4/7, meaning that it is fairly widespread. This means that most of the people have access to the Internet, especially those enrolled in secondary schools and the higher institutions of learning. Also of importance is that the adult literacy rate is 85.1%; and secondary enrolment rate is 81.7% (Global Information Technology Report, 2014). Table one summarises the ICT infrastructure in Botswana as of 2012.

Table I: **ICT Infrastructure in Botswana (Global Information Technology Report, 2014, p. 116)**

Indicator	
Secondary enrolment rate %	81.7
Adult literacy rate %	85.1
Mobile telephone subscriptions/100	153.8
Internet users (2012) %	11.5
Tertiary education enrolment rate %	7.4
Mobile Network coverage rate (2012) %	96
Households with a PC (2012) %	12.3
Households with internet access (2012) %	9.1
Mobile broadband internet subscriptions (2012) %	74.9
Accessibility of digital content (2012) /7	4.5
Use of virtual social networks (Facebook, Twitter, etc.) / 7	5.4
Internet access in schools (2012) /7	3.4

Digital technology, a term used to describe the use of digital resources used to find, analyse, create, communicate, and use information in digital context; encompasses the use of Web 2.0 tools, digital media tools, programming tools and many software applications and hardware that can be used on a computer (Van Rooy, 2012). The proliferation of digital technologies over recent years has accentuated the need for creative thinking in all aspects of our lives, and has also provided tools that can help teachers to reinvent themselves in teaching and learning. For instance, these digital technology tools and applications create rich content using various multimedia components that has not been possible to create using a textbook; and also at much reduced cost in the long term. Once created, the digital technology can be distributed whenever there is an Internet connection at very low cost. This technology makes it possible to simulate processes, play educational videos, provide rich text and sound and can be combined when required for a multimedia classroom.

The increasing ubiquity of the Internet among all types of users and usability among the school generation has been taken advantage of by the teachers and learners; particularly in the western world (Harrison, 2013; Holbrook, May, Albers, Dooley & Flint, 2012; Joubert, 2012; Van Rooy, 2012). The current student generation; the *digital generation,* has made it increasingly necessary and ideal to use current digital technology in everyday teaching and learning. School teachers are increasingly called upon to engage in professional development to foster a community-wide culture conducive to integrating digital technologies in teaching and learning. It is important that the current teachers and pre-service teachers play an increasing role in creating content and application software for their subjects; as well as recommending and searching for the relevant hardware, software and content to be used during classes or out of the classroom by the students. The creation of content has lately been influenced by Web 2.0 digital technologies available on the internet; proprietary or open source, and some free; that can be effectively used during the teaching of computer studies, mathematics and science in secondary schools. Contemporary secondary school students are called the *digital natives* or the *digital generation* (Baltaci-Goktalay and Ozdilek, 2010; Green, 2012; Jones, 2010; Lee et al., 2014; Lei, 2014; Tkalac Verčič and Verčič, 2013; Valtonen et al., 2013), as they have grown up immersed in digital technology, and are technologically adept and interested. The *digital native* is described in contrast to a *digital immigrant*, who; having been exposed to digital technology later in life, is fearful of it, mistrustful and lacks the skills to use the technology adeptly (Lei, 2014; Prensky, 2001). The *digital native* is prepared to use current digital technology. They are highly motivated to use software for learning (Harrison, 2013; an Rooy, 2012).

The current university student has grown immersed in digital technology, and has taken adequate information and communication technology (ICT) courses to familiarize with current trends; especially Web 2.0 tools and end-user application software. They do not require much effort to learn graphical user interface user friendly interfaces common today (Prensky, 2001). The cost of software and accompanying hardware has gone considerably down and is affordable to many, and the digital services are provided even on cell phone networks that are available all the time at comparatively reduced cost compared to a few years ago. These digital technologies support constructivists argument that instruction must be “content and stimuli-rich and must embrace visual formats, promote teaming and collaboration, and be flexibly organised” (Johnston and Barker, 2002, p. 88). From a practical standpoint, pedagogy is primarily influenced by the undergraduate education a teacher receives. Current trends in developments in computing power in all areas of life dictate that the current computer studies, mathematics and science teachers need to be better equipped to meet their future students’ instructional needs.

