Research Article

Design-based approach to technology innovation: Teacher educators' experiences with tablets as instructional tools in South Africa

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ARTICLE INFO	ABSTRACT
	The role of higher education in improving educational practices and access through research in technology innovations across the wider spectrum of schooling has especially increased in the information driven 21st century lifestyle. Pre-service teacher training plays a significant role in this transformation. For South Africa, research in technology integration has not provided requisite skills for teacher educators to bring about this envisaged transformation. The purpose of this study is to investigate the affordance of the design-based research (DBR) when combined with community of practice (CoP) framework in mitigating context-based technology integration related challenges and professional development in teacher education through the social learning theory. The qualitative paper explores the experiences teacher educators had of using tablets in a DBR as technology integration tools for contextual pedagogical practices. Teacher educators (n = 10), in one university in South Africa were given tablets to use over a year before they responded to semi-structured interviews about their experiences and were also observed as they engaged in both the CoP and in classroom practice. After a thematic analysis, the main results were that the CoP provided space for teacher educators to improve their confidence and technology integration skills. The combination of DBR and the CoP was found to be complementary in bridging the gap between theory and practice for teacher educators. The CoP provided the much needed safe space for professional growth and confidence building for teacher educators. However, learning engagements were limited by inadequacy of ICT tools for the students. In light of this, the implication of the study is that professional development plans for teacher educators in technology integration skills must be context based and subject specific through DBR programs for practical results and sustainability. **Keywords:** community of practice, design-based research, pedagogical practices, modelling, professional development, tablet

INTRODUCTION

The world has seen a tremendous shift from traditional models towards integration of information and communication technologies (ICT) in education. This use for education is increasingly becoming the norm across the globe, especially after COVID-19 (Pedagoo, 2020; Rangel-Pérez et al., 2021; Velchik, 2020). A corresponding response from scholars in the form of massive researches in both the types of ICT tools and their benefits for the classroom are at stakeholders' disposal for all levels of education (Kim et al., 2019; Ndume et al., 2021; Omoso & Odindo, 2020; Rossouw & Goldman, 2023; Winstead, 2022). Higher education is seen as the logical place for such innovations as they prepare pre-service teachers who will eventually effect these changes across educational levels when they join the world of work. While these innovations with ICT

are taking place in the generality of world classrooms, research from sub-Saharan Africa is reporting otherwise (Barasa, 2021; Dlamini, 2022; Ngao et al., 2022; Tiba & Condy, 2021). South Africa has not been spared this lag in its teacher training programs despite evidence of upgraded ICT infrastructures within its higher education institutes. Related studies from the country report on how universities are partially transformed, and that much needed to be done to improve ICT uptake to ensure production of relevant graduates from departments of education (Alenezi, 2023; Jakoet-Salie & Ramalobe, 2023; Kanyane, 2023; Mhlanga et al., 2022).

It is important to note that, if there should be a transformation in the provision of relevant 21st century education for citizens of any country, teacher educators become the epi-center of such innovations (Parker, 2011; Pedagoo, 2020); they train and model best practices for pre-service teachers who effect desired changes as envisaged by stakeholders. Thus, the greatest challenge for South Africa is the lack of digital integration skills among teacher educators in higher education institutions (Masenya, 2021; Nazir, 2023; Yende, 2021). On the other hand, scholars are consistently calling for improved ICT integration skills among teachers to alleviate the dearth of relevant curriculum implementation that is 21st century compliant for the country's citizens (Dlamini, 2022; Graham et al., 2020; Mueller & woods, 2012; West & Malatji, 2021). However, there is still limited knowledge on how this professional development in ICT integration for teacher educators can be achieved for South Africa and with what devices or tools that can be used to kick start the process.

According to Winstead (2022), devices such as tablets and iPads are fast replacing desktop computers and laptops for classroom use because of their portability and distinct intuitive touch screen features as well as their close resemblance to the smart phone which most educators are already exposed to. Tablets are regarded by educators in the developed world as tools with potential to enrich the pedagogical quality of learners' classroom activities with high engagement through one-to-one technology integration (Graham et al., 2020; Kim et al., 2019). Thus the reason for adopting the tablet for this study, the purpose was to nudge teacher educators into focused, deliberate attempts at integrating this ICT tool into their pedagogical practice. What support then should be provided to these teacher educators to ensure that the ICT tools and infrastructures provided are put to intended use? This has resulted in the search for research methodologies that provide practical solutions to technology integration challenges dodging universities especially in developing countries like South Africa. This study aims at contributing to such knowledge. We argue that the conceptual framework of community of practice (CoP) and social learning theory (SLT) when applied to design-based research (DBR) provide applicable and sustainable mitigations to technology integration challenges currently faced by the generality of higher education institutes in sub-Saharan Africa as they provide hands-on collaborative research for practice.

