# Embedding Digital Pedagogy in Pre-Service Higher Education To Better Prepare Teachers for the Digital Generation

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Received: October 9, 2013 Accepted: October 24, 2013 Online Published: October 28, 2013

doi:10.5430/ijhe.v2n4p131 URL: http://dx.doi.org/10.5430/ijhe.v2n4p131

**Abstract**

In preparing pre-service teachers for their professional practice in the information age, we need to impress upon them that the children in their classrooms will be Digital Natives, with skills for digital fluency rather than skills in the orthodoxy 3Rs developed with talk, chalk and board; paper, pencil and pen. Since most of our pre-service teachers belong to the pre-digital generation without the skills for 21st century digital fluency, there is a great need for us as higher education practitioners, to prepare them well for the new classrooms they will work in so as to prevent a mismatch between them and their students where they could be seen as illiterate teachers trying to teach literate children. Embedding digital pedagogy in the skilling of these teachers is urgently needed to help them appreciate the role of technology in the teaching of pedagogy and content knowledge (TPACK). Fortunately enough, a wide range of apps are available for use on iPads, Androids, eTablets, Smart Phones and other platforms, which our pre-service teachers could apply in their teaching. One example of how this was achieved in higher education with two cohorts of 2nd year B.Ed pre-service teachers is discussed in this paper. The paper demonstrates that social media digital tools can be embedded in pre-service higher education to help train pre-service teachers so they appreciate the TPACK model. The paper concludes that it is incumbent upon higher education providers, to ensure that graduates are well prepared to be effective teachers for the digital generation.

**Keywords:** Digital immigrants, Digital natives, Digital pedagogy, Orthodoxy pedagogy, Illiterate teachers teaching literate children, Student-centric technology, Teacher-student mismatch, Technological-pedagogical-and-content-knowledge (TPACK)

## 1. Introduction

### *1.1 Conceptualisation of the issue*

By digital pedagogy I mean the embedment into the art of teaching, computer driven digital technologies, which enrich learning, teaching, assessment and the whole curriculum. In this definition, I seek to extend the meaning of pedagogy beyond the orthodoxy notion which tends to limit its meaning to the practice and process of teaching. As Jennifer Howell (2012) points out, research-based evidence suggests that an application of technology enables us to "learn differently and to engage in different types of knowledge creation" (p.5). Therefore, we can define a digital pedagogy in the words of Howell (2012) as "the study of how to teach using digital technologies.

Those of us privileged with the opportunity of providing higher education to teachers for tomorrow are duty-bound to ensure that as the pre-service teachers graduate from our institutions, they are well equipped with the skills that will enable them to help the children that they will teach, become better citizens. This, as Fullan (2001) eloquently admonishes, is the moral purpose of education. Apart from a few mature entrants, most of our higher education students preparing to be teachers are aged in their 30s. This age bracket qualifies them among the group that Prensky (2001) characterizes as "Digital Immigrants" (p.3). He coined this term to articulate the fact that such people, which is most of us born before 1980, are in the process of learning a new language, - a process that is typical of all immigrants in their new country. Yet these graduates are destined to teach in classrooms where the majority of the children will be those whom Prensky (2001) termed "Digital Natives". These are the children who have grown up into a world

surrounded by and using computers, videogames, digital music players, video cams, cell phones, and all the other modern technological toys and tools. They are the generation who, according to Prensky (2001) by the time they are 21, "will have played more than 10,000 hours of video games, sent and received 250,000 emails and text/instant messages, spent 10,000 hours talking on digital cell phones, and watched more than 20,000 hours of television and over 500,000 commercials" (p. 1). This is the generation that Howell (2012) has referred to as the "Gen C, Gen I, Net Gen, Gen Y, Gen Z and Internet Generation (p. 6). In referring to these Digital Natives simply as the "Digital Generation", Jukes, McCain and Crockett (2010) say, "teachers ignore the skill level of (these) students … because they don't recognise the skills this generation has developed to operate in the digital world" (p. 51). We, as pre-service teacher educators have a duty to make sure that this mismatch between teachers and students is overcome by embedding digital pedagogy in our pre-service higher education.

*1.2 Pertinent Literature: The Imperatives for a Digital Pedagogy*

In teaching our pre-service teachers, we are guided by foundational theories bequeathed to the profession by great thinkers. I refer to those thinkers as 'giants in the field' of pedagogy. Most relevant to my advocacy of embedding digital technologies into teacher preparation are Piaget (1896 - 1980), Vygotsky (1896 - 1934), Bruner (1915-), Edward de Bono (1933-) Bloom (1913 - 1999) and Gardner (1943-). Without going into details of how the insights and understandings developed by these giants in the field contribute to our understanding of how children learn, and therefore how we should teach to facilitate their learning; and how these insights marry with the benefits derivable from embracing and applying a digital pedagogy in teaching, learning, assessment and curriculum; it will become clear in this paper that "children of the 21st century, the Digital Generation, .. spend most of their time texting people on their cell phones, chatting with friends using instant messaging, interacting with people on Facebook or MySpace, playing games on Xbox or Wii and surfing the Internet", (Jukes, McCain and Crockett, 2010, p. 54). If properly embedded in pedagogy, these technologies have great potential to provide for social learning (Piaget, 1923), co-construction of knowledge (Vygotsky, 1978) are very engaging and exploratory (Bruner, 1966) encourage children to approach learning from different perspectives (de Bono, 1956), which helps them to learn from their peers by applying knowledge (Bloom, 1956) and in their own way (Gardner, 1999).