This study examines the pre-service teachers' "perceived affordances" (Hartson, 2003) of digital technologies in the teaching of computer studies, mathematics and science subjects in secondary schools of Botswana. Coupled with the "perceived affordances" will be the use of the TAM3 (Technology Acceptance Model) (Venkatesh and Bala, 2008) to examine the "perceived usefulness" and the "perceived ease of use" of the digital technologies in teaching and learning. Previous studies (Brooks-Young, 2007; Harrison, 2013; Johnston and Barker, 2002; Joubert, 2012; Van Rooy, 2012) have suggested that the school teachers agree that the digital technologies can make teaching and learning effective in secondary schools. If this is true, then the same benefits for using digital technologies can accrue to countries like Botswana. Little is known about pre-service teachers' usage experiences, perceptions on affordances, usefulness and ease of use on teaching using digital technologies in computer studies, mathematics and science. Understanding the pre-service teachers' perceptions as they teach this *techno-savvy* generation in secondary school is very important and essential for understanding how and if they will use these and similar digital technologies in their future work. The perceived attitude among pre-service teachers is "an important determinant in the successful integration of technology in teaching and learning in their teaching practices" (Wong et al., 2013, p. 90). The current usage, perceptions on affordances, ease of use and the usefulness of the use of digital technologies during teaching will enrich our understanding of their attitude towards use of the said technologies in future.

The following questions are addressed by the study:

1. How often do secondary school pre-service teachers in computer studies, mathematics and science use digital technologies in their teaching practicums?
2. What are the perceived affordances of using digital technologies for teaching and learning of computer studies, mathematics and science?
3. How pre-service teachers' perceived affordances impact on the perceived usefulness and perceived ease of use of digital technologies used in the teaching of computer studies, mathematics and science?

2.0 Theoretical Framework

There has been a growing necessity for understanding the reasons why technology is accepted or rejected by users. Acceptance has been conceptualised as an outcome in a psychological process that users go through in making decisions about technology (Chuttur, 2009; Davis, 1989; Norman, 1999). The Technology Acceptance Model (TAM) (Davis, 1989; Venkatesh and Bala, 2008) was developed to explain the dynamics of human decision-making in the context of accepting or rejecting current digital technologies, and it has been applied with various systems. The model has kept on developing through the years of research and experienced various extensions reaching TAM3 Venkatesh and Bala, 2008); incorporating additional factors and variables suggested by some authors to explain the predictors of TAM. The educational system encompasses a wide range of potential users of the computer and Internet technology, and the issues of rejection and acceptance has been explored using TAM with many applications; including teaching and learning (Tamim, 2013; Valtonen, et al. (2013); Van Rooy (2012); Zhao and Frank, 2003).

Coupled with the TAM constructs of perceived usefulness and perceived ease of use are the affordances (Hartson, 2003; Norman, 1999; Webb, 2005); an important usability concept for interaction design. An affordance gives or provides something that helps a user do something. Hartson (2003) states there are four kinds of affordances (cognitive, functional, physical and perceptual) in the context of interaction design and usability. The field of human-computer interaction (HCI) emphasises the importance of user-centred development and its influence on how digital technology is used. Though not equivalent to the concept of acceptance, most HCI researchers put emphasis on designing more user friendly environments; with the assumption that the more usable a technology is, the greater its chances of proving acceptable to a type of user. The TAM and affordances assume that the user's perceptions on usefulness and ease of use; and what the digital technology is able to achieve during work play a significant role on user acceptance of a digital technology. The following explains affordances before briefly explaining TAM constructs of perceived usefulness and perceived ease of use.

3.0 Affordances in the Teaching/Learning

The term affordance has been used to describe opportunities that users perceive to be "afforded by ICT-based environments"(Szeto & Cheng, 2013, p. 54). It is concerned with what a user perceives to be possible within or with the technology, and what actions the user perceives to be useful on using the digital technology (Norman, 1999), and also the ease of discoverability of possible actions that can be performed by the digital technology at hand. Affordances are used as frameworks for designing interactions and interfaces (Hartson, 2003; Norman, 1999), necessitating considerations of issues related to cognitive load theory and the differences in user levels. In the context of interaction design for digital technologies, Hartson (2003) named four different kinds of affordances for the role they play in supporting users during interaction with an artefact; namely *cognitive affordance*, *physical affordance*, sensory *affordance* (sensory actions) and *functional affordance* (ties usage to usefulness). Norman's (1999) perceived affordances become c*ognitive affordance, "*helping users with their cognitive actions" (Hartson, 2003, p. 316) and "real affordance becomes *physical affordance*, helping users with their physical actions*"* (Harson, 2003, p. 316) as parallel and equally important usability concepts, are connected, and are considered together in any design context. The two are design issues; but they are done for the usability of the application; thus; they can only be tested by involving the user. They are named for the role they play in supporting users during interaction, reflecting users' processes and the kinds of actions users make in task performance (Hartson, 2003).