REVIEW OF RELATED LITERATURE

Global North universities and colleges are ranked among those leading in the field of information technology in education. United States universities and colleges belong to this group (Bowman et al. 2024). Classrooms in these universities are rarely without ICTs and are dictating what is found in the professional field of education and closing gaps of digital disparities in their societies. DBR has played a critical role in these achievements in that region (Amiel & Reeves, 2008; Ford et al., 2017; Kim et al., 2015). DBR differs from traditional methodologies in that it is premised on collaborative approaches which engage practitioners and researchers in designing, analyzing and evaluating educational interventions to solve real world context based educational challenges (Anderson & Shattuck, 2012). According to Davis (2003), success in ICT in schools began with pre-service teacher education as good practice, with ICT use as a response to their societal needs and government funding such programs as Preparing Tomorrow's teachers to Use Technology.

For Canada, the last decade has seen a rise in digital demand and use in education in the country (Bates et al., 2017; Johnson, 2019). The common trend in higher education for the country is online and blended learning (Donovan et al., 2018; Veletsianos et al., 2021), with few cases of teaching and learning without ICTs. There is a clear and decided route that Canada has been well established regarding technology in higher education, whether online or blended, with classrooms on campuses and distance education scattered across the globe (Veletsianos et al., 2021). DBR provided greater opportunity for new innovations and a focus on quality standards as technology expands and emerges. This situation in higher education ignited a
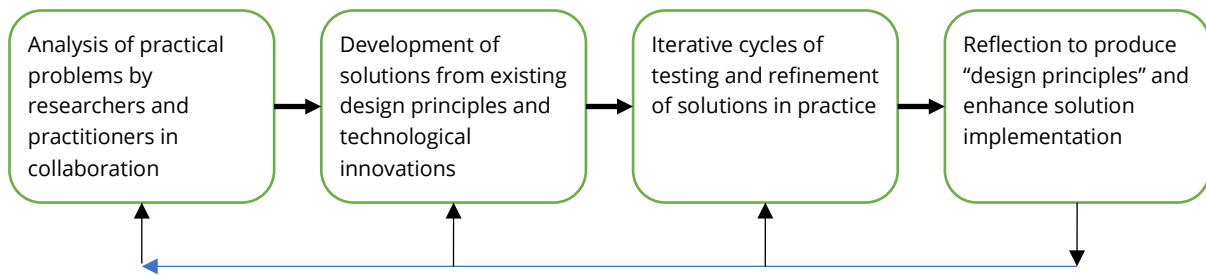
Figure 1. Design based research phases (Amiel & Reeves, 2008)

corresponding exponential growth of technology use in primary and secondary schools, where high percentages of integration is reported through allowing students to bring their own devices for classroom use to complement school ICT tools (Kapoor, 2019).

In Spain, Rangel-Pérez et al. (2021) asserted that educators have embraced massive adoption of ICT as a way of guaranteeing quality teaching and learning. Quality for universities is measured by the type of graduate the system produces, among other factors, and that the product must be able to function qualitatively in the global village, which has become completely digital. DBR was credited for the general increase in ICT use by university educators, which has improved efficacy and bridged previous varieties of gaps in technology use (Antón-Sancho, 2023).

The origins of the DBR can be traced back to 1990 with Allan Collins and Annie Brown (Armstrong et al., 2020). Their argument was that educational research was detached from actual classroom practice and not context based bringing out questionable results which accounted for insignificant change in the system. Ford et al. (2017) argued that, if educational research was intended for practitioners, it should cease to be abstract but must inform existing designs and practices in pragmatic ways. Such methodologies must support sustainability in the use of the findings that work contextually rather than adopting generalized research results that have to undergo adaptations before they can be replicated, especially so in culturally divergent settings.

DBR is a methodology of carrying out research where researchers are actively involved in the process of the study by collaborating with participants in alleviating real challenges in given settings as innovation (Anderson & Shattuck, 2012; Parker, 2011). According to Reeves (2016), for educational settings, the methodology has four phases; problem analysis from a realistic classroom; designing and developing innovations according to the given participants' situation; evaluating the innovation designed in an authentic classroom and reflections on the process and the principles learnt. This becomes the first cycle of the process and the results of the reflections inform the second cycle. When teacher educators, who are practitioners get involved hands-on in research meant to evolve worthwhile strategies to improve their pedagogical practice, they also develop as research scholars in their areas of specialization (Armstrong et al., 2020; Easterday et al., 2014; Hamed et al., 2019; Harrington et al., 2009). **Figure 1** shows DBR phases (Amiel & Reeves, 2008).