As Plante (2012) explains, in today's digital landscape in which the Digital Natives learn, "the world is getting more and more technology centred, focused and driven" (p. 1). Accordingly, Kelly, McCain and Jukes (2009) ask: "An important question … why hasn't education changed as the world has changed around it" (p.3)? In answering their own question these authors assert that the reason education has not changed as the world has gone digital is because schools operate under a very formidable force called "**TTWWADI** (which) has awesome power over people" (p.3). They unpack TTWWADI as "**T**hat's **T**he **W**ay **W**e've **A**lways **D**one **I**t" [Ibid]. As pre-service teacher educators we are well placed to change the mental models of our students so that their habits of mind (Costa, 2000), behaviour and professional practice develop along the trajectory that recolonizes that digital pedagogy is no longer the way children will be taught in generations of the future but of the present. Whereas it must be recognized that introducing our students to the latest technological tools and skills to use them is not the answer to everything, it needs to be emphasised that for our pre-service teachers to graduate as effective teachers in the technologically driven world of the 21st century, they need to be able not only to speak the language of the Digital Natives with an accent but with fluency.

The development of that digital fluency starts with the realization that the power of technology in producing better citizens of the digital world lies in its ability to facilitate critical thinking and problem solving in the real world in which children live, play and learn. As McCain (2007) advises, although equipping "students with up-to-date technology skills (is) critical for students' success, they are not enough if we want our children to keep up with the job market and … our country to remain a leader in the world economy" (p.1). It is true that encouraging our pre-service teachers to embrace technology in their teaching is not the solution to all problems but as McNierney (2004) admonishes teacher educators "must model instructional methods which help future teachers understand that technology-based instruction is no longer an option. It is a requirement" (p. 28). Only then shall we have realistic hope for "making student-centric technology a reality" (Christensen, 2011, p.123).

Making our pre-service teachers technology savvy ought to be given a high priority in our curriculum so that they can capitalize on the Internet information explosion that is taking place. This explosion is set to amplify as Google complete their scan and digitization of more than 50 million books from five of the largest research libraries in the world and Archive.org do likewise to the 500 million volumes in the Library of Congress to integrate all the knowledge pools from around the world. Richardson (2010) advises, "there's no doubt that the ability of our teachers and students to use that knowledge effectively is of the highest importance" (p.147). That importance is supported by

evidence from Australia which shows, for instance, that there had been a rapid increase in the numbers of students' use of instant messaging, blogs and podcasting between 2005 and 2007 and that over 90% of 1st year engineering and business students used online resources for their study (Oliver & Goerke, 2007). This is supported further by data from the Australian Bureau of Statistics (ABS, 2011) that show that over a decade ago, some 99% of 12 – 14 year old adolescents in Australia used a computer at home or at school. And that was before the advent of broadband, which is set to revolutionize the seamless transfer of information, sharing and co-construction of knowledge.

The same survey (ABS, 2011) also found that social networking was the most popular use of the Internet technologies. Most of that social networking was occurring via the cell phone. For these Digital Natives, their cell phone is not a want. It is a necessity for their very survival. As Prensky (2010) puts it, these are children who will say, "If I lose my cell phone, I lose half my brain" (p.2). These children lose themselves without their cell phone because their cell phones have become networked computers which they use for the construction of their perceived social reality driven by what Mitch Resnick (1996) called distributed constructionism. This understanding posits computer networks as a new medium for construction of knowledge through engaging in activities that are completed in a collaborative way with a group of other members in what may be called Peer Learning Networks (PLNs). As I will show in the methodology section of this paper, my introduction of Google+.Discussion Circles into my pre-service teacher units was an attempt to get my students engaged in seamless transfer and collaborative sharing of information to take advantage of social constructionism built around PLNs.

Such PLNs can be developed further into interconnected networks for learning driven by connectivism. Connectivism, according to Howell (2012, p. 28), is a theory of learning that enables students to combine the trilogy of "know-what, know-how and know-where" – the three pillars on which many pedagogical theories are based. Among other principles, connectivism posits that "Learning and knowledge rests in diversity of opinions; learning is a process of connecting specialized nodes or information sources; the capacity to know more is more critical than what is currently known" (Ibid, p.28). In all these principles, as with the other principles of connectivism not elucidated here for lack of room, embedding technology in our teaching is critical. One way to enhance this understanding is to invoke the TPACK model developed by Mishra and Koehler (2006) and Koehler and Mishra (2008) outlined below.

*1.3 Applying the TPACK Model in Higher Education*

TPACK is the acronym for **t**echnological **p**edagogical **a**nd **c**ontent **k**nowledge framework which is a model developed by Mishra and Koehler (2006) to help us understand how we can be effective teachers in a digital classroom. The central proposition of the model is that technology; pedagogy and subject content all need to be integrated if we are to use technology effectively in teaching subject matter. These authors admonish that the holistic understanding and integration of these three dimensions, is greater and deeper than that of an individual expert in each of these fields. What this means is that applying the TPACK model enriches our teaching by more than we could add through the use of the solo activities of an expert in technology, another in pedagogy and a third in content. As knowledge from these three domains is integrated, the TPACK model comprises seven bodies of knowledge summarized in Table 1 and illustrated further in Figure 1.

With reference to Table 1 and Figure 1, if we assign TK to technological knowledge of the digital literacies that we can apply in our teaching (Element 1), CK to having mastery of the content knowledge of our subjects (Element 2) and PK to pedagogical knowledge of how our students learn and the strategies we can use to enhance effective teaching and assessment (Element 3), then as these three are integrated, new bodies of knowledge and professional practice emerge as represented by TCK (Element 4) where technology and content intercept, TPK (Element 5) the confluence of technology and pedagogy, PCK (Element 6) at the intersection of pedagogy and content knowledge and the core of all these is the summation TPACK shown as Element 7.