A cognitive affordance is defined as "design feature that helps, aids, supports, facilitates, or enables thinking and/or knowing about something" (Hartson, 2003, p. 319). Hartson (2003) gives an example of clear and concise label for a button label to be a cognitive affordance enabling the user to understand the meaning of the button in terms of functionality behind the button and the consequences of clicking it. It is the primary mechanism to support learning and remembering by system users. A *physical affordance* is a design feature that helps, aids, supports, facilitates, or enables physically doing something (Hartson, 2003, p. 319). It is about characteristics in the appearance of a digital technology that gives clues for its proper operation. Adequate size and easy-to-access location could be physical affordance features of an interface button design enabling users to click easily on the button. Although physical affordance has been treated as occurring with physical objects, active interface objects on the computer screen can be treated as real physical objects, since they can be on the receiving end of real physical actions by users. As many in the literature (Hartson, 2003; Norman, 1999; Szeto & Cheng, 2013) have pointed out, it is clear that a button on a screen cannot be pressed. Restricting the discussion to clicking on buttons easily dispatches this difficulty. A physical affordance gives access to functionality, the purpose of the physical affordance attached to its clicking/pressing.

Student-centred learning is the notion that the learner is the central entity who must be actively engaged in seeking and constructing knowledge is grounded on the constructivist learning theories. Research suggests that technology can support key practices of student-centred learning, such as assessing individual students' strengths and needs, flexible scheduling and pacing, advising, presenting content in alternative ways and encouraging project-based learning and personalised learning (Klopfer et al., 2009; Van Rooy, 2012).Teachers are most likely to use technology to personalize learning if (1) it supports already existing, student-centred practices and helps to solve problems or address challenges; (2) it is part of a systemic, organization-wide initiative to implement student-centred learning; and (3) teachers have access to ample professional development and on-going support (Harvey & Kotting, 2011; Klopfer et al., 2009; Valtonen et al., 2013). Schools are historically teacher-centred, and they naturally resist changes that will put pressure on existing practices (Collins and Halverson, 2009; Cuban, 2000; Zhao and Frank, 2003). Unless the culture and structure of a school is compatible with and supportive of specific uses of technology, technology integration is not likely to succeed.

Teachers' attitudes towards technology and their expertise with technology have been identified as key factors associated with technology use in the classroom (Zhao & Frank, 2003). Moreover, their pedagogical beliefs and existing practices will shape how they incorporate technology into the classroom. These are shaped by their perceived and real affordances of the digital technologies in place. Here, the emphasis is on cognitive and physical affordances, as well as student-centred affordances. Student-centred teaching models are more likely to put digital technology tools in the hands of the learners. This is particularly important when learning objectives involving higher-order learning skills such as presentation of information in new forms, problem analysis, data analysis, and the visual representation of ideas (Drijvers, 2012; Holbrook et al., 2012; Joubert, 2012; Kingsley, 2007; Legris et al., 2003; Perrotta, 2013; Szeto & Cheng, 2013; Van Rooy, 2012).

4.0 Technological Acceptance Model (TAM)

There exist various theoretical models to explain factors that cause individuals to accept, or to reject to use new technology (Wong et al., 2013). Among them, TAM (Davis, 1989) has provided valuable insights into, and predict, how and why new users make a decision about the adoption and use of a digital technology; with many other researchers (e.g. Venkatesh and Bala, 2008) developing other determinants to the two TAM constructs of *perceived usefulness* and *perceived ease of use*.

TAM posits that individuals' behavioural intention to use a digital technology is determined by two beliefs: *perceived usefulness*, defined as "the extent to which a person believes that using an it will enhance his or her job performance" (Venkatesh & Bala, 2008, p. 275); and *perceived ease of use*, defined as "the degree to which a person believes that using a digital technology will be free of effort" (Venkatesh & Bala, 2008, p. 275). It further theorizes that the effect of external variables (e.g., design characteristics) on behavioural intention will be mediated by perceived usefulness and perceived ease of use (Venkatesh & Bala, 2008). Four other determinants of *perceived usefulness* and *perceived ease of use*; individual differences, system characteristics, social influence, and facilitating conditions were included in literature as determinants over time (Venkatesh & Bala). TAM has also been extended to TAM2 (Venkatesh & Davis, 2000); and then TAM3 (Venkatesh & Bala, 2008), by identifying and theorizing the more determinants of *perceived usefulness* and *perceived ease of use*. Thus, TAM3 is expected to present complete nomological determinants of individuals' ICT adoption and use.