Centering DBR in the context in which intervention is required at the same time making the process, subject area specific for teacher educators, is as critical as the methodological rigor needed to get satisfactory results for the whole research process (Fishman et al., 2013; Ford et al., 2017; Reimann, 2016). In DBR, theory and practice are married, with the teacher educator at the center of the research, working towards achieving an educational practice backed by theory to give meaning to their overall pedagogical actions (Amiel & Reeves, 2008). Thus, a methodological process in DBR can be qualitative, quantitative or mixed methods because the aim is to develop, test and refine innovation generating principles to address connections or non-thereof between the teaching, learning, tools and context variables (Anderson & Shattuck, 2012; Hamed et al., 2019; Karsten & van Zyl, 2022). The researchers, teacher educators and administrators collaborate to bring about a context based solution which is evaluated as to whether it bridges the initial gap that gave rise to the research in the first place (Amiel & Reeves, 2008).

It is not always the case that DBR is to be employed to make interventions in educational challenges. According to Ford et al. (2017), there are points to ponder before embarking on this journey because of primarily the costs that are generally associated with the research process.

According to Kelly (2013), DBR is applicable when content knowledge to be learnt is new or poor, when there is poor teacher efficacy or when policy factors are not favorable to the innovation to be implemented. The South African context meets all these criteria (Barasa, 2021; Dlamini, 2022; Ngao et al., 2022; Tiba & Condy, 2021) making it a rich ground for DBR as a way to mitigate technology integration dearth for teacher educators.

The fundamental point to note before starting on a DBR is the knowledge that it is inherently labor and time intensive, therefore demands a careful selection of the research team which is at the same time relevant to the intervention (Karsten & van Zyl, 2022). The research methodology is a series of cycles of designing, implementing and refining (Amiel & Reeves, 2008; Ford et al., 2017; Kim et al., 2015), where the results of the first cycle feeds back to the itinerate process of knowledge development, which in educational spaces may span over a number of semesters or a number of years (Armstrong et al., 2020; Kelly, 2013; Plomp, 2013) during which unforeseen events may overtake the process in the form of resources, collaborative partners or funding, which are all key to the success of innovation generation (Kim et al., 2015; Plomp, 2013). The idea is that we finally end with, a sustainable intervention developed over a number of iterations.

Combining DBR and CoP in a single search for sustainable and pragmatic intervention for ICT integration has been shown to increase rigor in the process of studying possibilities for the classrooms (MacDonald, 2008). Here researchers are to take note of the labor and time intensive element in DBR before carefully adding a CoP to guarantee success in the procedure. Plomp (2013) concluded that DBR improves practice by testing theory in the classroom and works well when practitioners, researchers and students collaborate closely in an interactive way. This proves the importance of putting together the DBR with a CoP for trustworthiness and high validity in results. Making researchers, teacher educators, pre-service teachers and administrators to be connected and related for the mutual goal of improved ICT integration with pedagogy. The process thus impact professional learning and development and creates space for policy formation (Cook-Sather et al., 2014). This collaborative approach to professional growth enhances commitment and help these stakeholders to continuously improve in their practice.

A CoP is a collection of people who share the same interest towards achieving the same goal and has three crucial characteristics, the domain, the community and the practice (Wenger-Trayner & Wenger-Trayner, 2015). The domain entails identity of members as defined by their shared interest and shared competences, the community exists as a space for members of the CoP to have joint activities and discussions where information is shared and assistance rendered to members in relation to common practices and interests (Brown, n.d.) and the practice, means members of a CoP are practitioners (lecturers in this study), sharing a range of resources such as tools, stories, experiences, methodologies and expertise (MacDonald, 2008).

While there has been concerted calls from scholars for transformation in teacher education in higher education in South Africa, there are limited studies focused on hands on teacher educators' professional development for transformative technology integrated education in pre-service teacher training. Our study is unique in the sense that it explored how teacher educators' experiences in using tablets as pedagogical tools through DBR in a combined CoP and SLT frameworks contributed to their professional development and we went on to identify specific aspects of the design process that influenced them to effectively integrate innovative technologies in their pedagogical practice. This paper is cycle one of the DBR, with all the four stages, identifying the challenges and developing innovation to mitigate them. It ends with a proposition for cycle two based on results of the reflections phase.

Research Questions

The following research questions guided this study:

1. What opportunities are created by DBR when combined with CoP in mitigating context based technology integration challenges for teacher educators?

2. What specific aspects of DBR when combined with CoP provide professional development for teacher educators?

METHODOLOGY

Research Design

The study used a qualitative method approach. It is informed by phenomenology as its aims are those of improving educational practice from personal perceptions and experiences through design based approaches (Gill, 2020; Pool & Laubscher, 2016). Phenomenology in qualitative research seeks to provide an explanation with detailed descriptions on the nature of things through an in-depth understanding of how participants experience them (Onwuegbuzie & Leech, 2007), making it suitable for this study in its aim of explaining the DBR phenomena in mitigating contextual technological issues in teacher training (Gill, 2020). The study used DBR buttressed by a CoP to contextually mitigate the challenges of insufficient technology integration by teacher educators as a case study in one university in South Africa. DBR combined with CoP were considered the most appropriate as they provided space for the development of sustainable interventions for real world technology challenges in teacher education for the South African context (MacDonald, 2008).

