An Investigation of a Technological integration framework to best align with the Technical Vocational Education Training Sector (TVET)

BY

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DECLARATION OF OWN WORK

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ABSTRACT

In recent years, technical and vocational education and training (TVET) has become accessible to students who are eager to develop their skills, knowledge and attitudes that are needed in the labour market. The sector faces various challenges such as lack of resources, lack of adequately training staff, low-income levels within communities which can impact learner absenteeism rate etc.

Over and above the mentioned challenges is the lack of appropriate teaching method(s) which can best align with the 21st century skills and competencies. Even more importantly now during and post COVID19, the need to identify appropriate method of teaching has become critical.

To address this, the aim of the study is to investigate and identify an appropriate technology integration framework within TVET sector. In this study, Qualitative approach using Action research paradigm was used to investigate a contemporary phenomenon of technology integration by TVET college lecturers. A Purposive or judgmental sampling was used to select the participants that were interviewed through a focus group discussion. A Technological Pedagogical Content Knowledge (TPACK) approach was adopted as a framework of technology integration within TVET sector.

Findings of the study show that educators believe that an appropriate technology integration framework (TPACK), improves teaching method and it is student centred. Analyzed data from participants' responses show that, out of a total of 74 sub-themes that emerged from this study, 'improved teaching and learning' theme had 30 sub-themes, which represents a 40% contribution and a student-centred learning had 28 sub-themes which contributed a 38%.

A TPACK technology integration framework leads to development of ICT skills amongst learners and educators, which can lead to employment of TVET college graduates and provide a solution on outdated curriculum challenges.

The study recommends a technology teaching expert led development approach within the TVET sector, who will work with a small group of lecturers to assist with the development of Technological Pedagogical Content Knowledge (TPACK).

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LIST OF ACRONYMS

ACOT	: Apple Classroom of Tomorrow
ICT	: Information Communication Technology
NASFAS	: National Student Financial Scheme
OER	: Open Educational Resources
PCK	: Pedagogical Content Knowledge
TCK	: Technological Content Knowledge
TPACK	: Technological Pedagogical Content Knowledge
TPK	: Technological Pedagogical Knowledge
TVET	: Technical Vocational Education and Training
UNESCO	: United Nations Educational, Science and Cultural Organisation

CHAPTER 1

1.1 Introduction and Background

Technical Vocational Training Education plays an important role providing individuals with the skills they require to succeed in the competitive labour market. Young people who did not acquire a Grade 12 are able to get necessary skills for the labour market within TVET colleges. According to UNESCO (2015), the purpose of TVET sector is to find solutions to the unskilled persons to equip them with relevant skills, for entry to the labour market as well as to ensure that learners become life-long learners. The debate of whether TVET colleges provide learners or graduates with required skills is still a debate within the broader society.

Unemployment within South Africa is a problem, especially amongst the youth, the TVET sector has been identified by government to play a key role to reduce unemployment within the youth. This is to be achieved through TVET colleges capabilities to produce students with relevant skills for the labour market. However, as Ngcwangu (2019) finds, qualifications provided by this sector do not always translate to what labour market requires, this therefore puts qualified learners from TVET colleges at high levels of unemployment. One key challenge that impacts on TVET system is that the system fails to provide labour with a TVET college graduate who has required skills (Inyiagu 2014). The need therefore exists to address the route of the problem, which is the unemployable TVET college graduates.

TVET colleges enrolment numbers keep increasing without providing solutions to youth unemployment problem. Enrolment figures in TVET colleges was 688 028 in 2017, which was lower than 2016 by 2.5% (17 369). The South African government aims to improve this enrolment number by 2030 to 1.6 million (Statistics South Africa, 2017). This becomes an additional projected number of a million learner intake in the next 10 years within this sector. Such huge projected targets of learner intake unfortunately do less to improve on high levels of youth unemployment. The report by Trading economics (2021) shows that youth unemployment keeps growing, from 2018 at 53.7% to recently in January 2021 at 63.3%. Youth unemployment in South Africa remains problematic and COVID19 may not be pointed at for this challenge. In fact, in January 2020 youth unemployment was seating at 61.3%, a period just prior to COVID19 impact.

Although not all is lost in this area, considerable improvements are required, at least at curriculum level. The need to ensure that TVET graduates are able to find work and are prepared to participate within the 21st century economy is a reality which can be achieved. Curriculum change is key according to Terblanche (2017), who states that the change in curriculum within the TVET sector is critical, to ensure that students graduating from this sector finds employment. Central to this curriculum change should be advanced teaching methods which will cater for the 21st century requirements.

Teaching method within TVET sector is criticized by the broader public, the view is that educators within this sector lack appropriate teaching qualifications, importantly

they lack advanced skills to teach a learner to be absorbed in the 21st century labour market. To deal with this challenge, the Department of Higher Education and Training has formed a partnership with Germany, this cooperation will see Germany providing necessary support for the development of lecturers within the TVET sector in South Africa (Zinn et al., 2019). The support received on this joint project will not be limited to lecturer development but will include a curriculum design support.

South African education is still at the initial phases of integrating Information Communication Technology, and teachers are embracing some ICT tools, however as literature points out, many institutions of education do not use technology to full capacity for teaching and learning. The study by Tarhini et al. (2016) identified the challenge of not integrating technology within teaching and learning in South African schools that it can be associated with lack of ICT skills amongst educators.

1.2 Problem statement

The lack of an appropriate guideline relating to technology integration within the classroom is a major challenge within TVET Sector, which has an influence on the current low levels of technology integration. Research shows that educators do not necessarily use resources and technology skills even when provided. Educators who were part of the Intel teach for the future project, which had a goal of assisting educators with ICT skills development did not fully utilize technology and its applications for teaching, all support and ICT resources that were made available for educators were not fully utilized (Angeli & Valanides 2008; Wilson-Strydom et al. 2005).

Exposing educators to resources such as ICT resources does not necessarily lead to an improved technology integration within the classroom, when an appropriate technology integration guideline is not in place. Thus there is a need to provide ICT resources for educators for the integration of technology within education cause is important. However, most importantly, there is a need to ensure that there is a guideline and framework of technology integration for a successful technology integration to be achieved when teaching takes place.

1.3 Purpose of Study

The purpose of the study is to investigate and identify an appropriate Technology Integration model/framework. The model will endeavour to assist TVET colleges to adopt the use of technology in the classroom in a systematic way.

1.4 Research Question

What kind of technology integration framework is required within TVET sector?

1.5 Limitation of the study

The study occurred during level 3 and 4 of COVID19, with movement been restricted as per legislation. Data collection was done through remote methods, challenges of

internet connectivity impeded the anticipated smooth running of group interviewees. Chapter 3 deals with this point in some details.

1.6 Significance and importance of study

The TVET sector has to undergo necessary curriculum changes as it seeks to align itself with the 21st century. The reform around method of teaching is critical for this objective to be realized. TVET sector has to embrace advanced methods of teaching to enable the sector to provide skilful and well qualified graduates in the labour market. This study makes a contribution of assisting TVET sector with curriculum reform, specifically with the role of technology or the integration of technology within method of teaching.

1.7 Dissertation Outline

Chapters still to come

Chapter 2 is the review of literature, with the following sub-topics being: Professional technology knowledge, benefits of ICT in education, technology integration models and Technological Pedagogical Content Knowledge (TPACK).

Chapter 3 is the review of Research design and Methodology, research design, methodology approach, sampling, data collection technique, data analysis method, data quality strategies and ethical considerations.

Chapter 4 is a review of Technological Pedagogical Content Knowledge (TPACK), exploration of TPACK through PCK and TPK, technology tools relevant for the TVET sector and participant's exposure to technology integration.

Chapter 5 reviews data presentation and analysis, looking at data presentation; data analysis and findings and summary, conclusion and recommendations.

CHAPTER 2: Literature Review

Overview

This Chapter presents a review of literature around Professional technology knowledge, Technology use challenges, Benefits of ICT in education, Technology integration models and Technological Pedagogical Content Knowledge (TPACK). The review will answer the question 'Why TPACK'?

2.1 Professional Technology Knowledge

The concept of professional technology knowledge is premised on the idea that teachers should embrace technology as a professional tool and use it effectively to enhance their profession. The importance of incorporating technology into the educational system is broadly accepted with the community of scholars (Coggshall et al., 2011). There is a strong voice which advocates for digital learning as a strategy to be embedded within the future of teaching and learning, for education to be relevant in the 21st century. As Mishra et al. (2011) confirms, TVET instructors must acquire multiple massive knowledge across different specializations, engage in "high level of thinking and participate in adaptable and changing learning processes" (Mishra et al., 2011).

Technology knowledge is becoming increasingly significant in the way teaching is viewed, it should be considered alongside teaching profession. To ensure that the benefits of technology are realized by the educational system, technology should be integrated with curriculum and instructional methods.

2.2 Benefits of ICT in education

A technology-aligned curriculum is essential for enhancing learners' technology skills. This enhancement manifests itself in a variety of ways, including offering a competitive advantage in the market (Nokwali et al., 2015). Learning that is supported by technology allows learners to adapt to new learning abilities in a structured and systematic manner. More importantly technology allows learners enter the labour market and compete effectively.

Insufficient ICT resources are a barrier towards technology integration, schools can find strategies to improve on ICT resources availability through improvising. Ng'ambi et al. (2016) found that 98% of learners owned mobile phones. Sanchez-Prieto et al. (2016) found that introduction of mobile learning puts learners on the centre of learning, because mobile learning provides for a more contextual, individualized and situated learning. This means these gadgets can be used to supplement lack of resources experienced in schooling system, especially within TVET sector. The usage of available ICT resources, insufficient as they are, with learner cellphones to supplement can create an important resource collaboration of enhancing technology learning within schools.

The use of technology for learning provides additional benefits such as improved knowledge, this is achieved when learners work together when doing activities online.

The study by Wihlborg et al. (2017) found that there is knowledge improvement when learners collaborate virtually during learning activities. Collaboration through online learning improves learner ability to solve problems (Delialioglu et al., 2007). This means technology provides learners with learning opportunities which were not available before, traditional learning settings allowed for learner collaboration but only during limited times such as in class only. With technology, learners are able to collaborate outside the classroom, in a flexible way at their convenience. Learners with high achievement levels can provide additional support to others thereby assist them to achieve improved learning outcomes.

A student-centred learning approach is an endorsed concept with academia, which enables more benefits for teaching and learning broadly. Virtual learning allows for collaboration amongst learners, allowing educators to take a more facilitation role thereby creating a student-centred learning environment (Hanewicz et al., 2017). Online learning therefore plays a critical role of creating a student-centred environment as learners learn more outside the classroom, using technology tools to improve learning outcomes through collaboration.

2.3 Review of ICT integration models

ICT integration models involves the integration of technology within the institution at various levels of the institution's environment. The approach to integration can be systematic, organizational, or classroom-based. This section will discuss a few well known ICT integration frameworks, their pros and cons with a focus on the level of technology integration in the classroom. They are the *Schoolnet Intel Teach to the Future Programme* in South Africa, *Apple Classrooms of Tommorrow (ACOT*) introduced in the USA and *UNESSCO.* The next section will explore Technological Pedagogical Content Knowledge (TPACK).