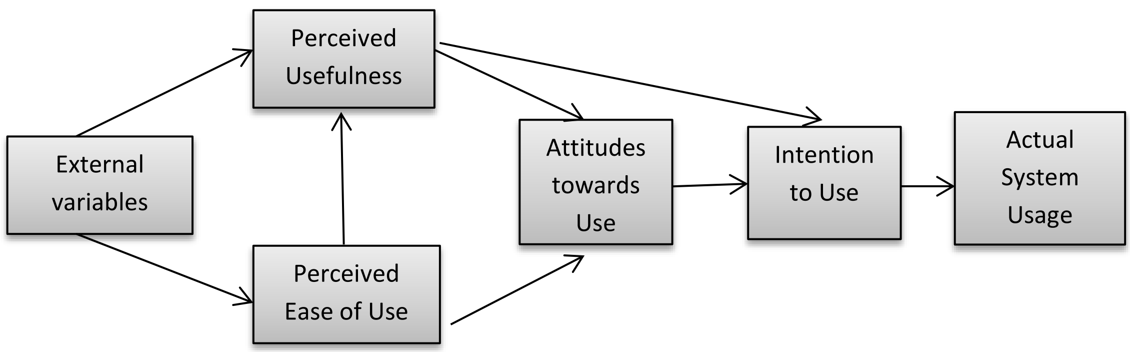


Figure 1: Technology Acceptance Model

This model and its extensions have received a lot of attention to date (Chuttur, 2009; Legris, Ingham, & Collerette, 2003; Park, 2009; Porter & Donthu, 2006; Venkatesh, 2003; Venkatesh, 2008, Wong et al., 2013). It examines the mediating role of *perceived usefulness* and *perceived ease of use* (Davis, 1989) in their relation between system characteristics or external variables and the probability of system or application use. It suggests perceived usefulness and perceived ease of use as the most important factors in explaining adoption of new technologies. *Perceived usefulness* indicates the likelihood that people will use technology because they believe that it may enhance their job performance. The attitude towards computer use among pre-service teachers is shaped by how they perceive the usefulness of the digital technology in their teaching and learning. Furthermore, perceived usefulness has a direct and indirect effect towards "behavioural intention to use a technology"(Wong et al., 2013, p. 91). A pre-service teacher will use the digital technology if he/she "perceives the technology to be a useful and meaningful" (Wong et al., 2013, p. 92) way to work more effectively. Venkatesh and Bala (2008) suggested the following questionnaire items (we have modified them for use with various digital technologies) to measure the *Perceived Usefulness* for a digital technology resource measured in 1 (1: strongly disagree) -7 (strongly agree) on a Likert Scale.

1) Using digital technology improves my performance in teaching (PU1).
2) Using digital technology in my teaching increases my productivity (PU2).
3) Using the Digital technology enhances my effectiveness in teaching practice (PU3).
4) I find the digital technology to be useful in my teaching practice (PU4).

On *perceived ease of use*; a user could believe that the technology is useful, but at the same time believe it to be difficult to use, and that the benefits of usage of the technology are outweighed by the effort of using the technology. TAM3 does not have crossover effects; that the determinants of perceived usefulness will not influence ease of use (see Venkatesh & Bala, 2008). Venkatesh and Bala (2008) used the following constructs for the *Perceived Ease of Use*:

1) My interaction with the digital technology is clear and understandable (PEoU1).
2) Interacting with the digital technology does not require a lot of effort (PEoU1).
3) I find the digital technology to be easy to use (PEoU1).

4) I find it easy to get the digital technology to do what I want it to do (PEoU1

TAM has developed to become the key model in understanding the predictors of human behaviour towards potential acceptance or rejection of technology. Literature review from 1986 to 2013 by Marangunic & Granic (2015) has indicated continuous progress in revealing new factors and applicability to various technologies and situations. Davis (1989), Venkatesh and Bala (2008) and others (Park, 2009; Porter, 2006; Wong, 2013) have used other determinants; like computer self-efficacy, computer anxiety and perceived enjoyment to gauge the behavioural intention to use a technology. These were not considered during this study.

5.0 Methodology

The study was carried out from June to July 2014. A total of 86 pre-service teachers on teaching practice from the University of Botswana in the Department of Mathematics and Science Education voluntarily participated in the study. All of them were doing Bachelor's degree in Education, majoring in the computer studies, mathematics and sciences. The reason for including computer studies was because computer teachers sometimes may not necessarily use the digital technologies in teaching many of the concepts in the syllabus to explain some concepts. The participants were all second year (n=59) and third year (n=27) pre-service teachers on teaching practice. Table 11 presents the demographic profile of the sample.

Table 11: Demographic Information of the Participants

Variable	Number	Percent (%age)
Year of Study		
2nd	59	68.6
3rd	27	31.4
School of Teaching Practice		
Junior secondary	30	34.9
Senior Secondary	47	54.7
Both Junior and Senior Secondary	09	10.5
Gender		
Male	41	47.7
Female	45	52.3
Major Subject		

Biology	24	27.9
Chemistry	16	18.6
Computer Studies	16	18.6
Mathematics	21	24.4
Physics	09	10.5
Number of Digital Technology Courses Taken Previously		
1		0
2	0	47.7
3 or above	41	52.3
Availability of High-Speed Internet at Home	45	
Yes		
No	39	45.3
Total	47	54.7
	86	**100**

6.0 Instrumentation

The instrument was developed by the researchers based on the study objectives and previous literature. The instrument was pilot tested with twenty people for content validity; eighteen fourth year students who had previously attended the teaching practice sessions and two lecturers who have taught ICT courses; all of them from the Department of Mathematics and Science Education. The teaching practice session lasted seven (7) weeks for all pre-service teachers. The participants were assured that their responses would be confidential and that they would be reported as aggregates. A questionnaire, document reading and interviews about the participants' pedagogic practices and observation of class sessions were the methods used for data collection.