The current study followed the four phases of a DBR in one cycle. The first phase began by purposively selecting teacher educators and carrying out a collaborative discussion and analysis of the technological challenges faced by these teacher educators in their attempts to model and develop ICT integration skills with pre-service teachers (Armstrong et al., 2020). The tablet came out as the tool of choice which participants envisaged to use in the study. Each participant was thus, given a tablet as an intervention tool for familiarization and practice how they can integrate it in their teaching and learning in preparation for the second phase which was to come after a full year.

In the second phase (a year later), participants came together in a CoP to share and discuss their experiences. Each participant was observed as they presented and demonstrated how they used a mobile learning application of choice to teach a concept to using the tablets, for example, using Kahoot online games for assessments. It was done in such way that the rest of the group assumed the role of students while one at a time would play the lecturer's role and present their online teaching application, educational game or program. They then had discussions and clarifications on the modalities of creating and using the application and had a chance to learn from each other how to enhance or adapt the use of new tools learnt for their own areas of specialization.

Phase three involved iterative cycles of testing and refinement of the tools over time and the CoP was extensively used to provide the needed space to carry out these activities as learning spaces, practicing for efficacy and confidence building prior to using applications with students in actual learning activities (Wenger-Trayner & Wenger-Trayner, 2015). In the fourth phase, the reflection phase, was carried out as collegial discussions within the CoP where participants and researchers reflect on and suggested how to enhance solutions found during the research process and designed principles to adopt for practice involving identifying aspects to be adopted for further improvements (Amiel & Reeves, 2008; Ford et al., 2017; Kim et al., 2015). This study represented the first cycle of the whole, whose focus was professional development of teacher educators in technology integration skills for their pedagogical practices.

Context of the Study

The study was conducted at a university in South Africa. 10 permanent teacher educators at the level of junior lecturers were purposively selected to participate in the research and were provided with tablets in April 2022. They were asked to use the tablets as they wish for a whole year as a teaching tool as this is a mobile closely related to what their students already have, the smartphone. These educators were selected across different subject areas and taught different levels of pre-service teachers; that is Early Childhood Education (grade R to grade 3), Intermediate Phase or middle school level (grade 4 to grade 6), Senior phase (grade 7 to grade 9), and Further Education and Training (grade 10 to grade 12) teacher preparation. After a year of using tablets as instructional tools, the teacher educators were interviewed using semi-structured interviews and observed as they participated in a CoP through collegiality and sharing emerging technology based pedagogical practices. They were also observed as to how they were integrating ICTs in their individual actual teaching and learning processes in their areas of specialization.

Data Collection and Analysis

Semi-structured interview protocols and observations were used to collect data. The semi-structured interviews were done one-on-one with all the 10 participants in July 2023, slightly more than a year after receiving the tablets in April 2022. These were face-to-face and were recorded for accuracy of reporting, transcribed and saved in cloud ready for analysis (Hassan, 2023). The same participants were also observed as they participated in a series of CoP activities where they shared their experiences with the tablet not only as they improved their professionalism but also how this newly acquired practice was impacting their students. It was also a space to learn to adopt and adapt best practices from colleagues (Hamed et al., 2019). Further observations were done on the same participants as they integrated technology with their students in teaching and learning activities in real classroom learning environments. All collected data was qualitative.

For data analysis, we employed a rigorous protocol of coding, inductive analysis, triangulation, external audit and member checking to ensure trustworthiness and credibility (Creswell, 2014). This involved all the data from interviews and observations, emphasizing aspects of what teacher educators experienced in using tablets as pedagogical tools contributed to their professional development and what specific aspects of the design process that influenced them to effectively integrate innovative technologies in their pedagogical practice. The following outlines the process of data analysis (Hassan, 2023):

1. **Phase one:** The data analysis process began with transcription of interview data and coding it for thematic relevance. Each individual interview transcription was listened to several times before being filed in its separate folder and stored in the cloud after labelling, they were numbered chronologically, for instance, 1 to 10 for easy management purposes. The whole process of transcription was done by the researchers themselves as it helped to make us understand the data intimately.

2. **Phase two:** This phase involved analysis of data from observations of both the CoP activities and the classroom teaching and learning by the teacher educators. Our focus was taking note of what the educators did with the tablets both in the CoP and in the classroom (Creswell, 2014). This was triangulated with what they said in the face-to-face semi-structured interviews, we made and compared notes and themes were subsequently generated.

3. **Phase three:** We began the process of identifying common recurring themes as they emerged using cross-case analysis (Peel, 2020). The two researchers each generated categories individually and then discussed the wording of the categories before we started ascribing core ideas into their categories. We would go back to them back and forth whenever we needed to check and recheck the data with the observation data in phase two, making sure that all the themes are captured.