The Apple Classroom of Tomorrow (ACOT) project is based on a collaborative effort between public schools and universities. It assures that that participating teachers and learners have access to necessary ICT infrastructure including computers, CD-ROM drives, modems, and internet connection (Dwyer *et al*. n.d). Due to abundant ICT resources, ACOT achieved acceptable levels of interaction of technology amongst learners and teachers. Nevertheless, the programme does not provide enough detail on how technology integration might succeed when institutions have less resources such as in our South African context. ACOT's model is based on availability of ICT resources, demonstrated by ensuring that all participating schools are well resourced with ICT tools and infrastructure. ACOT is therefore unlikely to have a proper fit for this study's goal of technology integration, this research has a focus on schools in this case TVET sector which is at the low end of socio-economic standards. Most learners attending these institutions are funded by NASFAS, because their parents can't afford to send to school.

The Intel Innovation in Education teach to the future programme, which was launched in 2000 initially started in the United States and is currently used in more than 33

countries around the world including South Africa. The South African leg was based on a project-based learning approach which included 10 modules of four hours each. Educators collaborated to complete these modules, with an aim to of bringing learners and educators together to explore technology integration (Wilson-Strydom et al., 2005).

Schoolnet Intel Teach to the Future Programme has since been adopted by some universities with South Africa for preservice and in-service programmes. *Schoolnet Intel Teach to the Future Programme* provides somewhat a better approach compart to ACOT model, however, the Intel model does not provide evidence of success in South Africa since its inception in the year 2000. This technology integration model was introduced in South Africa 21 years ago, there is no evidence of any breakthrough and penetration of this model within South Africa's education communities. The slow technology integration with South African schools, specifically TVET colleges is collaborated by Tarhini et al. (2016), that this challenge is caused by lack of ICT skills amongst educators. This study by Tarhini et al. (2016) was commissioned 15 years after *Schoolnet Intel Teach to the Future Programme* was launched, the country is impacted by low levels of technology integration within the schooling system.

The UNESCO framework provides an interesting ICT integration guideline, which is based on four approaches namely: *emerging, applying, infusing and transforming* (UNESCO, 2002). This model provides an important technology integration for countries and with special focus on countries to adapt models to their own context. The challenge with the UNESCO model is arguably similar to the one discussed above relating to the *Schoolnet Intel Teach to the Future Programme.* UNESCO technology integration framework lacks penetration in South Africa, it can be argued that this is because of the model's challenges around context proper fit. In other words, countries are different with their different education landscape outlook, policy, resources etc. The UNESCO technology framework may be challenged at country specific context implementation.

2.4 Technological Pedagogical Content Knowledge (TPACK) Framework

This study argues that Technological Pedagogical Content Knowledge (TPACK) as compared to above ICT integration models, provides an appropriate technology integration model for schools and specifically for TVET colleges within the South African context. As such, this unique advantage ensures that technology integration is more than ensuring availability of ICT resources, but also a deeper engagement and interaction across all three knowledge areas, namely: content, pedagogy and technology. The origins of TPACK may be traced back to Shulman's PCK model, which was initially defined in 1986. Koehler & Mishra (2009) expanded on this work further to provide more context on the relationship of the three knowledge areas (content, pedagogy and technology). The three components cannot work in isolation, they must all have to interact for the development of new bodies of knowledge namely: Pedagogical Content Knowledge (PCK), TCK (Technological Content Knowledge), TPK (Technological Pedagogical Knowledge), then the development of TPACK becomes possible.

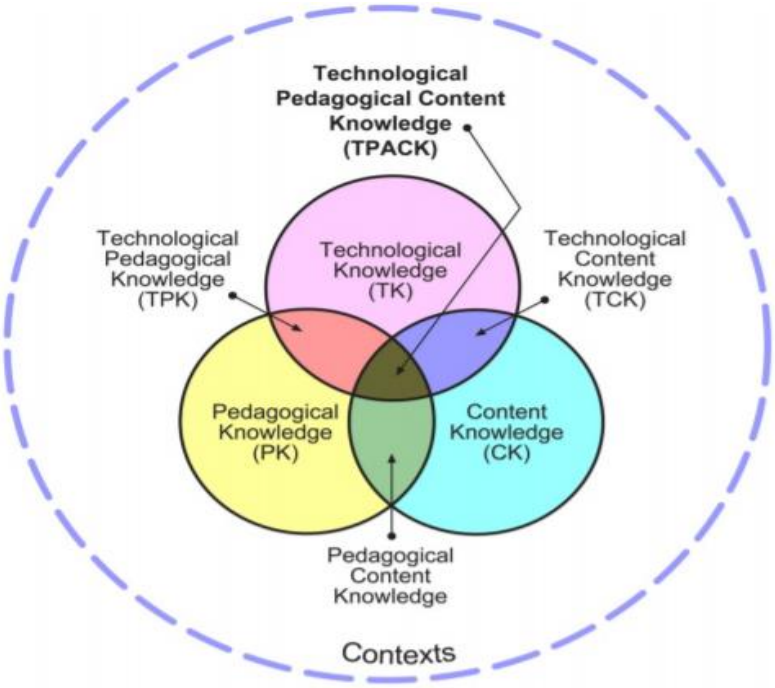


Figure 1: TPACK Framework and its related domain knowledge (Koehler et al.,2013)

2.4.1 Technological Pedagogical Knowledge (TPK)

TPK is an integration of Technology Knowledge (TK) and Pedagogical Knowledge (PK), based on the concept of how method of teaching can make changes to types of technologies, knowing what can and cannot be done when using technologies in the method of teaching. As a result, one's awareness of aligning relevant technologies with a teaching method, TPK. An example here might be, different subjects require different technologies to align with method of teaching (Koehler et al., 2013). A high order subject like mathematics will require different set of technological tools to align with method of teaching. These tools are aimed at mediating or scaffolding teaching methods, it is critical for educators to be able to use appropriate technology tools to align with their learning objectives. It can then be argued, depending on the subject, high order subjects will require a more scaffolded approach when teaching.

Using technologies that will align to this guided teaching method. Whilst theory subjects may not require much scaffolding, this knowledge is critical for an educator who integrates technology into learning. Details of this work appears on chapter 4, were the participants are exposed to technology integration methodology. TPK at its highest level can assist educators to come up with ICT answers to challenges experienced when teaching, through integration of appropriate technologies into method of teaching based on barriers and limitations.

2.4.2 Technological Content Knowledge (TCK)

Technological Content Knowledge is a combination of Content knowledge (CK) and Technology knowledge (TK), the technology element is about knowledge of various technologies that can align properly with content. With the rapid change of technology

in the world as result of globalization, technology has an impact in all spheres of what we do. Koehler et al. (2013) illustrates this point by making an example of a heart, which can now be viewed almost like a pump, as a result of technological influences. Other examples include the discovery of X-rays in how they impacted on medical field, coming closer to home on education, it means a teacher have to have an understanding of technologies that are relevant within their content subject.

One can relate to many examples to make a point, emails have taken over from posting letters, the disappearance of fax machines. In a subject like office practice, which is taught at TVET colleges, teaching learners about posting letters and faxing documents may not be helpful, since these two areas have almost diminished.

However, teaching learners about the use of emails and to write proper emails can go a long way to assist learners. An added advantage of using emails is that they are technologically driven, so, learners will also have knowledge using a computer as well, whilst the other examples has no link with improving computer skills of learners.

TCK at its highest level can assist educators to come up with ICT answers to content related challenges, through integration of appropriate technologies into content, based on affordance and constraints.

2.4.3 Pedagogical Content Knowledge (PCK)

Pedagogical Content Knowledge becomes an important alignment between content and method of teaching. TPACK framework originate from PCK as was crafted by Shulman (1986), the actual conception from the founder Shulman is that PCK changes and improves when a teacher with content knowledge finds various ways to present this content to a learner. In this way, being able to touch all learners because not all learners will gain understanding from a single approach to teaching.

2.4.4 Technological Pedagogical Content Knowledge (TPACK)

TPACK becomes the highest knowledge as a result of the combination of the three knowledge bodies PCK, TCK and TPK. It becomes the mastery of the three based on the effective and efficient execution of the integration between content, pedagogy and technology. Application of the three at a highest level, an ability to use technology efficiently to align with content (TCK), this is achieved when affordances of the two are taken into account to achieve a partnership that will enhance learning outcomes (Koehler *et al*., 2013).

The mastery of TPK, an understanding that appropriate technologies should be aligned with method of teaching to achieve the upper most efficient technologically delivered lesson. The key point to take about TPACK is that it is journey of development for educators, allowing those who have achieved TPACK to become mentors to other educators who are still yet to achieve TPACK.

2.4.5 TPACK pathways

There are three TPACK pathways as identified by Koehler et al. (2013) to teacher development in developing TPACK, namely: From PCK to TPACK, From TPK to TPCK and Developing PCK and TPACK.

From PCK to TPACK

In this approach educators use technology and align it with existing method of teaching and content knowledge, this is to improve on the delivery of learning towards the development of TPACK. Because of pedagogic and content knowledge experience already exist, this pathway is used predominantly for in-service teachers (Koehler *et al*., 2014). This pathway is ideal for the a TVET lecturer who has gained content and pedagogy knowledge over a number of years, but needs two knowledge areas to be integrated with technology.

From PCK to TPACK pathway is about the integration of teaching method, content and technology. This is the most ideal pathway for TVET lecturers, except the lack of technology knowledge is real hence the need to incorporate the second pathway to this pathway, the second pathway will have a focus on the development of technology to ensure that educators have adequate levels of technology knowledge, prior to this pathway being used.

Another challenge or barrier to technology integration is the views experienced teachers have about the use of technology, traditional method of teaching allows individuals to defend the method, that's how they know how to teach. Any other new method can be viewed negatively as a thread to current method. Belland (2008) describes teacher method of teaching and held beliefs as a possible barrier towards technology integration. With a lot of educators within TVET colleges who have lots of experience on traditional teaching method, the issue of educators failing to embrace technology integration might be a reality. Therefore, the PCK to TPACK pathway may be insufficient to ensure a successful technology integration. Hence the need to look at the second TPACK pathway, TPK to TPACK discussed next.

From TPK to TPACK

Normally used for pre-service teachers, these are trainees of method of teaching and have just entered a university. These trainees are normally exposed to this TPACK pathway when they start their training at universities. This is where these trainees have not yet taken any content and related methods on their subjects. Technology subject then becomes mandatory, it allows this trainee teacher to get exposed to technology first and then later choose specific content subjects of choice (Koehler et al., 2014).

Then pre-service educators are then able to integrate this broad technology acquired knowledge with content and pedagogy later during their training. Technology training is taught by highly skilled ICT personnel such as Instructional designers (Koehler et al., 2014). The same pathway can be used for in-service experienced TVET educators, with guidance of an expert on technology method of teaching. This approach can be helpful within TVET colleges to ensure that that technology integration is separately

handled or educators are trained on, acknowledging we talking about in-service experienced educators. This pathway can be the starting point and be implemented within a specified time line.