An understanding of the interplay among the different elements of the TPACK model can enable teachers to increase the permeation of digital tools into their teaching, assessment and curriculum development. For example, many digital apps are freely available from the Internet and can very easily be embedded into our teaching and curriculum if we are aware of their existence and conscientiously try apply them. Among the many that are available are the iPad and iTunes apps that Suzanne Lustenhouwer (2012) has put together for use in the classroom to facilitate students' engagement with learning. In the example I have chosen just to illustrate the apps we could use when teaching Howard Gardner's (1999) Multiple Intelligences (MI), children could work with these apps by simply tapping on objects embedded within the MI that best serves the content being taught. Figure 2 illustrates the wide range of apps icons that could be used in teaching curriculum relating to the Interpersonal MI. Examples of apps suggested for learning and teaching with the

other seven MIs (Intrapersonal MI, the Naturalist MI, the Musical MI, the Bodily-kinesthetic MI, Visual-Spatial, Linguistic and Logical-Mathematical MIs are also given in the same Lustenhouwer (2012) blog.

Table 1. Implications of Embedding Digital Pedagogy in Higher Education: TPACK

| Element | Code | Pedagogical and technical meaning |
|---|---|---|
| 1 | TK | Awareness of digital literacies and how to apply them with our students |
| 2 | CK | Having mastery and command of our subject knowledge |
| 3 | PK | How students learn, effective teaching, and assessment |
| 4 | TCK | How technology can be used for new ways to teach content |
| 5 | TPK | Technology affordances as enablers of new teaching and learning |
| 6 | PCK | How to combine pedagogy and content effectively |
| 7 | TPACK 1+2+3 | Understanding of the interplay between TK, CK and PK when using technology for teaching in the 21st century context. |

Source: Mishra and Koehler (2006) and Koehler and Mishra (2008).

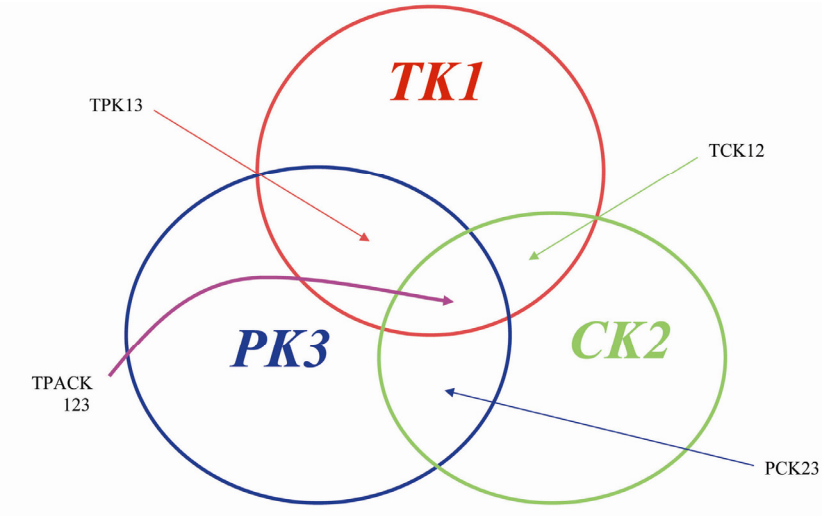


Figure 1. Digital Pedagogy TPACK Model Application in Higher Education
Source: Mishra and Koehler (2006) and Koehler and Mishra (2008).

**TPACK:TCK-TPK-PCK**
**iTunes- Apps**
**for the Interpersonal MI**


Figure 2. Examples of digital tools to engage children in the Interpersonal MI critical thinking using TPACK

Source: Suzanne Lustenhouwer (2012). Apps for multiple intelligences. Posted 21 August, 2012. Accessed at http://www.ipadders.eu/apps-for-multiple-intelligences/ (5 October 2013).

Lustenhouwer's (2012) blog is helpful in our understanding of TPACK because it illustrates what it takes to use cutting–edge-technology in the real-life experience of day-to-day teaching. It shows that students and teachers can easily choose whichever app serves them the best in developing their understanding of the content knowledge. For in stance, in critical thinking using Howard Gardner's (1999) Interpersonal MI which I have chosen for illustrative purposes, as shown in Figure 2, students could work with Facebook, Skype, Storify, Twitter, Sharedpaper, Dropbox, Nearpod and Georiot.co. Each of these eight tools (the 9th also shown in the Figure is non-responsive) has an active icon that a student can click on to engage in critical thinking using the Interpersonal MI. These tools are all well suited to an understanding and application of TPACK using the Interpersonal MI since they enable the student to engage in communication with others in the web using digital tools that they are familiar with, including Facebook and Twitter; engage in cooperative learning with students on the other side of the world using Skype, collaborate with their peers internationally using Scoop.it; develop essays, reports and other textual documents and share them with their friends and teachers across the world using Dropbox and post or publish with others using Nearpod. Here then is an excellent example of how technological, pedagogical and content knowledge (TPACK) can be applied in our teaching and shared by children using the tools they prefer and in their language of digital nativity.

This example from Lustenhouwer's (2012) work is important because it helps to drive home the message that in embedding digital tools in pre-service higher education it is not enough to know what technological tools are available. What is more important is to know how we can integrate that technology as part of our pedagogy to teach the content that enables our students to achieve the learning outcomes intended for their learning stage. This example demonstrates well what Richardson (2010) refers to as the "seamless transfer of information; of collaborative, individualized learning and active participation by all members of the class" (p. 149) made possible when TPACK is well integrated in our teaching. In recognition of the importance of such integration, Richardson advises, "In many ways, these technologies are demanding that we reexamine the way we think about content and curriculum, and they are nurturing new, important shifts in how best to teach students" (p. 149).