Theoretical Framework

The study combined two frameworks, social learning theory (SLT) and CoP, where CoP became the practical aspect of the theories espoused by SLT. SLT is premised on the concept of learning by observation, imitation, and interacting with others in a social context and the most crucial being context and community (Taylor & Hamdy, 2013). The theory was posited by Albert Bandura in 1977 and developed over time (Firmansyah & Saepuloh, 2022). SLT provides the foundation for understanding how individuals learn within a given setting, emphasizing the importance of physical interactions and observations. The theory further demonstrates that environment is critical to the human learning process (Schunka & DiBenedetto, 2023). According to Firmansyah and Saepuloh (2022), SLT enables group engagements to solve problems and to carry out inquiry learning for innovative interventions in any sphere of life.

The CoP provided a framework for understanding collective engagements in learning and knowledge construction. The tablet use among teacher educators, coupled with their participation in a CoP, aligned with the principles of social learning (Rumjaun & Narod, 2020). The CoP became the social environment for teacher educators to collaboratively share their work experiences, learn from colleagues and collectively improve on their profession through practicing technology integration on colleagues. The DBR seamlessly aligned with these frameworks as the process sought to integrate theoretical insights into the design implementation by creating social spaces for the research cycles (Taylor & Hamdy, 2013). SLT emphasizes the importance of observing, imitating, and interacting with others which were key activities for our study. The DBR methodology, actively engaged with both CoP and SLT by iteratively designing and refining the technology

interventions in authentic pedagogical environments through an ongoing feedback loop. DBR allowed researchers not only to investigate interventions on social learning, but also refine and adapt them based on real world outcomes within a safe space created by the CoP. The approach is a dynamic synergy between theory and practice providing space to ground education in the principles of social learning that continually refined through empirical evidence and practical application.

FINDINGS

Findings in this study were able to reveal the experiences teacher educators had when they adopted the tablet as a pedagogical tool and shed light on the specific aspects of the design process that influenced them to effectively integrate innovative technologies in their pedagogical practice. The findings fell into four broad themes; efficacy in technology integration, confidence development in using tablets, perceived impact of modelling tablet use on pre-service teachers and gaps in the integration process.

Efficacy in Technology Integration

When asked how confident they were in integrating ICT tools provided by the university in their pedagogical practices prior to being selected for the tablet project, only three out of the ten participants indicated some degree of confidence. The rest indicated that their integration was limited to PowerPoint presentations, which followed traditional methods of note-writing on a chalkboard and sometimes playing videos selected from YouTube. One participant explained how limited her integration was before she joined the project:

> "I could only use PowerPoint with my laptop and later taught myself how to include pictures on the slides. Of course, I would show some videos sometimes with my pre-service teachers, to show maybe water sources and uses. That's all I knew to integrate" (Participant 4).

Participant 5 added voice to Participant 4's comment by saying that,

> "with training in Blackboard use, I also felt more confident using PowerPoint only with my pre-service teachers for lectures and nothing more, to me that served my purpose of giving them the concepts."

Participant 1 indicated that even before she joined the project, she had her own tablet. However, she was not aware that other than for social media and watching some movies, she could also use it for teaching and learning:

> "Yes, I have used my own tablet before. I could have apps like WhatsApp, sometimes to form groups with my students. I didn't really use the tablet as a tool for teaching and learning itself until I joined the project. Sometimes when you have something, you are not really informed [on] how you can use it for your teaching and learning. My students passed and that was it."

For participant 2, even with early exposure to technology, still lacked the skills for pedagogical use.

> "With me, I was fortunate that when I started my career as a teacher … my school had some ICT tools, though I did not deepen my knowledge of the tools because I never gave them much thought as that important. So, the experience helped me here, though in a limited way, for I used only videos to show the practical side of whatever I would be teaching if it is available on YouTube, but not on a tablet but using the laptop."

Another participant (Participant 5) explained that they lacked the confidence to venture into different apps because they believed that their students were more skilled with technology than they were. Queried why they could not practice before going to class, she stated that she never did and just integrated PowerPoint presentations in her lectures:

"I knew that there was something better about technology and teaching but the most important work I used my computer for in teaching and learning was using Google for information and making notes for my class. I would make slides and present my lessons that way. Really, I couldn't risk it with my students. My skills on integration are still not what I want even now, but it is better than before."

Confidence Development in Using the Tablet for Teaching and Learning

Participants were asked how being given a tablet for use in their teaching and learning and becoming a member of the CoP had impacted their efficacy in technology use. In response, participants explained that they were excited about the project and indicated having greatly benefited from the tool. Here is how Participant 1 responded:

"Once I got the tablet, I played around with it for some time and discovered I could do a lot of things on it. I then went on to use it to teach designing of digital stories. With the tablet, all the tools or the apps that I need, they are all in there. I can have sound music in the tablet, I can have pictures, videos, which are all that I need … for digital stories … it's an all-in-one tool. Now, I am confident on this one and I got to practice on colleagues in the CoP… I encourage my students to go search different apps to create stories with."