Educators will be exposed to various technology tools, gaining important knowledge of using technology during this period. This exploration of technology training lead by a technology teaching method expert or champion, can arguably ensure a smoother integration of technology to method of teaching and content, this being the first pathway. The combination of the two pathways will arguable ensure a smooth TPACK framework integration with TVET colleges.

Developing PCK and TPACK simultaneously

To build TPACK, all three knowledge areas of pedagogy, content, and technology interact during this process (Koehler et al., 2013). During pre-service teaching, an educational technology module is replaced with designed technology methods which are integrated within pedagogy and content during training. PCK and TPACK are then developed together during this approach, unfortunately this model cannot be appropriate for the TVET sector, because these are in-service lecturers with pedagogic and content experience but without technology knowledge.

Table 1: TPACK pathways Table

TPACK pathway	**Limitations**	**Successful application**
PCK to TPACK	For in-service training, there are strong limitations regarding institutions that can offer this type of training. Majority of educators are working fulltime	Training can be offered by institutions to working educators on a part time basis. There is a limited number of institutions that can effectively provide such training.
TPK to TPACK	Suitable for pre-service training, not necessarily ideal for an in-service experienced TVET educator, but can be used on TVET lecturers as the starting point of training	Can be applied successfully for new trainees, some elements of ICT expert can be combined with PCK approach for TVET sector
Developing PCK and TPACK simultaneously	Suitable for pre-service training, can be challenging to achieve success on this pathway, not Ideal for a TVET educator training approach.	Can be successful for trainees who have not yet acquired any experience in teaching.

Conclusion

This chapter provided a comparison of technology integration models, well known technology integration models were looked at, these models provide learning opportunities though these models are not able to provide a fully student-centred learning environment. Integration of technology within method of teaching and content

is not fully explained on these models with a proper guideline on integration. The study adopts TPACK because of the model's benefits of providing an appropriate guideline on how the three knowledge areas (content, pedagogy and technology) integrates better to improve the learning experience within the context of the 21st century.

The shortfall from other models is their lack of sufficient clarity on how the three knowledge areas will be integrated. Most of these technology models have been used in the past in South Africa, there is little success of these models if any.

Chapter 3: Methodology, Research Design and Approach

Overview

This chapter presents the review of Research design and Methodology, methodology approach, sampling, data generation technique, data analysis method, data quality strategies and ethical considerations. The review will further answer why a certain methodology was chosen.

3.1 Methodology approach

In choosing an appropriate methodology for the study, a comparison between the two most recognized methodologies (qualitative and quantitative methods) was done, those were reviewed alongside Action research. The decision of choosing the most appropriate methodology was based on methodology fit or alignment to the study. This study had an interest to understand participants' experiences based on their exposure to Technological Pedagogical Content Knowledge, with a goal to dig deeper and understand as compared to making inferences based on quantitative data extracted from responses.

Quantitative research methods are reliable when working with large amount of data where conclusion of the research could be based on direct observation or comparing the variables and draw the conclusion of phenomena through empirical, often experimental (Denzin & Lincoln, 2005). A quantitative method is used to deduce information, in the sense that inferences from tests of statistical hypotheses lead to general inferences about characteristics of a population (Denzin & Lincoln, 2005). Quantative is therefore not fit or aligned to the purpose of this study, due to the methodology's statistical hypotheses approach. The construct of this study is to work collaboratively with professionals within a profession of an education environment, most importantly to seek to understand deeper the experiences of the participants.

Qualitative research methodology most often relies on the researcher's personal contact with the group of people where the research is being studied (Antwi & Hamza, 2015). Building a close partnership with the participants may lead to more understanding regarding the matter being researched, adding richness and depth to the data (Antwi & Hamza, 2015). Thus, qualitative methodologies are inductive, they are constructed towards discovery and processes Babbie & Mouton, 2001, p.80. This methodology provides an alignment of purpose with this study, this is based on the methodology's approach of discovery and gaining deeper insight.

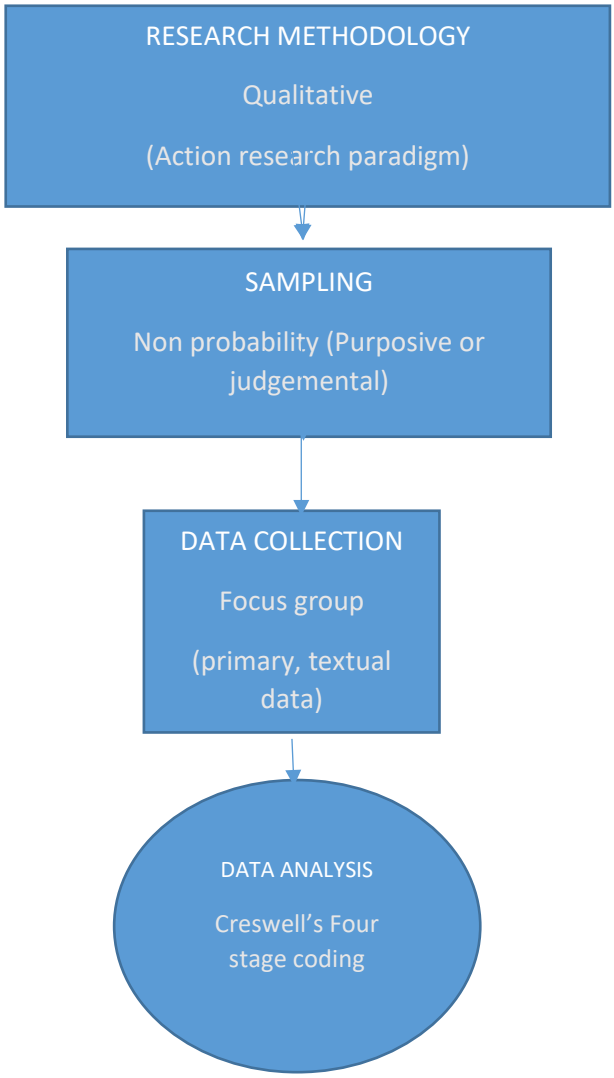
Action research talks about an action professionals participate in when developing their profession, starting smaller with a committed individual but gains speed when others collaborate (McNiff, Lomax & Whitehead, 1996). Action Research points to a preference of qualitative methods. PAR (Participative Action Researchers) chose to use qualitative methods more than quantitative methods, this view is based on the experience most Action researchers came across that they need to describe and elaborate more (Babbie and Mouton, 2001, p.326). The importance of using Action research and qualitative methods is the complimentary nature of both approaches.

This study has two important key concepts: (i) professionals coming together to collaborate and to improve their profession which relates to the *action research paradigm*, (ii) the study's objective of seeking to understand deeply perspectives of participants on technology integration by asking them seven questions, this approach relates to the *qualitative nature of the study.*

This study is Qualitative using an Action research paradigm, the researcher takes the central role within the Action research. Best described by McNiff, Lomax and Whitehead (1996), as a practitioner research done by practicing persons within their own practice. Action research approach in this study is about us practitioners working to together to improve our profession. The researcher took up the central role of an expert to assist educators with the integration of TPACK within their profession.

Acknowledging that the process of technology integration is a complex one and requires someone who has been exposed to technology integration concepts. Chapter 4 of this study is dedicated to TPACK exposure for participants with the guidance of the researcher.

Figure 2: Research Methodology



3.2 Sampling

This study is based on non-probability, a purposive or judgmental sampling type which allows the researcher to choose his own sample, based on existing knowledge of the sample in question (Babbie and Mouton, 2001, p.166).

Participants chosen on this study had some level of exposure to the use of technology, eight questions were prepared to identify lecturers with basic technology exposure from vocational school (NCV), a questionnaire was then sent to six lecturers. The National Vocational Certificate school has 24 lecturers. Out of six lecturers who participated on the technology skills survey, two educators were chosen because of their exposure to technology applications and use. The survey included questions around computer packages usage level, internet use level including types of packages used like google, online banking exposure levels, etc.

Two educators who were chosen for the study, had been identified to have the minimum required technology skills as per above criteria, they were found to have used technology applications as per above criteria and met minimum requirements.

The choice of the two lectures was driven by purposive or judgmental sampling, due to the nature of work that was done regarding technology integration, exposing these two educators to technology integration is a complex process. Chapter 4 describes the entire journey of technology integration.

3.3 Data generation technique

Data was initially planned to be generation using focus group interviews, COVID19 happened and data was generated during the early stages of COVID19, as such a remote data generation plan had to be developed. As a result of prohibition on gatherings, generation of data occurred in July 2020 when the country was experiencing a lock down level 4. Schools and TVET colleges were closed, a remote data generation plan was developed, based on technology tools. Important issues to consider relating to usage of technology, included connectivity, data usage costs and available technology tools to use.

It was important that data generation occurs in the most cost-effective manner for all involved. Other technology tools such as ZOOM and Microsoft teams were investigated, but challenges of poor connectivity and data costs became a barrier in possible using either tool.

Interview questions were sent to participants on Microsoft word document via social media, participants responded via the same platform, having compiled their responses on word document. To ensure that the originally envisaged focus group interview still remained in-tact, WhatsApp voice notes and text was used for exchange of clarity was sort. *The remote plan to generate* data did not compromise the integrity of data generation. The use of personal documents such as keeping a diary, photos, writing letters etc, is an acceptable method of collecting data when doing qualitative studies (Babbie and Mouton, 2001, p.300).

3.4 Data Analysis Method

Qualitative data analysis is about working on massive of words, summarizing these words and describing them (Lacey & Luff, 2009). There are key concepts or phenomena when analyzing qualitative data, they are: *data reduction, data display and drawing and verifying conclusions* (Punch n.d., p.174). This study adopts Creswell (2003)'s data analysis method, due to the method's systematic manner in how data is analysed step by step. The data reduction approach will however be influenced by Punch (n.d., p.174) who provides a more simplistic view regarding data reduction, that it is not something separate from data analysis, it happens at all stages of data analysis.

Below provides a systematic process of Creswell's data analysis.

<u>Stage 1: Organize and prepare data:</u>

- Arrange documents and visualize data
- Transcribing of the text
- Organize the data for analysis

The following actions were undertaken during step 1:

- Participant's responses were displayed in a form of a table using Microsoft word, with all responses shown on a table.

- The table was separated into two columns representing two participant's responses with multiple rows for each question.
- Each question on a table was analyzed.

Stage 2: Read through all data:

- Read through the collected data
- Write memoirs
- Check for trends and distributions

The following actions were undertaken during step 2:

- A reading of generated data began, with emphasis on reading responses of each question slowly to gain understanding of meaning.
- A response to a question was read atleast three times to ensure understanding.
- Trends and distributions started to emerge
- Once trends were picked up, it was time to identify emerging sub-themes from sentences
- Tables that display data, will show only data that has been reduced, not initial full responses from participants will appear, but paragraphs drawn out from checking of trends and distributions.