Like Lustenhouwer, Kathy Schrock (2013) has assembled a wide range of digital tools with icons each of which has a clickable hot spot for Web 2.0, iPad, Google and Android apps that could be used to apply technology (TK1) to support our teaching of critical thinking (CK2) using Bloom's Revised Taxonomy (PK3) of Remembering, Understanding, Applying, Analysing, Evaluating and Creating. She identified several apps applicable to facilitate learning at each of these different cognitive levels as illustrated in Figure 3, for the iPad and in Figure 4 for the Android. Space does not allow me indulgence for detailed discussion of each of these and so, while I refer the reader to the original source of this information (Schrock, 2013) I make the following brief comments.

As illustrated in Figure 3, in applying iPad apps while studying at the low thinking level of Remembering, Schrock listed apps including Recalling, Listing, Bookmarking, Searching, Mindmapping and Word Processing. As we move to the second higher-order thinking involving Understanding, Schrock included Categorizing, Annotating, Tweeting, Blogging, Subscribing and Explaining. As she raised the bar to the third cognitive level - Applying, - she included Interviewing, Simulating, Demonstrating, Presenting, Editing and Illustrating. At the fourth cognitive order of Analyzing, she assembled Outlining, Structuring, Organizing, Surveying, Deconstructing and Mashing apps. For Evaluating, - cognitive level five, the apps that Schrock highlighted are Moderating, Conferencing, Networking, Posting, Collaborating and Critiquing. At the highest learning level of Creating, Schrock outlined Storytelling, Video Editing, Videocasting, Mixing, Animating and Podcasting. As already stated above, the common icons for all these apps are illustrated in Figure 3. Those for use on the Android when teaching critical thinking using Bloom are illustrated in Figure 4. Space does not allow me indulgence for detailed discussion of these and so readers are encouraged to source the details from Schrock's (2013) excellent website.

Other equally interesting digital tools such as Langitch's (2013) apps that could be used on the iPad by teachers and students to complete class activities using Bloom's Revised Cognitive Taxonomy must wait for another paper as it is not possible to deal with them at length here. Suffice to comment that they range from the simple iBook for the low content level of Remembering, through to the creation of iMovies at the highest thinking level - Creating. The work of Lustenhouwer, Schrock and Langitch has been reviewed here briefly to demonstrate that the interactive nature of these digital apps has potential to engage students deeply in their learning, utilizing tools that interest them and which are consistent with their digital nativity. We can conclude from this literature review that there are strong arguments in support of embedding digital technologies into teaching and curriculum in a manner that is fully consistent with the TPACK model.

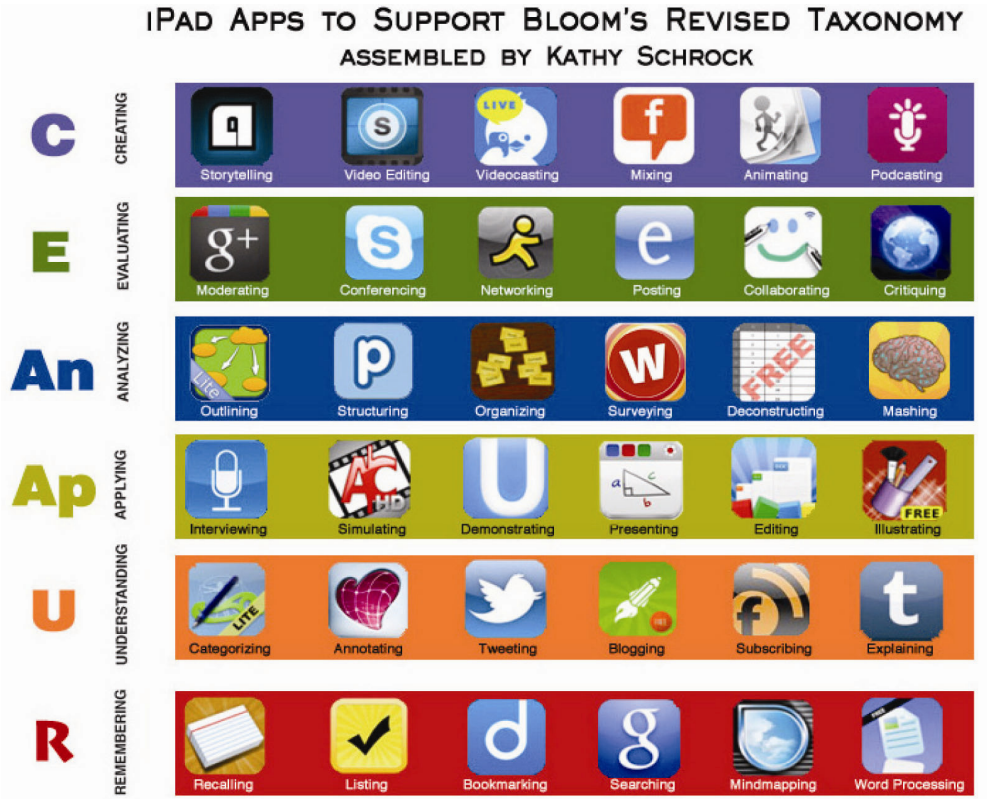


Figure 3. Examples of iPad digital tools to teach children critical thinking using Bloom's Revised Taxonomy
Source: Schrock, K. (2012).