Participant 4 echoed Participant 1's sentiments by explaining how being part of the tablet project has actually developed both him and his PST students:

"I had never used or thought a tablet can be used for teaching and learning and since I joined the project, it helps me to download apps that was not possible with university laptops in the computer lab, apps such as PhET simulations for experiments … Kahoot! Games for quizzes. Having the tablet has opened a whole field of practicing and integrating new applications and engaging with my students on their phones."

When asked if his students had tablets too, he further explained that they used their smartphones:

"In my case, most of them have phones and the engagement is just maximum."

Participant 3 reiterated that the CoP had benefited him tremendously:

"The biggest benefit is the experience of the colleagues … I was fascinated by the projects the colleagues were doing and I learnt quite a lot; you are able to ask for help and also share your best practices in the CoP."

Participant 9 shared his experience as enriching as he learnt from the CoP activities integration skills and applications and adapting them for his subject area;

"You know, the fact that you can learn from and with colleagues and go on to practice on them before you use the skill with your students is a great way of developing. It's a safe space to learn and you don't feel judged or pressured, you can lean and after the engagement you can go further and say, 'Hey, so and so, I saw you presenting on this tool. Can you train me and I am taught how to do it?' "

Perceived Impact of Modelling Tablet Use on Pre-Service Teachers

Participants were asked what their views were on the impact that their increased use of technology was having on their PSTs. Participant 8 was quite excited about the performance and engagement of the PSTs in his lessons:

"I never thought this would change how I do things in my class because we were just using a PC and sometimes you would think your students don't like to learn, but I have since realized that it's because we are not aligned … since we have integrated ICT now, we connect, because I use what

they have in their hands most of the time, their smartphones, with my tablet. My confidence with ICT has increased and their engagement in class is growing. I was grading their work right now and I have only two below 60% – it's great! They are discovering that their phones can be used as ICT gadgets for teaching and learning, besides social media."

Participant 10 indicated that even though he had never used the tablet before but was used to using PowerPoint mix and thought there was no better way of integration, he discovered that his presentations were much better after having gained knowledge from the CoP compared to before:

"In the past with my English lessons, one would just discuss those pertinent aspects on storytelling and hope they make sense and students passed, but we do this with an understanding that there is a problem down there (in schools) and that our pre-service teachers should go there and do things differently … With this project, I have gained confidence enough to venture into allowing my students to use their own applications as well, it's about how they can use technology to enhance certain literacy skills, like reading; they are submitting assignments on what apps they can use."

Participant 1 was very positive about the impact that her modelling of ICT integration with the tablet was having on her students. She was actually excited about the progress that she and her PSTs were having in the integration process:

"This semester we were focusing on teaching literature in the Foundation Phase, and I was able to task my students to create stories as part of their apparatus for teaching, it's exciting really for both me and them. I have gained confidence to venture into these integration areas and am happy about my progress … there is a competition in the multilingual unit where they are looking for seSotho stories to use in schools in South Africa and I am going to enter my students' work and see if they can be published for use in the wider schools."

Gaps in the Integration Process with Pre-Service Teachers

All participants agreed that they had greater success with integration with the tablet with smaller classes than with bigger ones. This is because in smaller groups, very few PSTs lacked smartphones to engage in the lessons, with the number being bigger with big groups, which impacted negatively on the need for hands-on training in integration for the PSTs. This is what Participant 7 said:

"I also think the students as well should have tablets so we can develop at the same pace, because it does not matter how equipped I am with the skills and the resources; if they don't have the tools, it still falls short of giving them the skills … instead of going to the computer lab afterwards to practice on their own, you know, other things we really need to do practically in class … I end up grouping them so they share gadgets, but are they all participating hands-on, or they are just sitting back? They need to each handle the gadgets and practice and produce work."

Participant 4 also echoed the same sentiments when he said:

"There is maximized engagement in my classes, but we need tablets in the lecture halls for hands-on practice during lectures."

On being queried as to how that can be achieved considering issues of safety, he explained thus:

"Tablets can be fixed on tables in selected lecture halls as they do with computers in labs. Our students can get to use them and when they graduate and find schools with these tools they can confidently use them or be the change schools out there are looking for."

Another challenge cited by six of the ten participants was the need for training for the educators. Participants indicated that as technology was emerging daily, the university must have a program for continuous training of lecturers in integration. In this regard, Participant 6 said:

> "I am young, and my supervisors may assume that therefore I am able to integrate ICT in my lectures; yet I was not, I only used PowerPoint, until I was picked for this study. I am able to use my phone and several applications for myself but technology literacy did not give me the skills when it came to integrate for teaching and learning. We need training a lot, a lot, a lot on using ICT. There is a lot of gap there that I think we need to attend to."