Stage 3: Begin a detailed analysis with a coding process:

- Code the data
- Assign labels to codes and questions with similar subject
- Create categories according to similar subject or question and merge topics that are related to one another.
- Finalize the categories and perform the initial analysis

The following actions were undertaken during step 3:

- A decision on conceptual analysis was done and 'a string of words' within a sentence was used. This means a string of words will be highlighted in a specific colour, a blue colour was used in all sub-themes.
- Sub themes that emerged were highlighted with a blue colour on each sentence.
- An entire sentence may not necessarily be highlighted, but most words within a sentence will be highlighted to achieve a certain meaning.
- Sub-themes were then drawn from these sentences and these sub-themes were assigned themes. For example: the first question which asked participant's to describe their overall experience on this research project, with participant's responses (p1)' *I would say it was very important for me as a lecturer to participate on this research as it taught me so many technological methods of learning and teaching* '.
- The next step was to highlight only a string of words which carried a certain message relevant to the question to identify a sub-theme, in this case the following words from the entire sentence were highlighted with a blue colour 'learned a lot of technology methods of teaching'.
- From the sub-theme, a 'developmental' theme emerged

Stage 4: Use coding process to generate description for the case study:

- Assess how the research questions were answered
- Compare the findings
- Reflect on the personal meaning of the findings

- State new questions based on the findings

- Findings were arrived at by analysing meaning from sub-themes, themes and global theme that emerged.
- Sub-themes with a common meaning were grouped together and allocated a theme.
- This means, ONE theme may have different number of sub-themes, it could be one, two, three or more sub-themes which were categorized as a particular theme. The number of themes at this stage was not important, but the meaning of what each theme represents was more important.
- Once categorization of sub-themes into themes was completed, a global theme emerged. Same as the categorization of sub-themes into themes, a common meaning from sub-themes was used to develop a global theme.
- At the end of this process, findings were drawn from the meaning of themes and global themes. Reflection of meaning came from the number of themes which shared a common meaning, these were counted. This means, if a global theme had more themes as compared to others, this global theme will have a 'significant and important' meaning.
- Global themes with less number of themes then carried a meaning of importance.
- These themes and global themes were now compared to TPACK literature, this combination was used to develop conclusion and recommendations.

3.5 Confidentiality and Privacy

The respondents were informed and guaranteed that the information collected from them would remain confidential and it would not be shared with anyone. Data obtained would be kept for the duration of my study (two years). In addition, they were promised that their names would remain anonymous, only pseudonyms would be used instead of actual names. For example, participant 1, would be code named P1, participant 2, would be code named P2. However, it is optional whether they would like the information to be disclosed or shared with them. The collected data was encrypted and password protected, then saved on a CD or removable disks as backup, these tools were locked up in a SAFE. With the other files password protected on cloud.

3.6 Ethical Considerations

The researcher was issued with the ethics clearance letter to interact with the two TVET college lecturers who served as participants (respondents). The researcher applied for the ethics clearance letter through the university research committee of which I received (see Appendix C) allowing me to undertake data collection from sampled TVET college lecturers. Accompanying the ethics clearance letter were independent declarations and non-disclosure/confidentiality consent with the university letterhead.

These forms were presented to the participants to opt to volunteer in participating in the study. The forms were fully explained to the participants before engaging in the research activity. The respondents were assured that their responses will be kept confidential and/or anonymous. In addition, the participants were made aware of the dates for research data gathering well in advance to give them enough time to confirm their availability or withdrawal from the study in time.

3.7 Limitations of issues of research

Limitations of research were experienced during data generation stages were challenges of internet connectivity were experienced due to COVID19 restrictions. A remote plan of collecting data was put in place and data generation was not compromised at all.

This remote plan for data generation was in line with qualitative studies approaches and did not compromise data generation at all. Data generation used written responses from participants though typed Microsoft word send via Whatassp. The use of personal documents such as keeping a diary, photos, writing letters etc, is an acceptable method of collecting data when doing qualitative studies (Babbie and Mouton, 2001, p.300). With additional tools such as Whatsapp voice notes and text to keep an interview in alive, this remote plan ensured that no data generation was compromised.

3.8 Credibility and Trustworthiness

Trustworthiness refers to the level of confidence in collected data, how it was interpreted and the methods used to describe it. Therefore, the most accepted criteria of evaluating trustworthiness of qualitative studies amongst most qualitative study researchers includes *credibility, dependability, confirmability and transferability* (Connelly, 2016).

Credibility

Credibility refers to the use of standard procedures for the study and variations must be justified (Connelly, 2016). This study applied all standard and relevant procedures normally used for qualitative studies, these include but not limited to 3.2 data sampling, 3.3 data generation technique and 3.4 data analysis. Another description of credibility is that researchers should ensure that participants of the study are described properly (Elo et al., 2014). This study has described participants as follows:

Below is a brief background of both participants:

Table 2: Participant's experiences

	Subject teaching	**Work experience**	**Qualifications**
Participant 1	Life Orientation	5 years Lecturing experience	Post Graduate Certificate in Education
Participant 2	Mathematical literacy	10 years Lecturing experience	Post Graduate Certificate in Education

In addition, these are participants who demonstrated the minimum use of technology and related tools such as cellular phones, computer packages such as Microsoft word, Powerpoint, Excel and the use of internet.

Another technique to ensure credibility of the study is exposing the research to peer briefing and feedback (Nowell, 2017). This research was exposed to peer briefing

through normal research peer briefing meetings which occurred within the Educational Information Technology department.

Dependability and confirmability

Dependability and confirmability can be used interchangeably, meaning the degree of consistency of findings and if they can be repeated. Methods involved in this process include an audit trail to be maintained (Connelly, 2017). Findings of this study were arrived at through use of an appropriate qualitative study data analysis procedure by Creswell, complimented by other literature. All research material including questions and responses from participant's, analyzed data records have been file electronically with a password, to ensure that an audit trail is available should it be required.

According to Graneheim and Lundman (2004), the term confirmability means that findings of the study should reflect accurately the version of collected data and not the view of the researcher. Findings were drawn from themes which emerged from participant's responses as a result of a rigorous data analysis process as described in 3.4 above. Data was not altered in any way to change participant's version, raw participants responses was analyzed.

Transferability

Transferability reflects the extend to which those who read the study believes the findings can be helpful and applied to other environments (Connelly, 2017). According to Babbie and Mouton (2001), transferability means that a sample of study satisfied relevant identified group, findings can be extrapolated to other teaching and learning strategies. This study is about an important concept within education of this country and most importantly, a global challenge. Technology and learning was always a critical aspect of 21st century learning, but the advent of COVID19 has made this even more important. This study will hopefully be transferable to other environments, findings of this study are based on credible procedures used to analyze qualitative studies generated data.

Triangulation

Triangulation is another important way in which reliability and validity can be shown during qualitative study analysis, it means the researcher used various sources to gather and analyze data (Lacey & Luff, 2009). This study complimented generated data analysis from participants with responses from students, the student version was asked by the researcher after learners were exposed to TPACK teaching method for six months in class in a form of a random questionnaire. Questions were send to learners via social media (WhatsApp), their responses were text based on the same application. Learner responses on this questionnaire was be used on the main findings and conclusion.

3.9 Development of questions

Development of seven questions asked to participants was based on the TPACK framework. In developing each question, all components that construct TPACK were considered.

As per figure 1 above which describes the TPACK framework and its related domain knowledge, TPACK develops from the relationship of Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK) (Koehler et al. 2013). In formulating questions, it was important that each knowledge area is represented from all questions to ensure that TPACK aligns to questions to be asked to participants.

The first question, (a) how would you describe your overall experience having participated on this research? The question relates to the entire TPACK experience and exposure as a result of participating on this study. So, all three key TPACK domains (TCK, PCK and TPK) were represented. The second question (b) how has teaching with technology impacted on content of your subject? This question has an interest of technology integration with content, a focus on the (TCK) domain. The question wanted to establish the view of the participants when it comes to integration of technology and content they taught.

The third question (c) provide examples of areas that were influenced by technology within content you teach, the question is linked to the second question and it is positioned on the TCK domain. The difference between the two questions is that the third question is looking for examples on the impact of teaching using technology. Whilst the second question sought the view point regarding the educators experience when teaching with technology. The fourth question, (d) describe learner experiences when they were exposed to practical examples of technology-based activities. This question is still located on the TCK domain, with a difference in that learner experiences needed to be understood.

The fifth question, (e) how has teaching with technology influenced your teaching method? This question is located within the Technological Pedagogical Knowledge (TPK) domain. It is more about seeking to understand an educator's experience when technology and method of teaching are combined and used in the class room. The sixth question, (f) provide practical examples of how learners were influenced by technology method of teaching. This question is also located within the (TPK) domain like question five, except the view of learners through the educator's perspective is sought.

The last question (g), are there areas of development you can suggest for ITC integration on pedagogical knowledge? The question evaluates the overall impact of TPACK as participant's has experience it through exposure. The need to ask about areas of improvement becomes critical to the enhancement and development of TPACK.

The third domain of TPACK, Pedagogical Content Knowledge (PCK) is the combination of content and method of teaching, this time in the absence of technology. So, content and pedagogy have been fully represented on the other two domain TPK and TCK. Therefore, all seven questions have featured with the TPACK framework.

Conclusion

This Chapter described the research methodology of this study including collection of data and analysis. The study is qualitative using an Action research paradigm. The Action research aspect is described on the following chapter in some detail. The journey to adopt TPACK requires a lot of commitment and practice of technology skills by educators. It is with this in mind that the next chapter is designed with this deep and detailed technology exposure and training.

Chapter 4: TPACK training for participants and exploration of technology tools for TVET sector (pre-data collection stage)

Overview

This chapter is a review of Technological Pedagogical Content Knowledge (TPACK) training for participants prior to data collection, together with the exploration of technology tools relevant for TVET sector. The chapter represent a pre-data collection stage, a critical stage prior to participants responding to questions.

The background of participants is as follows: Participant 1 was teaching Life Orientation within the NCV school, he had 5 years of teaching experience and he had a Post Graduate Certificate in Education. Participant 2 also had a Post Graduate Certificate in Education with a 10 years teaching experience, she was teaching Mathematical literacy.

4.1 Exploring the development of TPACK Through PCK and TPK

Theories of learning inform what goes into the use of technology for teaching and learning, as such the relationship between pedagogy, content and technology is explored in this section. Koehler et al. (2013) describes the development of TPACK as a challenging process that allows for the highest execution of the three knowledge areas (technology, pedagogy and content) when integrated together.

Both TPACK pathways (from PCK to TPACK and from TPK to TPACK) adopted by this study are aligned with Constructivism and Cognitivism theories. The easiest way to make a point about this chapter is like taking a driving license, one does not just jump on the driver's seat and drive, there can be lots of accidents. One needs to prepare for the learner's license first by reading signs and rules of the road, then move to the next stage of learning how to drive, this is acquired though driving schools etc. Only then can one go for the driving license test to see if a person can drive, TPACK training plan is shown on Appendix B.

4.1.1 Technology learning theories

To establish a theoretical pedagogic background prior to engaging in any technology development is critical, because technology for learning is informed by literature on teaching and learning. As Clark (1983) argues, media does not motivate learners or improve learning outcomes, it is instruction capabilities within media which is responsible for motivation of learners and improved learning outcomes. One cannot just use technology in class, without appropriately understanding how it connects with method of teaching.