**TPACK: TCK-TPK-PCK**

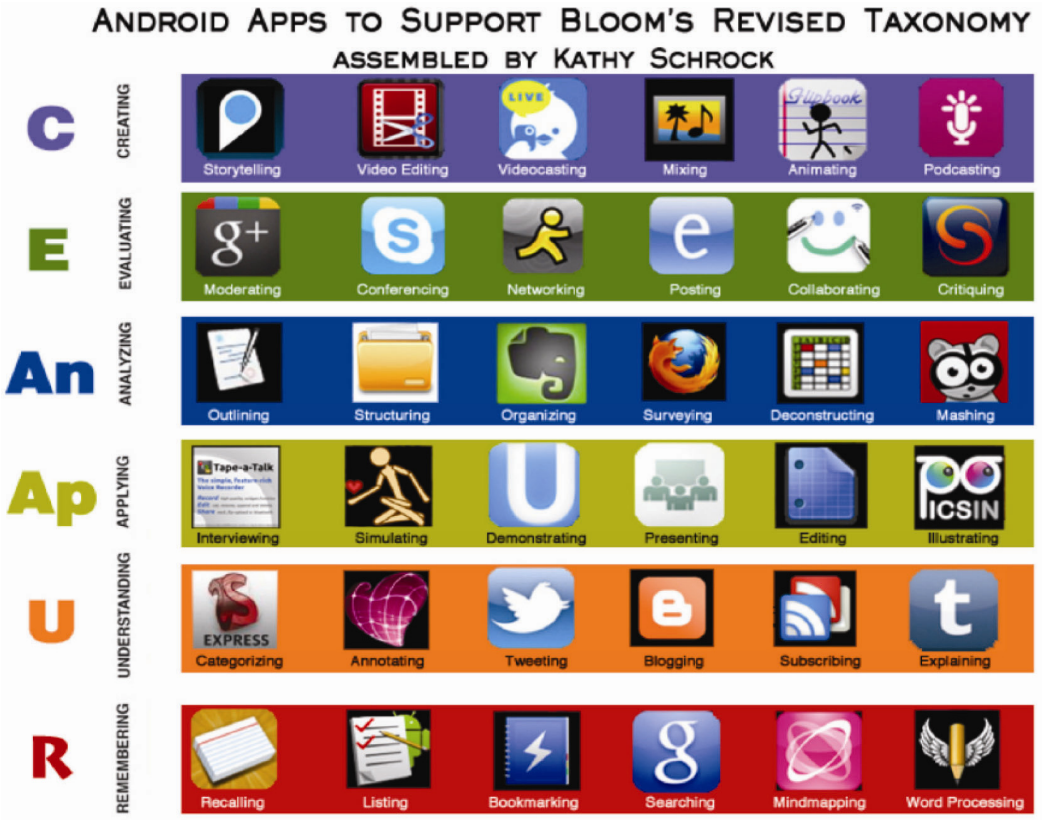


Figure 4. Examples of Android digital tools to teach children critical thinking using Bloom's Revised Taxonomy
Source: Schrock, K. (2012).

## 2. Methodology: From Theory to Practice

What follows in this section is a description of my application of TPACK as I embedded some social media technological tools, namely Google+.Discussion Circles (GDCs), eFoliospaces and YouTube products, in my pre-service teachers' unit in their second year of the B.Ed degree in two successive cohorts in 2012 and 2013. I have embedded these tools in my doctoral unit as well over three years, but the focus of this paper is pre-service higher education to prepare primary teachers and so the former are not discussed in this paper.

Having successfully embedded GDCs while teaching 15 students enrolled in a doctoral degree Unit EDCX782 (Leadership and Culture in the workplace) in 2011 over two semesters (n = 9 + 6), I decided to have a go at introducing these cutting-edge-technologies in my pre-service teachers' Unit EDLT217 (Planning and Assessing for Active Learning) starting in trimester 2 of 2012. This undergraduate Unit has a much larger cohort than the doctoral Unit. The first cohort in 2012 had 258 students and that in 2013 had 169. So over the two cohorts, I have had the opportunity to apply the GDCs along the TPACK model while teaching 427 (258 in 2012 and 169 in 2013) undergraduate pre-service teachers enrolled in my Unit.

Although 86% of all our students receive their instruction and learning resources online, all our students (the internal and external cohort) have access to the University's Learning Management System called Moodle. As was standard practice, before I introduced GDCs all cohorts in the Unit relied on posts in Moodle Forums for their discussions of pedagogical and content knowledge relating to their teacher preparation. So, they were familiar with working with, for example, Wikis, Blogs and to texting chats within their groups. For the external cohort, (n = 160 in 2012), these digital tools were their primary means of collaborative learning. Therefore, their participation in Forum activities was mandated. For the on-campus students (n = 98 in 2012), they do have weekly face-to-face lectures followed by workshops. So for them participation in these online Forums was ad libitum.

The external students are given instructions in Moodle to sign up into groups of ten with any of their peers. However, each group of ten can communicate only among themselves. Interactions across group boundaries are not possible. As I monitored the posts in the Moodle Forums I noted that the ability for students to communicate with each other and to provide peer support was being undermined by this restrictive group structure (of a maximum of ten) with no opportunity for seamless transfer of information across group boundaries. I sensed that there was a demand among the students for greater opportunities to interact with one another across their groups. As said earlier, most of the 2$^{nd}$ year students are digital immigrants in their thirties but there is, among them, an increasing use of smart phones and eTablets. However, such communication is mainly for their non-academic discourses. For me, this familiarity with these digital tools was an opportunity to encourage these students to develop their digital fluency (TK) beyond social discourses and apply them in the pursuit of learning (CK) and development of skills for effective teaching (PK); hence, a lived experience with TPACK.

Since I had worked well with Google+ Discussion Circles, eFoliospaces and YouTube products with the smaller two cohorts of doctoral students in 2011, I decided to work with these digital technologies with the larger cohorts of the undergraduates. This was a challenge, not only because it hadn't been done before at this University, but also because it involved much larger numbers as indicated above.

I started by asking students to sign up into groups of ten that we were to call Peer Learning Networks (PLNs). Each PLN had a nucleus of 10 students but unlike a Moodle Forum, members of this core group were free to invite anyone they wanted into their PLN. Unlike the Forum which was embedded in Moodle, each PLN was located in Google.com at www rather embedded locally in the University's LMS Moodle. The PLN became the basis for each Google+.Discussion Circle for EDLT217. I gave each PLN a code-name designed respectively as PLNCKi …n-EDLT217. This code, for example, defined the identify of the PLN for Charles Kivunja's group (i … to group …n) in Unit EDLT217.