7.0 The Questionnaire

The questionnaire was divide into four sections; A) Student Background and Digital Technology Resources Available at Schools (11 Items); B) Experience with Digital Technologies (10 Items); C) Affordances (What the Digital Technology Allows the User to Do). The first part on Affordances part allowed the students to write all they thought was what they could afford to do using the digital technologies available; i.e.; what the digital technologies could offer them to do that would help themselves or the students to accomplish an academic task. The second part on Affordances was divided into the three

(Cognitive affordances, Physical affordances and Learner-centred affordance) on a 5-point Likert scale to measure the perceived individual affordances of using the technologies for teaching and learning. The items for the *Perceived Usefulness* and *Perceived Ease of Use* were modified from TAM3 (Venkatesh and Bala, 2008) constructs; each having 4 items. They were measured on a 7-point Likert scale (1: *Strongly disagree;* 2: *moderately disagree;* 3: *somewhat disagree;* 4: *neutral* (neither disagree nor agree)*;* 5: *somewhat agree;* 6: *moderately agree, and* 7: *strongly agree)*. The questionnaire was administered online using Google Docs Form to 97 pre-service teachers on teaching practice in junior and senior government and private secondary schools in Botswana towards the end of the teaching practice period, on which the pre-service teachers completed during their own time during the 7th week. The researchers had previously discussed with the pre-service teachers about the questionnaires to be sent during their weekly visits. The form was to be completed online, and all their responses will be collated into a spreadsheet document; stored directly on the interviewee's Google Drive page ready to be analysed by the researchers.

8.0 Document Reading

Documents in the form of records of work done, schemes of work (specifically the resources used during the week) and lesson plans for data/information (digital technology teaching aids) related to usage of digital technologies during teaching were also read and analysed for data in the sixth and seventh week of the teaching practice period. Data in the form of a unique ID to help track individual responses called Participant ID, Topic, Week and Date, Duration, Digital Technology Used/Planned for Use, Class was collected from the documents. This helped to check the frequency of use of digital technologies during the teaching practice period under consideration, and to determine the types of digital technologies they used during their day-to-day teaching; and the ones they had used before in their subject areas.

9.0 Interviews and Lesson Observations

The participants were asked to talk about their teaching and learning experiences using digital technologies. Lesson observations were conducted to observe if and how the digital technologies were used during actual teaching practicums. It was not mandatory to use some digital resources during teaching practice teaching period. It is entirely up to the teacher to employ teaching aids of his/her choice, be it digital or not for their lessons.