Vygostky (1978)'s constructivism provides us with an important platform to give proper meaning to the concept of learning. He outlines two levels of development when it comes to learning, with the first level of development being the stage were cognitive structures of development have formed and learners are able to handle learning independently. Learning during this stage has to be structured in a manner that makes it easy for learners to understand concepts by themselves. During this stage, learning

is facilitated because mostly happen independently, the design of online learning material should be less guided or less scaffolded during this stage. Theory subjects which require less guidance are mostly appropriate for this type of instruction.

The first participant teaches mathematical literacy and the second one teaches Life Orientation. We focus only on the theory part of learning for the Life Orientation subject and not the practical application. This provides the study with a good balance of a high order subject (Maths literacy) and a low to medium order subject Life Orientation. Design of online learning material will vary. Vygostky (1978) describes the next or second level of development as the zone of proximal development. On this level of development, concepts of learning are more challenging for learners and the need for a knowledgeable person in a form of a teacher arises, this stage required more of scaffolding and learning instruction is more guided. Hence a subject like Mathematics would be viewed within this light, when designing learning material this understanding is crucial for an educator to understand that the use of technology tools when designing a high order subject learning material should be guided more, as compared to a theory subject were guidance will be less.

A practical example of explaining the concept above is to say that a technology lesson for a high order subject will include more tools of technology which will assist to guide learners, this may include voice notes, vedios, pictures etc. Whilst a theory lesson will include less of these features, long as the design approach meets key design elements of easy to read, interesting and cost efficiencies.

4.1.2 Multimedia Lesson design elements

When designing technology-based lessons, there are important elements to take into account. This is important for participants, cognitive overload is an important area of attention to be looked at, like Clark and Feldon (2005) explains, that whilst technology brings its advantages to learning, like being more inclusive and learners being able to work together, technology also brings challenges of cognitive overload. Teachers should then ensure that a carefully scaffolded technology learning approach should be used (Clark & Feldon, 2005). Meaning, one needs to avoid lessons which show bright and many colours without any coherence with too many pictures on designed slides. As we move towards the practical side of designing online learning material with participants, this aspect becomes critical.

When designing lessons, it is advisable to focus on minimizing sentences to ensure they short and easy to read, short sentences allows for small bites information to be read and easily understood (Abadzi, 2006). Participants were exposed to these elements practically on various designed lessons by the researcher. Long paragraphs can easily become boring for learners and they can disengage learners, working memory challenge challenges of only attracting and retaining small bites of information should be taken into account.

Lessons should be designed in an interesting manner (Abadzi, 2006). The use of a visible font ensures that even those who have vision challenges can be able to see. Bright colour can advisably be used to cover small sections on the lesson, such as headings to create a point of attention only. Lesson designs are meant to be simplified with no graphic backgrounds and bright colours on text. Attachments and images should be used relevantly to support content and only a few is necessary.

4.2 From TPK to TPACK pathway (technology tools relevant for TVET sector)

The first adopted TPACK pathway on this study, From TPK to TPACK pathway explores the use of various technologies for learning, TPK is based on the concept of how method of teaching can change certain types of technologies, knowing what can and cannot be done when using technologies in the method of teaching (Koehler *et al*., 2013. TPK is therefore improves on the basis of one's awareness of aligning appropriate technologies within method of teaching, this means an educator should first understand various tools of technology and how they can be used prior to aligning them with method of teaching. Some tools will be adopted and some will be discarded based on lack of proper fit with methodology or other reasons such as cost efficiencies, access to learners etc.

Due to TVET sector's lack of ICT resources challenges which have been discussed at length on literature review, the fact that colleges don't even have learning management systems, it was important for this study to identify alternative methods of using technology for learning even without ICT infrastructure at TVET colleges. We used the combination of various technology tools, based on cost efficiencies, learner-centeredness and they should be accessible to learners. The use of tools computer packages such as PowerPoint together with other Open Educational Resources (OERs) such as Socrative, using social media packages such as WhatsApp and Telegram messenger, including usage of mobile technology (cellphones) were explored within the context of a TVET college learner.

4.2.1 Learning management system/Instructional design models

Learning management systems are an important base or platform on which technology materials for learning can be configured and designed. Learning management systems are also referred to as Instructional Design Models, Instructional design can be described as a learning instruction offered through multimedia, this in many case involves electronic platforms which incorporates hardware and software to deliver instruction, either through the use of a computer, multimedia connection point or other device, it can be an online learning through distance learning (Desrosier,2011).

There are various and mainstream learning management such as Moodle, ADDIE, ASSURE. These models are far too expensive and out of reach for the context of this study (TVET context). Other examples of learning management systems used for learning one can think of includes SAKAI and Blackboard, these are used by two prominent universities in the country. The challenge facing TVET sector is well outlined in this study, such advanced learning management systems are currently a dream for

the TVET sector. Hence the importance of improvisation, this sector is challenged with the development of highly skilled educators on technology method of teaching, such skills will as in this study assist the sector to leverage on the acquired skills to form a new learning path, which can ensure some level of technology within the sector is used for teaching and learning. In the absence of such technology skills, the current inequality of technology learning within the country between the highly resourced institutions of learning and the lowly resourced will persist.

4.2.2 Computer packages

The use of a computer is critical by the educator to design online learning material for learners. Due to COVID19 challenges were the country was on lock down during this study, it was important to include blended learning approach when designing lessons. Some lessons were designed for onsite learning when lock down rules were relaxed to allow learners to be in the classroom, whilst the next approach were designed lessons for offsite learning when learners are at home and cannot come to class.

The computer package found to be the most user friendly with efficient design capabilities, accessible and most cost effective for designing learning material is Microsoft PowerPoint as compared to other packages like Microsoft word. The first design is for classroom using an educator's laptop and a projector provided for by the college, such lessons are designed with the design elements discussed on 4.1.2 above which are aimed at easy to learn and read lessons. Most lecturers use own laptops, though this year in 2022 the college provided all educators with college laptops. PowerPoint designed lessons are also used for offsite learning approach, when learners are not able to come to college due to COVID19 restrictions, however, designing for offsite learning is more challenging and requires a lot more ICT skill because a combination of various tools like learner cellphones are involved.

4.2.3 Social media packages

Social media has become an integral part of society, mainly used for communication, but can also be used for learning. In the absence of ICT resources such as technology devices like computers for learners, the absence of a learning management system from college, an educator working in this sector has to explore various technology tools to assist leaners.

The use of mobile technology for learning is crucial for a TVET learner, cellular phones can be an important resource since most learners have them to supplement shortage of ICT resources and infrastructure. As N'gambi et al. (2016) points out, up to 98% of learners have cellphones. The issue of debate can be the kind of cellular phones. There can be a debate around cellular phones capabilities and that is justified. Not all cellular phones in the hands of learners have advanced smart phone capabilities, this means care should be taken when learning process is built on these devices.

The socio-economic status of a TVET learner informs the context within which the framework of learning with technologies should be directed. An online learning material designer should be cognisant always that they are designing for a low socio-

economic context. We are referring to a learner who go through school with the assistance of NASFAS, National Student Financial Scheme. This study explored two Social media packages, WhatsApp and Telegram messenger as other social media packages are good for communication but may not be helpful for learning.

4.2.3(a) WhatsApp

WhatsApp is used predominantly for social chats, it is popular amongst most learners, however, the tool can be used for educational purposes. We can create group chats for members who are on contact list, and these groups can be used for learning. The tool has voice notes capabilities, interactive text responses advantage, one can attach files and videos. So, WhatsApp was used as a learning management system within our context.

The most significant advantage of WhatsApp is that it is accessible to most learners as it is used for social networking. WhatsApp provides an advantage of purchasing data in bulk, this ensures that learners can purchase bulk data at low costs. An educator has to be careful not to send learning material that will deplete data, as learners will quickly not interact with such learning. The role of WhatsApp is almost like that of a learning management system such as SAKAI or Blackboard, ADDIE etc. When using the application for learning, lesson design themes discussed earlier of user friendliness, data cost efficiencies and interesting learning should be the guiding themes. Powerpoint designed lessons get send to learner's whatsapp after being converted to a pdf file. This is the cheapest method of delivering leaning to learners who cannot afford high costs of online learning.

My experience when such lessons are designed accordingly, a well-designed lesson should land to be understood by learner. This is the measure of an appropriately designed lesson aimed at independent learning process, it has to attract little to none enquiries from learners. Once lessons with clear learning objectives are send, the group chat is used as a discussion forum based on learning content. Voice notes are used to support lesson, can also be used to mediate on challenging concepts. Another important tool on WhatsApp is conference call, but due to time will require to be investigate, it was not explored with participants, the researcher used some of this element on his work. This development will be discussed under TPACK advancement work by the researcher as he the researcher also continue to develop his TPACK.

During the covid19 remote learning period, my college like many tried various ways of teaching remotely. One of the approaches the college tried was to use WhatsApp, most educators send bulk, uneasy to read and highly data expensive material to learners. This created a backlash and online learning was compromised, because learners complained of data cost issues and learning material that is not well prepared for learning.

4.2.3(b) Telegram messenger

Telegram messenger is another application which can be used like Whatsapp for learning, it became important to investigate this tool for its feasibility for learning, just like Whatapp was investigated. Three areas were looked at on telegram messenger, they are costs efficiencies, easy to handle design capabilities and access for learners. I was assisted by my level 4 learner for this short investigation and not participants on this study, during testing phases, I called her line, send images, messages and voice notes etc. Then cost analysis was done by viewing data balances at every point of testing a concept.

The following findings were arrived at:

a) Telegram messenger picture downloads attracted no data costs, (b) voice notes attracted no data costs, (c) attaching files attracted no data costs, (d) making calls attracted data costs from the sender, (e) texting interactively within telegram attracted no data costs (www. telegram.org).

Telegram messenger provides an important option which can complement whatsapp, they are both social network applications with complementary features and benefits. Whilst Telegram messenger has clear cost advantages, Whatsapp is more popular and used is used by majority of learners. Whatsapp has data bundle advantages which telegram messenger does not have. Whatsapp is more accessible on most cellphones used by learners, whilst telegram messenger is mostly available on latest smart phones, something most learners don't have. I requested most of my learners to download telegram messenger and of out of 120 learners, only 30 learners were able to successfully download telegram messenger. Whilst 115 learners were on Whatsapp at the time, this shows that Whatsapp is more accessible to learners.

Another unique advantage feature of telegram messenger is its capabilities of sending huge attachments, which one cannot easily send from most technology tools. I recently sent a folder which had 10 subfolders with a total size of 640megabits. This advantage means that one can send huge volume of information at a minimal cost from one tool to another.

4.2.4 Open educational resources (OERs)

This study explored open educational resources as an important element to support learning with technology. The benefits of OERs is the cost benefit, most OERs don't attract any data cost when used except that one has to be active on the internet to access them. Effective OERs should allow for learners to engage learning content in a collaborative manner, it must be cost effective and have automated feedback capabilities. There are various OERs available, the challenge is to find the correct and appropriate tool that fits the goal, examples of such OERs include Wiki books, Curriki, Merlot content builder and more. This study identified Socrative application as compared to most tools out there for effective teaching and learning, accessibility and cost efficiencies with strong learner feedback capabilities.