This way, the PLNs were designed to become the basic unit of conversation that served as an a-synchronous round table for the participants in each GDC. I provided some very simple instructions in Moodle, to help students transition their learning from Moodle to GDCs. For example, each student was asked to create a *gmail.com* account if they didn't already have one, and share their gmail address with other students. They were then given instructions on how to create a GDC and how to invite others to join it. They were also taught how to initiate a post and share the stream with members of their GDC in secret space rather than open www Facebook type of virtual arena. The beauty of this design was that they were now able to invite anyone they wanted, from anywhere in the world, to contribute to their discussions in the GDC. This meant that the participants could be the initial core of ten plus other students in this Unit in other PLNs, plus other students at this University in other Units, plus anyone that students wanted to invite to share their knowledge with. Apart from engaging in discourses with stream posts in the GDC, they could enrich their experiences and those of the PLN members by embedding *YouTube* videos, develop and share lesson plans using *eFoliospaces,* and make impressive illustrations of the flow of their arguments or discussions using *Lucidchart* graphic organisers, simple text or supporting images.

This Unit focuses on developing content knowledge (CK) as well as planning teaching and assessment strategies (PK) suited to the teaching of children of primary stages. As part of helping them to gain an understanding of such CK and

PK, I introduce the students to problem solving and to critical thinking strategies using Bloom 's (1956) Taxonomy, Gardner's (1999) MI, Bruner's (1966) 5E Instructional Model, de Bono's (1956) Six Thinking Hats, and Graphic Organizers (Pohl, 1997). And so, I encourage my students to demonstrate an understanding of the application of these tools in their learning and planning lessons. This time they were to do this using digital technologies (TK) thus putting into practice the 7 Elements of the TPACK model.

**3. Observations and Discussion**

Figure 5 and 6 help to illustrate my observations described in this section. The descriptions refer to my observations of the GDCs of my Unit EDLT217 which, as said earlier, had an external cohort of 160 and an internal cohort of 98 students making a total of 258 students in trimester 2 of 2012. The core of each GDC was the PLN each of which started with 10 students. As a result, the external cohort created 16 PLNs (comprising 16 of n = 10 each). The internal students formed 10 PLNs (comprising 9 with n = 10 and 1 of n = 8). As the internal students did not need the PLNs since they had face-to-face discussions in the on-campus weekly workshops, the most dynamic, learning activities across the GDCs occurred among the external cohort and so the two GDCs illustrated in Figure 5 and 6 are taken from the external cohort.

Although each GDC started with a core PLN of 10 students, the number of participants increased remarkably across all the GDCs. The numbers of participants varied from 18 in PLNCK4 to 48 in PLNCK2. Whereas these quantitative data shed some light on the multiplier dynamics that the application of GDCs introduced to TPACK, it is the contents within the streams of each GDC that really told the qualitative synergies that the use of GDCs brought to TPACK. These were greatest in PLNCK3 (n=25) and PLNCK2 (n = 48), which are illustrated in Figure 5 and Figure 6 respectively.

From Figure 5 we can see that the introduction of GDCs (TK) enabled students in PLNCK3 to increase the number of participants from 10 to 25. In Figure 6 we can see that the number of participants in PLNCK2 increased from 10 to 48. These figures indicate that the introduction of GDCs social media technologies in learning (CK) and teaching (PK), enhanced students' participation in discussions in their virtual classrooms founded on PLNs. The numbers say that in the GDC for my third PLNCK3, the number of participants rose by a multiplier of 2.5 from the original 10 to 25; and that for my PLNCK2, which was more dynamic and more proactive, experienced a multiplier effect of 4.8 from 10 to 48. How, you might ask, did this multiplier effect come about?

The significance of the GDC – TPACK multiplier effect is appreciated fully when we consider that without the GDC – TPACK model; the number of students in each group and in every Forum remained fixed at a maximum of 10 students. Students could only interact with their group members and there was no conversation possible across Forum group boundaries. However, with the introduction of GDC – TPACK, each student was asked, not only to participate in the discussions but also given the opportunity to invite other people from outside their core PLN of ten to participate in their GDC discussions. As a result of this design (TCK), instead of the ten members of each PLN holding their learning discussions (CK) and lesson planning strategies (PK) with their original members (n = 10), the PLNs increased their membership and were able to engage in academic exchanges of content knowledge (TPK) and teaching practice strategies (PCK) using GDCs (TK) thus completing their application of the TPACK model.