10.0 Data Analysis and Results

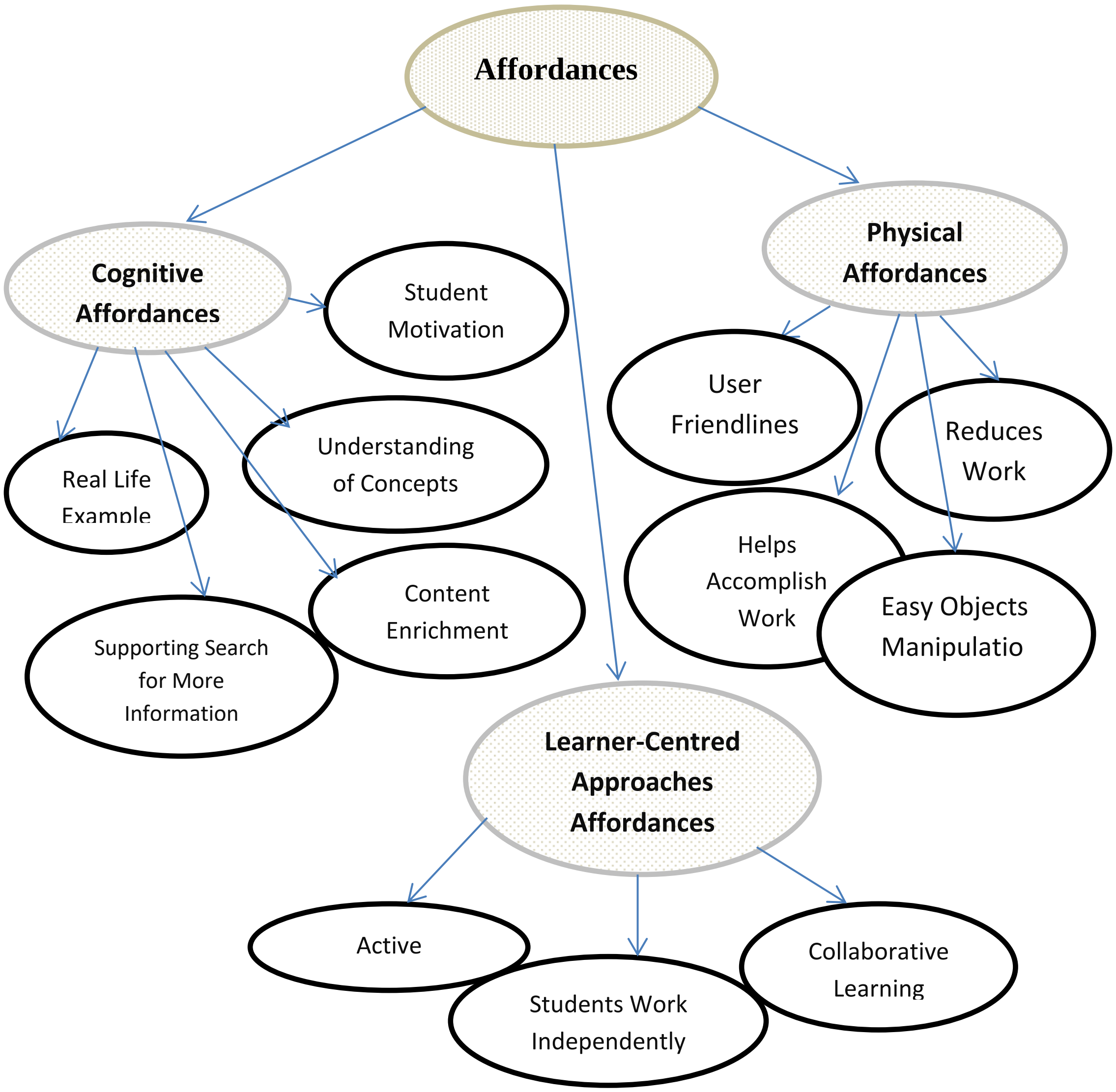
The data analysis for the affordances consisted of several iterative cycles by two coders. Interview data about teaching experiences, observation data, lesson plans and schemes data were coded to a predefined set of codes by the researchers. First, the framework derived from grounded theory literature was adopted to analyse the data with grounded theory(Corbin & Strauss, 1990). A large number of coded incidences related to affordances of digital technologies were initially identified and categorised by the researchers, paying attention to the relevance to the study goals. Each initial code was further categorised into sub-themes at subsequent stages where necessary and refined. Any disagreements between the researchers were resolved through discussions. The first round of coding reliability generated low levels of inter-coder reliability between the coders. Subsequent discussions generated higher levels of agreement;

and increased the reliability. It was generally agreed that the affordances fell into cognitive affordances (Hartson, 2003), physical affordances (Hartson, 2003) and learner-centred affordances (see **Table III**).

Table III: Illustration of coded categories, frequency of references and number of participants in each category

Category	**Freq. of Refs**	**No. of participants**	**Sample Quotes**
Cognitive affordance e.g. Content enrichment	123	*81*	*Digital Technologies provide a lot of information that cannot be provided by a text book, including video and audio*
Physical affordance e.g. User-friendliness	134	76	*The digital technologies are user friendly…they are easy to use and can provide different views according to the learner's tastes.*
Learner-centred affordances e.g. Students work independently	112	72	*The learners can learn on their own during their own time.*

Figure 11: Coded affordances of digital technologies and themes



11.0 Cognitive Affordances

Participants' responses regarding cognitive affordance were divided into five sub-categories by the researchers, i.e. 'Real life examples', 'Supporting search for more information', 'Content enrichment', 'Student motivation' and 'Understanding of concepts'. Eighty-one (94.2%) participants reflected beliefs that digital technologies provided real life examples and content enrichment, while 79 (91.9%) indicated that the digital technologies increased understanding of concepts by the students. Moreover, 83 (96.5%) participants felt that digital technologies increased student motivation in learning. Sixty-nine (80.2%) participants indicated that the digital technologies encouraged students to search for more information about a specific concept.

12.0 Physical Affordances

'Objects manipulable', 'User friendliness', 'Helps in accomplishing work' and 'Reduces work time' were the four sub-categories that were identified under physical affordances. Seventy-six (88.4%) indicated that the digital technologies provided physical affordances to work with the software. Seventy-six (88.4%) indicated that the digital technologies provided learning objects that were easy to manipulate; while 82 (95.3%) indicated that the digital technologies were user friendly. Eighty-one (94.2%) felt that they helped to accomplish work, while 69 (80.2%) felt that they reduce work time, since there is no repetition of work.