Participant 9 reiterated this need for training of teacher educators by bringing in the aspect fear of ridicule and inadequacy

> "I am fortunate to participate in this project, colleagues out there are doing what I used to do, pretending they are fine but knowing we need to integrate these technologies but could only use basic things like videos and PowerPoint, that's it, no more. There really must be hands-on training activities that are subject area specific so that one goes from there and do it in the classroom like we are doing with the CoP."

Another participant lamented the limits imposed by the free online applications and suggested that the university may subscribe for some of those as they do with libraries and other academic sites.

> "I think the university can buy rights or subscribe and pay for the applications to develop us and allow for integration at the same time model for our pre-service teachers to use in their micro teaching as they present to shape their efficacy and confidence with content as well, not only with ICT before they join the world of work."

DISCUSSION

The integration of emerging technologies for pedagogy though DBR has proved profitable for development in education for many countries in the developed world with countries like the United States, Canada and the United Kingdom leading in this innovation (Amiel & Reeves, 2008; Anderson & Shattuck, 2012; Ford et al., 2017; Hamed et al., 2019; Kim et al., 2015; Reeves et al., 2023). While much of these studies in the developed world are improving technology integration issues in education, surprisingly, for Southern Africa, there are more studies on the narrative of the deficiency in technology in pedagogical practices with limited attention on how this can be mitigated contextually for greater success (Dzinoreva & Mavhunga, 2022; Ndebele & Mbodila, 2022; Ndume et al., 2021; Omoso & Odindo, 2020). This is so much true of South Africa (Lubinga et al., 2023; Lusigi, 2019; Ndebele & Mbodila, 2022; Rossouw & Goldman, 2023).

DBR and Efficacy in Integration

The research site had its digitalization and implementation plan, stating the envisaged goal of providing technologies that empower and enable employees to build new competences and models. However, educators lacked the confidence to venture into different avenues with technology because they believed that their students were more skilled with technology than they were.

These experiences from participants reveal the inadequacy of the traditional predictive research in ICTs in education in that they do not inform actual use in the classroom. There is little systematic advice to educators on how to apply and use technology in their practice which DBR provides as it is a hands-on process that takes the practitioner through an experiential journey culminating in innovation and professional development (Amiel & Reeves, 2008).

It is important to note that while the generality of teacher educators in South Africa still lack efficacy in integrating technology in their practice (Armstrong et al., 2020), it remains a need for all 21st century teacher educators and the way to help them develop efficacy in this regard is professional development through training and extended exposure to the technological tools they must use (Amiel & Reeves, 2008; Bowman et al., 2024). By addressing the challenges through collaborative research processes such as DBR and CoP which foster support and safe spaces to learn, educators are developed professionally and tend to display an increase in skills and abilities in the use of technology related to teaching and learning in their classroom environments (Kim et al., 2017; Liu et al., 2015).

Framed by both SLT and CoP, the present study explored teacher educators' experiences with using the tablet as an integration tool in the process of professional development especially as a way of equipping them with requisite skills in technology integration in each educator's area of specialization. The participants had somehow lacked the skills to venture and explore technological integrated pedagogical practice in their areas of specialization. This lack of knowledge and skill had resulted in low confidence and a monotonous dependence on PowerPoint presentations and YouTube videos (Padayachee, 2017). According to UNESCO (2023), it is only when teachers are digitally literate on how they can integrate ICT into teaching and learning that students can be impacted positively. In this study, CoP combined with DBR was clearly observed as providing space for making the participants literate in ICT-integration skills for their areas of specialization. The CoP created a safe space for development where educators expressed how their anxiety and deficiencies were alleviated (Zhao et al., 2021).

Confidence Development through DBR

DBR is seen closing the gap created by traditional research methods that tended to explore the sufficiency of educational technologies without affordance of contextual requisite skills for teacher educators by providing space to discover what works and why it works within particular contexts with particular educators and their unique students. The CoP proved to be a safe space to learn through both trial and error and collegial interactions in purposively created professional settings that are situation sensitive (Dede, 2005). This implied a need for spaces for continuous professional development for educators to enhance profitable emergence of technology use in education.

Findings of this study align with previous studies (Bennan, 2013; Hamed, 2019; Reeves et al., 2023) that have highlighted the importance of DBR in mitigating educational challenges through contextualized in-situ strategies that provide hands-on experiences for sustainability and skills building (Amiel & Reeves, 2008; Armstrong et al., 2020; Hamed et al., 2019; Harrington et al., 2009; Plomp, 2013). The current study not only confirms this evidence but also presents additional evidence highlighting the augmented potential of combining CoP with DBR in processes of professional development in effective integration of emerging technologies in educational environments where traditional pedagogical models are still practiced.