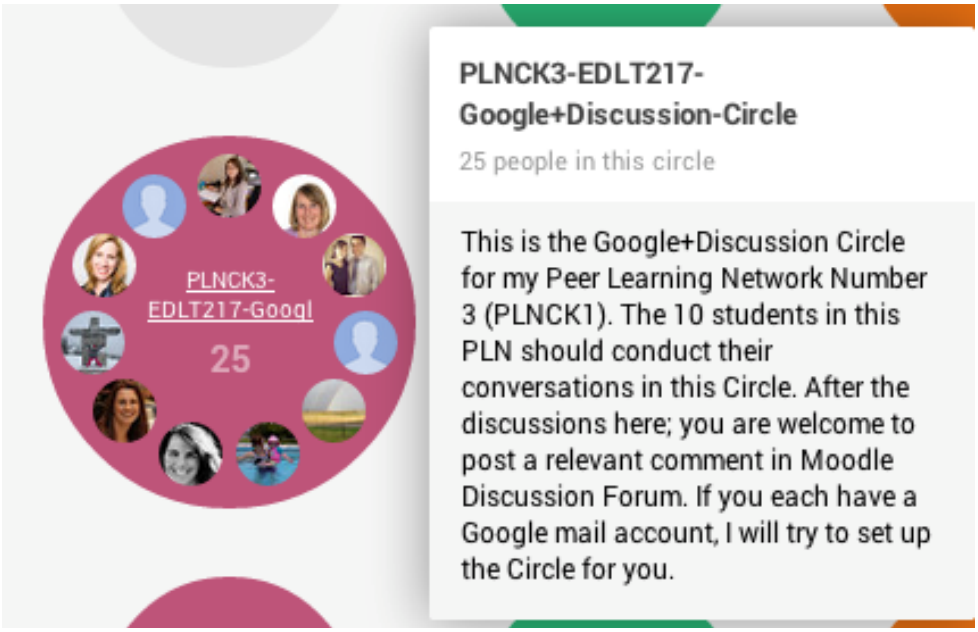


Figure 5. Google+.Discussion Circle of PLNCK3 (n = 25) in Unit EDLT217.

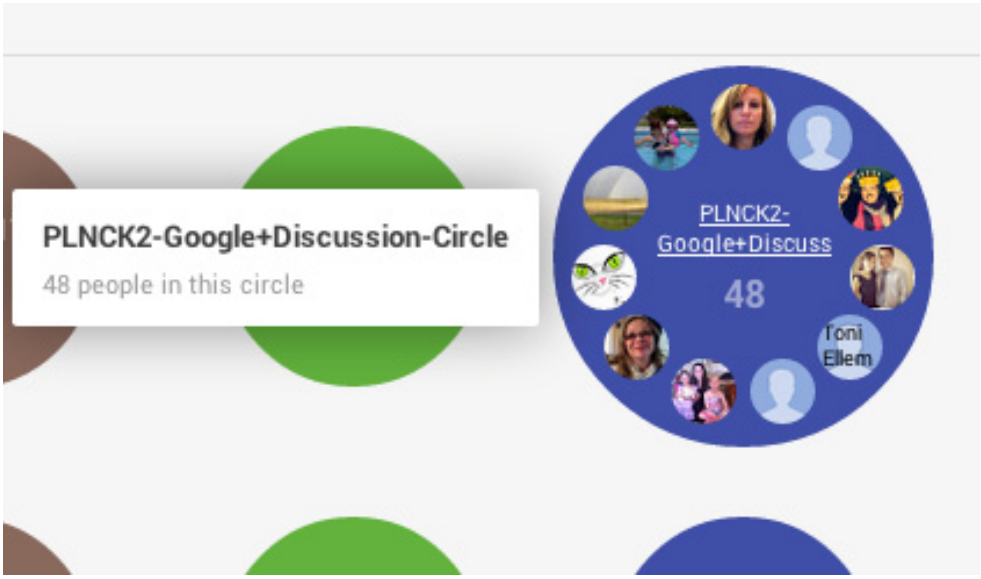


Figure 6. Google+.Discussion Circle of PLNCK2 (n = 48) in Unit EDLT217.

Whereas these quantitative observations are impressive, what fascinated me the most were the qualitative aspects of the application of GDC-TPACK with these undergraduate students. I summarise some of these in twelve findings. First, the observed multiplier effects were the results of personal interest and desire to participate rather than a response to mandated instructions. I make this observation because whereas I encouraged students to invite their friends into their GDC-PLN, there was no compulsion. So, students did so entirely on their own volition. Second, when students were given the opportunity to apply digital technologies (TK) in their learning (TCK) and professional practice (TPK), they took initiative to extend their understanding of issues and concepts (PCK) in a digitally connectivist mode (TCK). This was consistent with Prensky's (2010) advice that we should try to elicit maximum creation from our students when he says, "Today's students are incredibly eager to create, and don't get nearly enough opportunities to do so – just ask them" (p. 149). What's more it is fully consistent with principle number 12 that Kelly, McCain and Jukes (2009) propose for "creating a new vision for school" (p.37) which is that "students should assume responsibility for their own learning" (p. 40). Third, looking at the streams posted in the GDCs, it was also noticeable that students' engagement through GDC-PLNs-TPACK was not only absolutely greater than that under the old Moodle Learning Management System, but also more frequent and involved deeper and more critical thinking about what they were posting. Fourth, as I looked through the participants in each GDC-PLN, I noted clearly that some were not students in my School or at our University. This means that students extended their GDC beyond the University and so the learning that occurred was consistent with Kelly, McCain and Juke's (2009) principle number 9 for improving learning in the digital age which says that "Learning must be connected to the outside world" (p. 39).

Fifth, the comments students posted in the GDC-PLNs indicated that they appeared not to see themselves as learning in isolation, but in PLNs that were supportive of each other. Many of the comments in the streams reflected peer mentoring and guidance for each other. Sixth, they did not appear to be competitive with each other, but collaboratively seeking to engage with the concepts and issues being discussed rather trying to outsmart each other. This must be seen as a great improvement on the orthodoxy, instructional model where competition among students, against each other appears to be the understood approach to learning. Seventh, it was very interesting and encouraging, to see how students sourced and shared stimulus materials with members of their PLNs. Eighth, the extent to which students shot videos of the schools where they had completed their practicums and shared these in their GDC streams or designed Graphic Organizers using Lucidchart or used iPad and Android apps to apply Bloom or to discuss MIs in their discourses and freely shared these with their GDC-PLNs, indicated a move towards self-regulated learning based on interest, motivation and personal drive. Ninth, the comments made on other students' posts in the streams reflected aspects of peer feedback, peer learning, peer support and peer assessment. Tenth, it became apparent to me from monitoring the streams in the GDC-PLNs that students' construction of knowledge was moving from the orthodoxy cognitive constructivist thinking that emphasizes Piagetian (1923) personal construction of knowledge not only towards Vygotsky's (1978) social constructivism but more importantly towards digital connectivist pedagogy (Howell, 2012). Eleven, the skills that students demonstrated in their conversations appeared to fall within Bloom's (1956) higher-order critical thinking skills of Applying, Analyzing, Evaluating and even Creating. Finally, I found that

students' critiques of readings from the eReserve, designing eFoliospaces in which they embedded YouTube products and technological apps and sharing their Urls with their peers demonstrated high levels of Engagement, ability to Explore, Explain, Elaborate and Evaluate that appears to be consistent with Bruner's (1966) 5E Instructional Model, using GDCs-PLNs-TPACK.