13.0 Learner-centred Affordances

Participants' responses regarding learner-centred affordances were categorised into 'Active learning', 'Collaborative learning styles', and 'Encouraging students to find information on their own'. Seventy-two (83.7%) indicated active learning affordances; 72(83.7%) collaborative learning styles, and 63 (73.3%) indicated that the digital technologies encourage students to find information on their own.

Table IV: Summary of means, standard deviations for cognitive affordances, physical affordances and learner-centred affordances.

Affordances	Mean (STD)	Loading	Cronbach's Alpha
Cognitive Affordances(CA)			
Real-life examples.	4.40 (0.93)	.958	
Student Motivation.	4.04 (1.01)	.865	
Content Enrichment.	3.87 (0.78)	.739	.905
Understanding of Concepts.	4.03 (0.83)	.769	
Search for more information.	4.11 (0.69)	.731	
Physical Affordances(PA)			
User friendliness	4.77 (0.73)	.857	
Reduces work time	4.21 (0.84)	.846	
Easy Object manipulation	4.31 (1.01)	.840	.786

Helps Accomplish work	4.50 (0.77)	.892	
Learner-Centred Affordances (LCA)			
Active-Learning			
Collaborative Learning	4.20 (0.73)	.854	
Independent Study	4.60 (1.11)	.796	.857
	3.56 (0.89)	.848	

Scale: 1: strongly disagree, 5: strongly agree. All loadings were significant based on t-values.

14.0 Usage of Digital Technologies in Teaching

Analysis for usage data and correlations among the variables of interest was done using SPSS. **Table V** summarises usage of digital technologies by respondents during teaching practice.

Table V: Usage of Individual Digital Technologies According to Purpose in Teaching Practice

		Discussion tools	Create charts and graphs	Search information on the Internet	Develop web material	Use YouTube videos	Communicate Whatsapp or/and Viber	Use Subject-Specific S/W	Use DropBox
N	Valid	86	86	86	86	86	86	86	86
	Missing	0	0	0	0	0	0	0	0
Mean		4.42	4.53	5.00	3.56	4.60	4.80	4.73	3.06
Median		4.42[a]	4.53[a]	5.00[a]	3.56[a]	4.60[a]	4.80[a]	4.74[a]	3.10[a]
Mode		3	4	5	4	4	4	4	4
Std. Deviation		.246	.251	.155	.248	.242	.159	.241	.854
Variance		.060	.063	.024	.062	.058	.025	.058	.532
Minimum		3	3	4	3	3	3	2	1
Maximum		5	5	5	5	5	5	5	5
Percentiles									
	50	4.42	4.53	4.81	4.56	4.60	4.80	4.74	3.10

a. Calculated from grouped data.
b. The lower bound of the first interval or the upper bound of the last interval is not known. Some percentiles are undefined.
c. Percentiles are calculated from grouped data.

Table V indicates that there is high rate of usage of digital technology resources among the respondent pre-service teachers. On an ordinal level of measurement of 1 to 5, the mean for the usage of most of the digital technologies is above 4, indicating that usage is high.

15.0 Perceived usefulness and ease of use

For the purposed of the study; the questionnaire also sought to find the perceptions of the participant pre-service teachers on the usefulness and ease of use of digital technologies in their teaching. The TAM

(Venkatesh and Bala, 2008) questionnaire was adapted for use with the pre-service teachers with current usage of digital technologies for teaching and learning. A summary of the data is provided in **Table VI.**

Table VI: Summary of means, standard deviations, TAM construct loadings (Perceived Usefulness and Perceived Ease of Use) for the use digital technologies in teaching

Construct	**Measurement Item**	**Mean(STD)**	**Loading**	**Cronbach's alpha**
Perceived Usefulness	PU1	6.05 (1.10)	.869	
	PU2	5.97 (0.80)	.871	.847
	PU3	5.65 (1.13)	.845	
	PU4	5.91 (0.89)	.737	
Perceived Ease of Use	PEoU1	6.04 (1.11)	.829	
	PEoU2	6.30 (1.30)	.809	.812
	PEoU3	6.05 (1.21)	.756	
	PEoU4	5.98 (1.01)	.783	

Scale: 1: strongly disagree, 7: strongly agree.

16.0 Relationship among the Perceived affordances and TAM constructs

Question 3 sought to find if there was any relationship between the perceived cognitive affordances and perceived physical affordances and the TAM3 (Venkatesh and Bala, 2008) constructs of perceived usefulness and perceived ease of use among the pre-service teachers. Pearson's correlations were calculated to identify the correlations among four variables of cognitive affordances (CA), physical affordances (PA), perceived usefulness (PU) and the perceived ease of use (PEoU). The average scores of the multi-items for the constructs were computed since the single constructs in the questionnaire was measured by multiple items, and the scores were used in further analysis.