Integration Modelling with Pre-Service Teachers

Besides evidence of improved confidence in integrating a variety of technological applications in actual pedagogical practice by teacher educators, there is also evidence of the interaction of some of the most important aspects in technology adoption for education namely, technology intervention, role of the university and purpose and meaning of research (Armiel & Reeves, 2008; Zhao et al., 2021). DBR and CoP have provided a systematic and collaborative space where research is making a difference directly as part of innovation in the process of actual teaching and learning. The classroom became the place where measurable modelling results can be observed, projecting pre-service teachers' preparedness for the world of work.

Each participant was observed as they presented and demonstrated how they used their online application of choice to teach a concept. It was done in such way that the rest of the group assumed the roles of students while one at a time teacher educators would play the lecturer's role and actually teach their subject area to colleagues as role-play. They then had discussions and clarifications on the modalities of creating and using the application, modalities for adaptation for other subject areas and experiences of how it worked for the presenter's class (Brown, n.d.). Each of the 10 managed to present and demonstrate an application on the tablet. Although there were challenging moments at the very beginning of this collaborative research, based on poor efficacy and fear of ridicule, participants gained confidence through their practical experiences within the safe space provided by the CoP.

The tablet provided opportunity to help students to develop integration skills through using the readily available smart phones (Barnwell, 2016). Teacher educators were able to perceive gaps in technology integration within their institute which included the need to embrace emerging technologies such as educational games and other applications that the institution could subscribe for improved pedagogical practices. DBR, CoP and SLT created an environment where contextual technology challenges were identified and mitigated, turning theory into practice for sustainable educational designed interventions (Amiel & Reeves, 2008). In this paper, learning was improved by personalizing the pedagogical process for both

educators and their students in this way problem areas were identified and addressed immediately throughout the collaborative research process (Ford et al., 2017).

DBR and Revelation of Gaps in the Integration Process

Use of tablets were perceived to be more effective with smaller classes as most students could be engaged on their own smart phones and sharing was more applicable than with too large classes. Teacher educators' experiences in this research revealed three gaps, the need for tablets for students, the need for a systematic and consistent training for teacher educators and the need for universities to add educational online applications to their library subscriptions. These gaps are entirely context based, revealed by DBR and the safe space created by the collegial grouping of the CoP. According to Zhao et al. (2021), higher education can only equip pre-service teachers with relevant skills and knowledge appropriate for the present knowledge-based society through deliberate training for teacher educators to move them from traditional pedagogical models to technology driven innovative models which DBR provides.

Through cross-case analysis, our study revealed that participants were aware they needed to integrate technology but were lost as to how they could fulfill this demand before they were made part of the project hence the heavy reliance on videos and PowerPoint presentations. By the time the first cycle of the DBR was completed, all the participants exhibited comfortability and some efficacy with technology integration in a practical and hands-on approach (Armstrong et al., 2020). With this new consciousness and confidence in their integration skills, their perspectives on the necessity to embrace and adopt the emerging technology tools for education would not have shifted without the DBR and CoP experience.

CONCLUSION

Evidence from this study indicates that collaborative research methodologies that offer hands-on experiences like the DBR combined with a CoP framework, have palpable impact on professional development especially for new innovations that are linked to digital technologies where most teachers in the sub-Saharan region have limited efficacy. The purpose of this study was to highlight the importance of DBR within a CoP framework in mitigating context-based technology integrating challenges faced by teacher educators in higher education in South Africa. We argue that the conceptual framework of the CoP and SLT when applied to DBR provide applicable and sustainable mitigations to technology integration challenges currently faced by the generality of higher education institutes in sub-Saharan Africa.

The study with DBR improves professional development by equipping educators with know-why (theory) and know-how (practice) knowledge and skills in educational innovations. In this investigation, the teacher preparation process was also improved through participating teacher educators' modelling of teaching and learning with ICT in particular subject areas for their students. This helped transform practice from within and at the same time inspired hope for transformation in the wider environment through pre-service teachers when they enter the world of work. It is therefore important to solve issues in education contextually and at grassroots levels for sustainability.

The Future Direction of This Research

This study was a first cycle of the DBR. Further investigation will be carried out as DBR is an iterative approach that involves several cycles of design and in-situ testing of this same design to deeply explore the development of theory and produce innovation that scales the needs for integration in this same case study area of the current study. Iterative cycles will be done to refine solutions found in this first cycle and widening the research net within teacher education through mixed methodologies for informed policy formulations.

Limitations of the Study

In this study, purposive sampling method was used to select both the study site and participants (Creswell, 2017). It was limited to one study location and findings in this specific site may not be generalizable to other settings. The small sample of 10 lecturers in teacher education provided valuable in-depth data. However, the research focused only on junior lecturers and did not address senior lecturers or multiple case studies which future studies should focus on. Despite these limitations, the study offers insights on the sufficiency of

collaborative research methodologies in mitigating context based challenges in technology integration for pre-service teacher training in higher education.

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