Socrative can then be used to design a learning pathway for online learning, especially during lock down, learners need a tool that will be able to engage them and provide feedback. A learning pathway allows for a learning dialogue to happen between a student and an educator. In this way, an educator can establish if learning did indeed occur. I describe the learning pathway below as influenced by Laurillard (2002), called the conversational framework. Laurillard (2002, p.88) explains the conversational framework as a framework that describes the fundamental structure of an academic discussion. This is a process where an academic dialogue happens, with the main topic been broken down to sub-topics, then moving in each stage to ensure that learning has occurred by testing feedback from the learner. It includes own effort by a student through engagement with the teacher, until the learner understands. An academic dialogue within technology learning construct can be a challenge, but a fulfilling achievement when mastered.

As per the choice of technology tools we used for this study, a well-designed lesson on a power point starts with a topic, followed by learning outcomes, a brief summary of what the lesson is about and then some key pointers in short sentences to deal with the learning concepts. This is then followed by activities, whilst activities can be done via WhatsApp group chat, I found the use of Socrative application, an open educational resource which requires no data to use, to be mostly helpful to most learners. Because learners can remotely and privately monitor their improvement when using this tool. The work of an educator is to design automated TRUE/FALSE and multiple choice questions based on the learning material learners engaged with.

This tool allows for a conversation to occur between a learner and automated responses. The conversation framework on a technology tool is slightly different on the technology tool, would have ordinarily occurred in the classroom. A learner can start with a low score and log on to improve their score. The dialogue between an educator and a student happens when an educator views learner performance, and encourage a learner to logon to the tool to improve score. An educator can only monitor this important technology conversation in the background, the real work of an educator was the design process of this learning journey.

Table 3: Compatibility between WhatsApp and Telegram Messenger

	Accessibility	*Connectivity*	*User-friendliness*	*Social bundles/cost*
WhatsApp	√	√	√	√
Telegram messenger	x	x	√	x

Above section explored various tools that can be used with a TVET context, a multiple technology tools approach is required to explore most and get to the best fit. Hence an educator needs certain type of technology skills, together with the desire to continue learning so that the development of TPACK become a reality, as one learn and explore various technologies, TPACK is being developed.

4.3 From PCK to TPACK (a more practical integration approach)

Above described the first pathway (from TPK to TPACK), the technology and learning theories brainstorming stage. Now we focus on practical aspect of technology integration when teaching. Both participants were given similar Powerpoint designed lessons, they were expected to critique these lessons so that they are able to understand appropriate methods of designing technology-based lesson.

Participant 1 was given a Power point lesson designed by another educator who is less familiar with designing an appropriate online lesson, the lesson was centred around easy learning and interesting reading. This participant was asked to critique the lesson based on the acquired knowledge on 4.1 and 4.2 above. The participant did identify problem areas on the lesson, such as bright colours used in the background, the font size which was too big etc. Participant 1 was then asked to design an appropriate lesson aligned to the subject he was responsible for, that being Life Orientation. The designed lesson has to be an improved version as compared to the critiqued one.

Participant 2 was given the same power-point lesson designed by another educator within the same sector. She was asked to critique a lesson which had some cognitive overload issues. Participant 2 identified a few areas of concern on the lesson such as, colours were not used appropriately, the lesson was too long because it was a 20 page cannot make interesting learning for students. So both participant 1 and 2's observations were correct as they identified three problematic areas which do not encourage learning. That the background of the lesson slide was too bright with a heavy colour and could be heavy on the eye of the learner (cognitive overload issues), that the lesson was too long at 20 pages (concentration may be lost during learning). The font was too big as if this is a presentation and not a learning content. Bright colours which can be heavy on the eyes for learners, and these colours can cause cognitive overload. This critique finds resonance with cognitive overload theory by Clark and Feldon (2005), who highlights the importance of avoiding cognitive overload when designing online materials. This issue of long reading is a challenge for concentration element, this consistent with findings by Abadzi (2006), who indicate that lessons should be shorter because working memory has a short spells memory retention and lessons should be interesting.

Both participants were asked to prepare appropriate lessons and submit them within 7 days. Both participants submitted designed lessons which were improved and could be used for learning. Lesson designs by participant 2 shows on Appendix A.

Once lessons are submitted, feedback is given to each participant. In this example it was a mathematical literacy educator who got feedback. The lesson meets most principles of online lesson design, background colour is white and text black which is easy to read. Font used is visible, page 2 with formulae diagrams can be made larger, I thought font there was too small. All pages have a touch of pink colour, this is good

for an interesting reading page or bringing attention back to the lesson. The lesson had a clear topic and learning outcomes, the use of diagrams and arrows was important to direct learning areas. There were further examples or activities for learners to engage in, which is important.

This was a good first attempt of an online lesson designed by participant 2, areas of improvement included lack of using other tools to guide lesson like voice notes since this is a high order subject, this critique is consistent with Clark and Feldon (2005), who points to the importance of teachers taking into account that a carefully scaffolded technology learning approach should be used especially on challenging contents. Another missing link was the learning pathway; learners were not exposed to a process were they can engage online with the lecturer through a conversation. On 4.2.5 above I refer to the conversational framework by Laurillard, which allows for a discussion between a learner and a teacher to happen to ensure learning happened. The use of online educational resources (OERs) can be helpful for this important element of learning to be achieved, the use of Socrative was advised to both participants.

Participant 1's lesson design shows Appendix B

Participant 1's lesson had the use of colours which were easy on the eye, a white background with a touch of light blue colour on headings to capture interest for learners. Fonts were also at the readable level, not too small and not too large. The critique on this lesson is that it was a bit long with nine pages, it could have been shorter. Other pages were not included on this report. There were bullet points with shorter sentences, this is important learning because long paragraphs can impact on interest and memory retention.

4.4 Development of TPACK

This chapter explored the journey of participant's TPACK training and exposure to various technology tools relevant for TVET sector. It is important to note that most tools discussed on this chapter depend on the individual ability to acquire necessary technology knowledge, search for the tools and test them for appropriate use. The TPACK journey for participants was based on the two TPACK pathways, from TPK to TPACK and from PCK to TPACK. With the TPK approach having a focus on technology tools exposure for participants. Whilst PCK approach is the actual integration of pedagogy and technology.

This section deals with the more advance stage of TPACK, the stage which can be achieved through constant practice of TPACK by an educator. The section shares some of the work done by the researcher as a more advanced individual on TPACK as compared to the other participants.

The college were the researcher works was running a flexible timetable in line with COVID19 social distancing protocols, classes were divided in to two groups, one group attends class one day in and one day out. This means the need to use blended

learning approach is critical, to ensure that learners who are at home also receive learning, something that a TVET educator has not been trained to handle.

The offsite learning approach had to receive attention, it required more time and skills to design lessons. The blended learning offsite was based on mobile learning (cellular phones) with the use PowerPoint designed lessons send to learner's mobile devices, these were supported by voice notes, texts to create a learning environment. The use of posting pictures and videos is used at a minimal due to high data costs association.

Data costs analysis

Data cost analysis was important to be conducted on technology tools that were identified to for this study, costs are aligned to the key design principles of access and affordability for learners. As the leading person on this process of technology integration, I have set a target of designing lessons which do not exceed 10MB per month.

- The costs of designing lessons send to learner mobile phones should preferably not exceed 250 kilobits (KB) per lesson per day, the researcher has achieved this milestone during the 2020 season when designing online learning material for his learners. The next important investigation was to look at the cost of voice notes, as they will be send to learner's mobile phones to compliment PowerPoint slide lessons. A total data costs for online learning designed lessons per months is calculated to be 5.4 Megabits per month. This is based on the following calculations, 250kb per lesson per day multiplied by 5 days, multiplied by 4.33 weeks per months equal 5.4 MB

- Lessons should be designed not to be long and to have short time frames to ensure learners stay interested to learning. Lessons were also recorded through voice recording lasting about 11 minutes per lesson per day. This is in line with findings by Abadzi (2006) that memory have short spells and long lessons may not achieve learning goals as learners will easily switch off. A conversion of 11 minutes' voice recording to data is 11 megabits, multiplied by 5 days a week is equal to 55 MB, multiplied by 4.33 weeks per months is equal to 238 MB per month. In adding PowerPoint lessons at 5.4Mb per month plus voice lessons at 238Mb per months, we get to a total of 243Mb of data per month.

- At a monthly cost of a quarter of 1 GB WhatsApp bundle which cost an average of R35 on most cell phone networks, the total cost of the planned online learning material for 2021 would be an average of R9 per month, it means with this goal of designing lessons in mind, most learners will not be excluded on the technology learning platform. A huge milestone for a learner who comes from the low income bracket. Without the necessary ICT skills and technology integration skills, one can put together a technology blended learning plan which can be costly to learners and ultimately becomes not accessible. Something learners from this sector with a low socio-economic background and challenges will not support a costly learning project.

  Above work shows sensitivity to data and cost relating to the use of online learning material design and associated technology tools. This skill is developed through

practice of TPACK and it development, something at this stage only the researcher is can show as he is more advanced compared to the participants. Above demonstrates how when an educator shows TPACK development can assist to navigate the well identified challenge of lack of ICT resources and huge data costs within schooling systems of low income, in this case the TVET sector.

Below table shows participants exposure and improvement levels on ICT tools and technology Applications after TPACK training.

Table 4: Participants ICT tools and applications levels of exposure

	Beginner		**Intermediate**		**Advanced**	
	P 1	**P2**	**P1**	**P2**	**P1**	**P2**
Online learning lesson design Identify relevant tech tools Design online lesson	√ √	√ √				
Computer packages Microsoft Power point Microsoft word Microsoft excel			√ √ √	√ √ √		
Social media WhatsApp Posting of lessons Use voice notes Use text			√ √ √	√ √ √		
Open educational resources (OERs) Socrative Create a quiz Design automated responses Follow up through feedback			√ √ √	√ √ √		

Conclusion

This chapter reviewed participant's development of TPACK using the two adopted TPACK pathways, From TPK to TPACK and from PCK to TPACK. The first pathway from TPK to TPACK is more about the exposure of various technology tools for participants. The second pathway, from PCK to TPACK is more about the integration of technology with teaching method. Both pathways are suggested to work together to achieved a successful technology integration. One without the other may not necessarily achieve the success envisaged, *from TPK to TPACK* deals with exposing participants to various technologies and building technology skills. Whist another approach *from PCK to TPACK* is about integration of technology into method of teaching and content. This is relevant because of the context of a TVET college lecturer, who has teaching method qualification and teaching experience.

TPACK framework suggest that even those who come from the low end of the socio-economic levels of this country, can benefit from a method of teaching that uses technology. This view is contrary to the mainstream held view which seeks to narrow the definition of teaching with technology, this mainstream view suggests that only the privileged in society can benefit from technology based learning or online learning. Those who have ICT resources like laptops, smart phones including stable internet connection through wifi, optic fibre.