Table V: CA, PA, PE, PEoU Correlations

			CA	PA	PU	PEoU
Spearman's rho	CA	Correlation Coefficient	1.000	.104**	.884**	.125*
		Sig. (2-tailed)	.	.000	.000	.034
		N	86	86	86	86
	PA	Correlation Coefficient	.104**	1.000	.112**	.521**
		Sig. (2-tailed)	.000	.	.000	.005
		N	86	86	86	86
	PU	Correlation Coefficient	.884**	.112**	1.000	.101*
		Sig. (2-tailed)	.000	.000	.	.015
		N	86	86	86	86
	PEoU	Correlation Coefficient	.125*	.521**	.101*	1.000
		Sig. (2-tailed)	.034	.005	.015	.
		N	86	86	86	86

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The scales of measurement of the variables are ordinal. Prior to analysis, no violation of independence or linearity of ranks was indicated. The result of a Spearman's rho (ρ) analysis indicated a statistically significant positive association between Perceived Usefulness (PU) and Cognitive Affordance (CA), $\rho(84) = .886, p<.01$, where PU increased as CA increased. Also The Physical Affordance (PA) and Perceived Ease of Use (PEoU), $\rho(84) = .521, p<.01$ indicated a strong positive association between the two. The correlation between CA and PEoU was insignificant, the same as the between PA and PU; and that of PU and PEoU. Table V summarises the results of the analysis of the correlations between TAM constructs and affordances constructs developed by this research.

17.0 Discussion and Conclusion

The results indicate widespread usage of digital technologies in the teaching of computer studies, mathematics and science. Substantial growth of the Internet and availability of various digital technological tools and services is affecting the pre-service teachers' daily lives in how they plan their teaching using digital technologies. Similar to earlier studies, Baltaci-Goktalay (2010), Jones (2010), Szeto and Cheng (2013), Tamim (2013), this study confirmed widespread use of digital resources among the so called *digital generation*, among them the pre-service teachers in higher education today. The results provide insight/evidence to support substantial use of digital technologies in the teaching of computer studies, mathematics and science subjects in secondary schools in Botswana. TAM (Davis, 1989; Venkatesh and Bala, 2008) has been shown to be a valid means of predicting technology acceptability through usage. It suggests that user perceptions of a system are formed very early, after only minimal exposure to the system. Nonetheless, these early perceptions have a very powerful influence on whether users will actually use that system in the future. In particular, TAM suggests that designers must consider not only the system usage and ease of use, but also its usefulness in order to encourage end user acceptance of that system.

The pre-service teachers perceived that the digital technologies afforded cognitive affordances, physical affordances and learner-centred affordances during use. It can be interpreted that there is a perception among the pre-service teachers that using digital technologies enables them to think better. The physical affordances can also be attributed to the usability of the graphical user interface digital technologies available today; and the common interface across most windows-based systems.

Question 3 sought to find if there was a relationship between cognitive affordances and physical affordances and the TAM (Venkatesh and Bala, 2008) constructs of perceived usefulness and the perceived ease of use on using digital technologies. The results indicated a strong positive relationship between the cognitive affordances and the perceived usefulness of the digital technologies they have used for teaching. There was also a strong relationship between physical affordances and the perceived ease of use. It can be concluded that the pre-service teachers tied cognitive affordances to usefulness, and physical affordances to ease of use.

People tend to use a technology when they "believe that it will help them perform their job better" (perceived usefulness) (Chuttur, 2009, p. 5). People also use it when they believe that it will be "free of physical or mental effort" (Chuttur, 2009, p. 6). Chattur (2009, p. 6) also indicates that "perceived usefulness could have a direct influence on actual technology usage". The results from the study indicate that the usage is high among the pre-service teachers; and that they regard highly the integration of technologies in their teaching. They perceive these digital technologies to afford them various cognitive and physical benefits; pointing to usefulness and ease of use. Thus, these results validate the TAM that indicates a strong correlation between reported intention and self-reported system usage with perceived usefulness responsible for the influence on the people's intention to use a technology(Adams, Nelson, Todd, & Adams, 1992; Chuttur, 2009; Davis, 1989).The findings of the current study are highly similar to those reported by Krauskopf et al. (2012), Tamim (2013) and Szeto and Cheng (2013) in their studies with pre-service teachers in Germany, United Arab Emirates and Hong Kong respectively on digital technologies and tools in teaching and learning.

Finally, it is important to keep in mind that the current study serves as an exploratory study that provides insights into the way forward for the development of pedagogy of using digital technologies by prospective computer studies, mathematics and science teachers.

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