## 4. Conclusion

I am of the firm belief that the old, traditional approaches to education are no longer adequate to prepare our pre-service teachers for teaching in a classroom environment driven by information technology. This is true not only for pre-service teachers but for all students because the demand for labour in the 21st century economies is for people whose skills are well grounded in technological knowledge, skills and creativity. So, as the world becomes increasingly more and more interconnected, teacher educators need to equip their students with eLearning and eWorking technologies. Doing so is fully consistent with Vygotsky's Constructivism, Bruner's 5Es, de Bono's 6 Thinking Hats, Gardner's 9 MIs and Bloom's 6 Differential Cognitive Levels. Therefore, it is my view, that embedding digital pedagogy in pre-service higher education, not only helps us to better prepare teachers for the digital generation, but also meets the expectations of giants in the field.

As Jukes, McCain and Crockett (2010) point out, our students are digitally expectant whereas their teachers are not. For this reason, the mostly digital immigrant teachers need to up-skill and embrace digital technologies or they won't be able to guide their students in new knowledge creation. Our pre-service teachers, parents and the schools that will employ them, expect that we shall equip our pre-service teachers with the skills that will enable them to be effective teachers and productive contributors to the information-based, knowledge-driven, digital economy.

Old habits don't change easily and so we tend to do things the same way we have done them in the past. As McCain (2007) noted, whereas "it takes great strength to hold on to something, … it takes the greatest strength to let go of something you have done the same way for a long time" (p.7). Therefore, we as higher education providers need to make a great effort to change the way we have taught so that we apply the TPACK model in our teacher preparation programmes. When our graduating teachers replicate our model in their own practice, they will be able to narrow the gulf that exists between how teachers think and how their students think. Without striking a confluence between these two ways of thinking about learning, teaching and assessment, our graduating teachers will not be able to meet students' learning needs on the students' terms. The lack of such a confluence will have deleterious consequences on teaching, learning and assessment.

Whether our pre-service teachers are training to be teachers of English, other languages, mathematics, science, visual arts, creative arts or social science subjects, they need to be made fully aware that the children whom they will be teaching these subjects will not appreciate being taught the way the teachers were taught fifteen or so years ago when they were in primary school. For these children, the old traditional way of teaching will not excite their intellectual faculties. If anything, it will make them bored and disinterested in what the teachers will be trying to teach. To prevent such boredom and lack of interest among our graduates' students, we should train our pre-service teachers to consider themselves architects who listen to what their customers want and design and offer it at a price their customers can afford.

Since the digital children love working with digital tools, it will make our graduating teachers' job a lot easier if they adopt instructional strategies that utilize the children's existing and preferred skills than trying to hang on to the old, traditional approaches to teaching. Therefore, we should encourage our pre-service teachers, to utilize digital tools for construction of academic knowledge - TPACK. This way, our pre-service teachers will enable their students to learn in their own ways rather than simply asking them to replicate how the teachers learnt when they went to primary school some twenty or so years ago. Failure to do this will perpetuate the mismatch between digital savvy students of the 21st century and teachers stuck in the orthodoxy, traditional pedagogy of the last century

As said earlier, there is no denying that the children that our pre-service teachers will teach on graduation will be digital natives while our graduating teachers will speak digital language with an accent. (All immigrants do). The finding that today's students of almost any age, are far ahead of their teachers in computer literacy and that children as young as eight to ten years old were already social networking using technologies such as Club Penguin and Webkinz (Richardson, 2010, p. 7) sends us a clear message as higher education teacher educators, that we must improve the digital fluency of our pre-service teachers. Failure to do so will fail our teaching graduates and propagate the mismatch between digital native children and digital immigrant teachers. To ensure that this mismatch does not happen, and that we prepare teachers well skilled for the 21st century classroom, we need not only to introduce our pre-service teachers to the latest technologies in learning teaching strategies (TPK) and content (TCK)

but to rethink our teacher preparation methods and strategies (PCK) so that our pre-service teachers graduate as effective problem solvers in the digital classroom.

As shown with the GDC-PLN experience discussed in this paper, giving students the opportunity to learn using social media technologies enabled my students to connect with others in ways that had not been possible when they were learning using the old, Moodle Learning Management System. The challenge to encourage our pre-service teachers to embrace digital learning along the TPACK model is significant for us because we are more indigenous natives in the digital landscape than they are. We are first and they are second generation. However, we must lead and teach by example. By this I mean that we as pre-service educators, need to allow the new technologies to transform our pedagogical practices. For this to happen, we need to be brave and embed TPACK in our planning, teaching, assessment and the curriculum of our pre-service teachers. Just as we need to prevent the mismatch between our teacher graduates and their digital students, we ought to align our teacher-preparation strategies to the learning inclinations of our students who have seen more technology in their few years of living than we have in our longer life spans. This means that it is imperative for us as teacher educators to shed the old, traditional ways of teacher preparation and embrace technology driven strategies in teaching pedagogy and content knowledge (TPACK). Both our pre-service teachers and their students will benefit most, if we actively, and prudently, seek to maximise the use of technology.

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