CHAPTER 5: Data Presentation and Analysis

Overview

This chapter deals with Data presentation and analysis of collected data. Data collection was done through focus group interviews.

5.1 Data Presentation

The following questions were asked to participants:

(a) How would you describe your overall experience having participated on this research?
(b) How has teaching with technology impacted on content of your subject?
(c) Provide examples of areas that were influenced by technology within content you teach.
(d) Describe learner experiences when they were exposed to practical examples of technology-based activities.
(e) How has teaching with technology influenced your teaching method?
(f) Provide practical examples of how learners were influenced by technology method of teaching.
(g) Are there areas of development you can suggest for ITC integration on pedagogical knowledge?

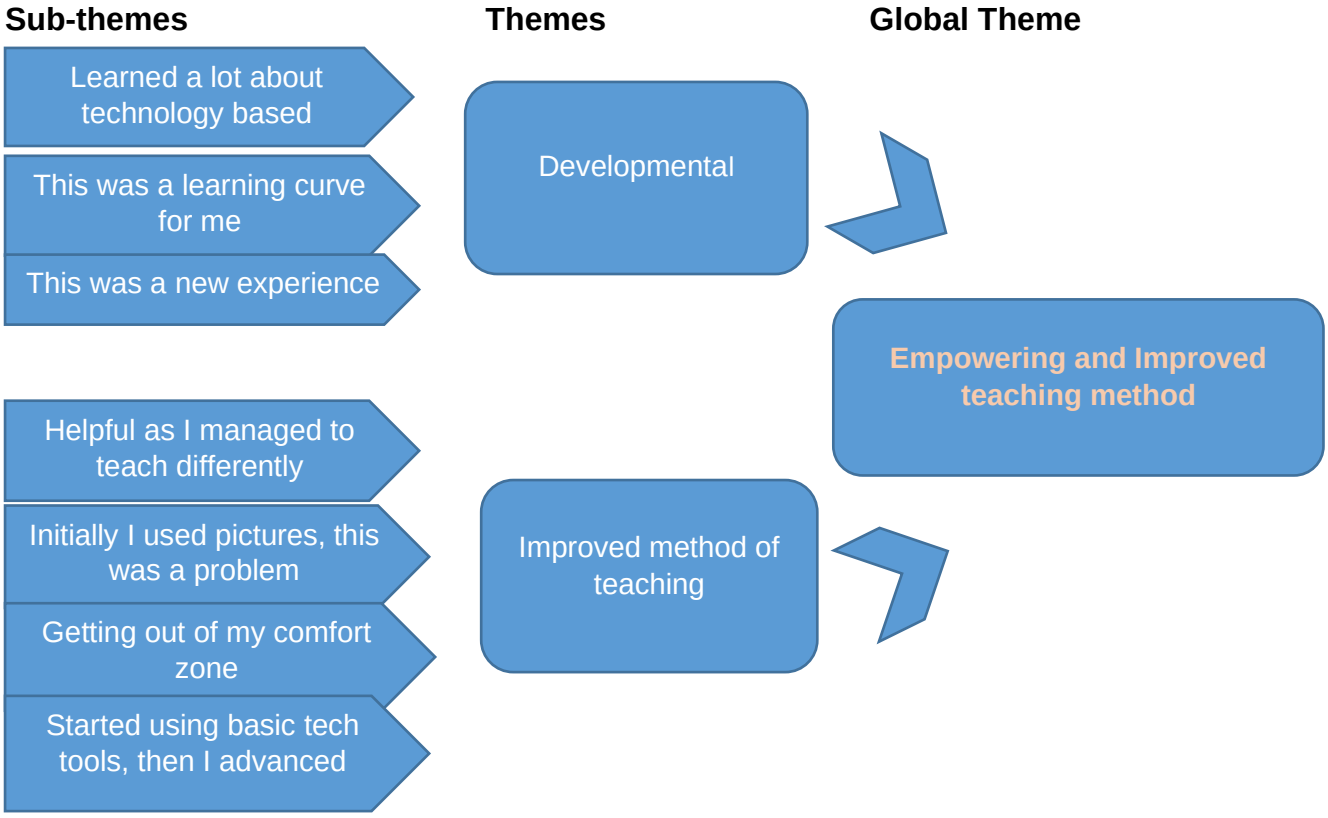
5.2 Data analysis

Table 5: Analysis of question (a) participant's responses

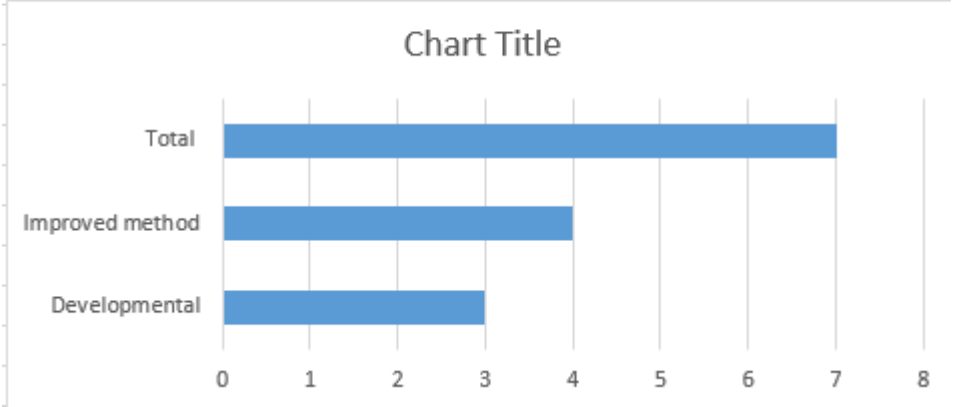
Questions to participants	Participant 1 responses (P1)	Participant 2 responses (P2)
a) How would you describe your overall experience having participated on this research?	*'I would say it was very important for me as a lecturer to participate on this research as it taught me so many technological methods of learning and teaching, it was really helpful for me as I managed to design a lesson.*	*'This was a learning curve for me, as I had to get out of my comfort zone. Teaching and planning for classes were the norm for, this was a new experience. At the beginning I was only using pictures to assist my students' with problems that may encounter with specific word problems in their textbooks. I started using PowerPoint presentations to make it more professional and helping students with some of the difficult concepts; it was then converted to a pdf file to minimize data usage. To consolidate and reinforce content I used Socrative to test the students on the content,*

		the reports allowed me to see areas of concern and to refocus on that'

Figure 3: The sketch below shows sub-themes and themes that emerged from participant's responses of question (a)



	Themes analysis
Developmental	3
Improved method	4
Total	7



Findings

The total of seven sub-themes were drawn from question one, with two themes emerging. The two themes that emerged are 'developmental and improved method of teaching', developmental theme had three sub-themes whilst improved method of teaching had four sub-themes.

Developmental theme constitutes 43% in terms of the total contribution of sub-themes and Improved method of teaching theme constitutes 57%. Both themes had a significant contribution on the participant's view regarding technology integration within teaching and learning.

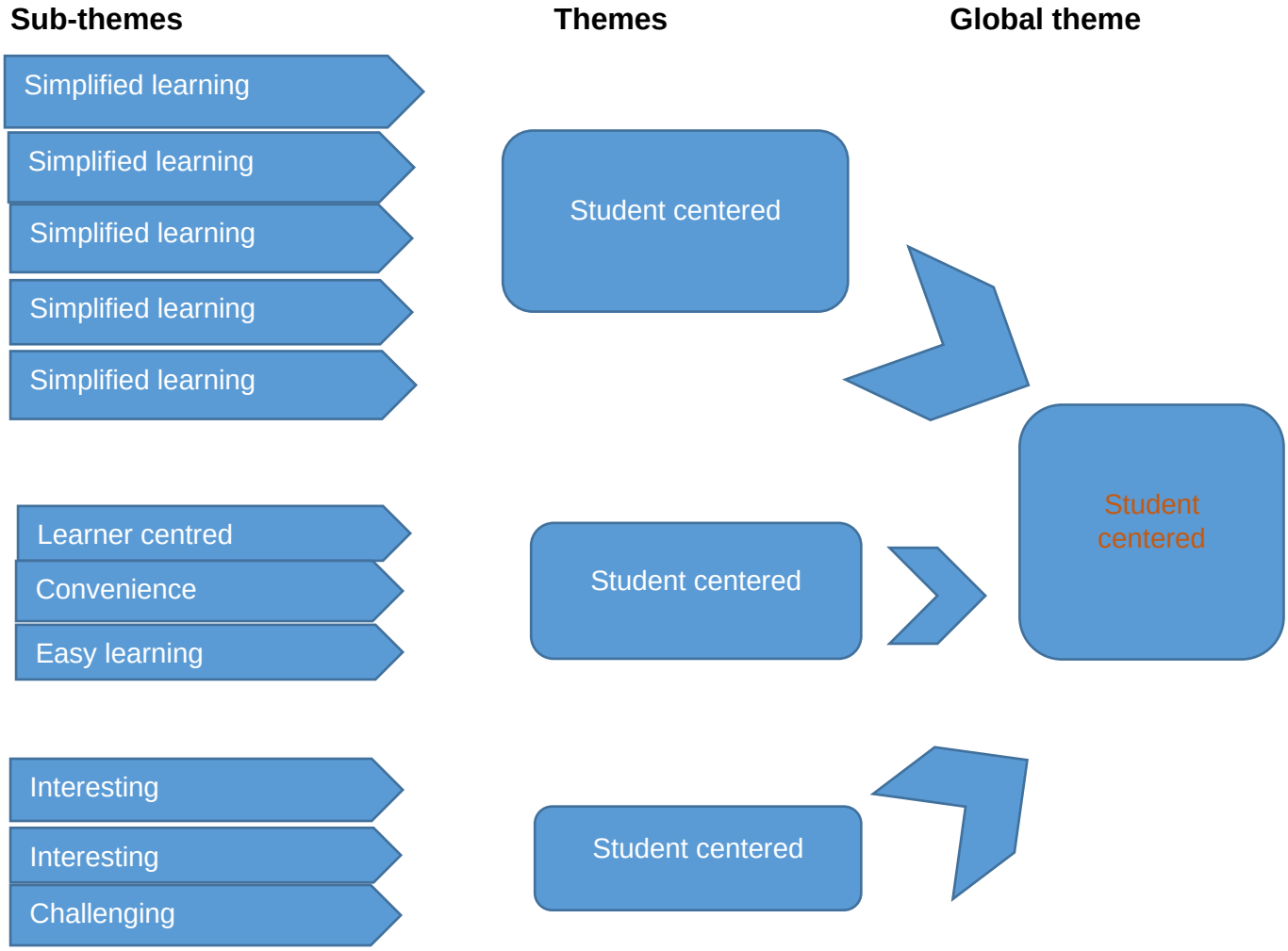
Conclusion

Participants felt that their participation on this research was developmental and their method of teaching improved significantly. Therefore, TPACK technology integration approach using two pathways (from TPK to TPACK and from PCK to TPACK) is developmental and it improves teaching method significantly. This finding is aligned to the study Hanewcz et al. (2017) that collaboration amongst learners improves as a result of virtual learning, allowing educators to take a more facilitation role thereby creating a student-centred learning environment (Hanewicz et al., 2017).

Table 6: Analysis of question (b) participant's responses

Questions to participants	**Participant 1 responses (P1)**	**Participant 2 responses (P2)**
(b) How has teaching with technology impacted on content of your subject?	*'It really made it easier and simpler for students to understand and for me as a lecturer to pass the information to students in a simplified manner, now my students enjoy my subject more than before as the introduction of technology excites them. I also enjoy using technology as it helps me to summarise my lessons and make them easier for students to understand and to participate and also it encourages them to be able to study on their own at the convenient time for them'.*	*'As students were used to me teaching in class using my projector and normal black board, it was difficult for them to just understand examples from textbook. With the use of the pdf file as well as Notes I guided the students to understand some concepts. When doing activities, the biggest obstacle was that students did not identify the correct shape and hence the wrong formula was used. I engaged students further.* Technology seems to now make it easy when linked to content taught.

Figure 4: The sketch below shows sub-themes and themes that emerged from participant's responses of question (b)



Findings

A total of eleven sub-themes were identified from question two, with the dominant 'student centred' theme emerging representing all eleven sub-themes. This constitutes a 100% overwhelming response from participants regarding how teaching with technology influence content they teach.

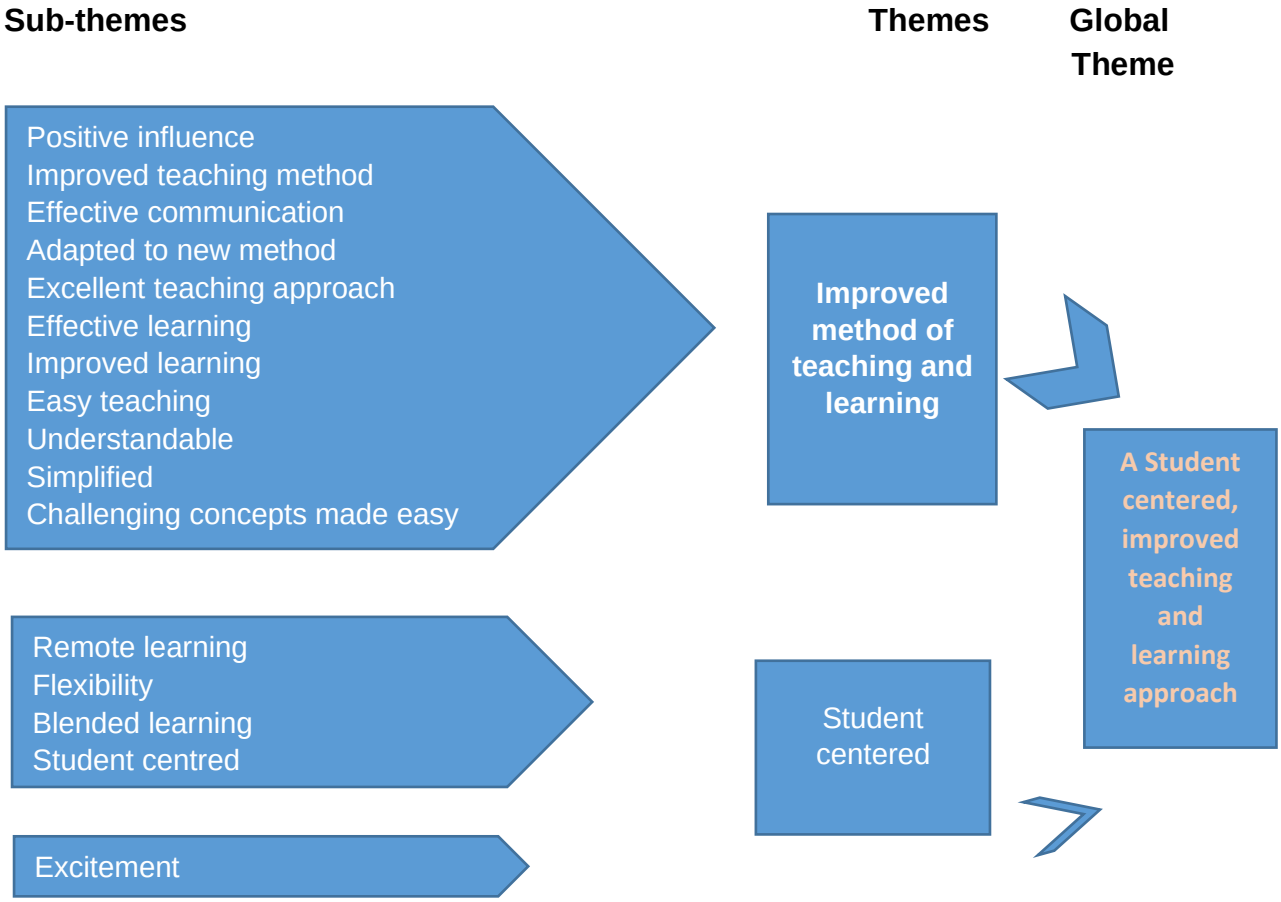
Conclusion

Participant's thought that the impact of technology on content they taught simplified learning and it is interesting. This finding aligns with Wihlborg et al. (2017), who found that there is knowledge improvement when learners collaborate virtually during learning activities Therefore, TPACK technology integration approach brought about a student-centred method of teaching.

Table 7: Analysis of question (c) participant's responses

Questions to participants	Participant 1 responses (P1)	Participant 2 responses (P2)
(c) Provide examples of areas that were influenced by technology within content you teach.	*'It influenced it in a very positive way, as I am now able to work with my students remotely; I am even able to teach from home and on weekends as we do some of things online. Technology improved my teaching method positively so as I am now able to communicate more effectively and at any day with my students. I am excited about this technology method as it makes my life easier and my lessons are more understandable as they are more simplified'.*	*'This enabled me to use more blended learning techniques, it also created ways for me to better understand my students as student do learn differently. By using notes, pdf file (visual), and Voice-notes (auditory), trying to get include as much students as possible. This was also a way of teaching them using building blocks from lower order thinking , using various teaching tools. I will be using these techniques from now on. This is an excellent way of teaching, this approach will help students to remember what was taught. The use of Socrative helped me with understanding the students' application of the content. Reading and interpretation is critical in my subject'.*

Figure 5: The sketch below shows sub-themes and themes that emerged from participant's responses of question (c)



Findings

Improved teaching and learning showed a more dominant view of participant's, with a 30 % gap between the first two leading themes.

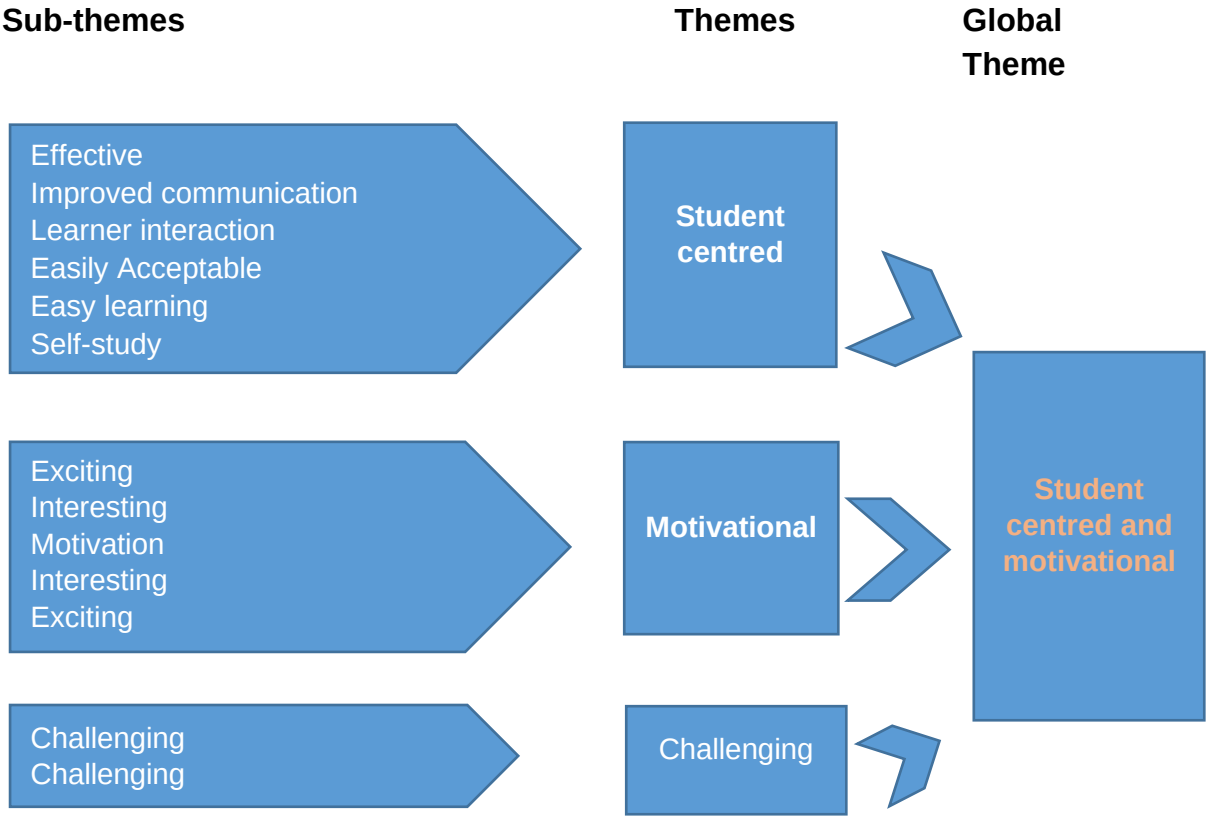
Conclusion

Participant's felt that technology teaching approach at a practical level strongly improved the method of teaching and learning significantly and this is a student centred learning approach. they used blended learning method of teaching, something they felt was important. Therefore, TPACK technology integration approach improves teaching and learning method and it is a student-centred method of teaching and learning.

Table 8: Analysis of question (d) responses

Questions to participants	Participant 1 responses (P1)	Participant 2 responses (P2)
(d) Describe learner experiences when they were exposed to practical examples of technology based activities.	*'Others struggled to use it as they have connectivity problems while others managed to login and use it effectively, they were so excited and willing to learn more using technology, they are so motivated and more willing to learn than when they were only using their textbooks for learning. They always communicate with me even on weekends as they are now using technology most of the time, so technology is so helping them to learn more and they received it with warm hands".* Both participants seem to now enjoy the use of technology and its various tools'.	*'Students interacted well; they used the steps I provided them in finding the shapes with their related formulas. They also did exercises to practice their acquired knowledge. I marked it with them using the WhatsApp platform*. It was not easy initially for leaners to engage with the use of technology".

Figure 6: The sketch below shows sub-themes and themes that emerged from the participant's responses of question (d)



Themes analysis	
Student centred	6
Motivational	5
Challenging	2
Total	**13**

Findings

Out of a total of thirteen sub-themes which were identified on participant's responses, 'student centred' and 'motivational' themes had a dominant meaning been close on margin variance.

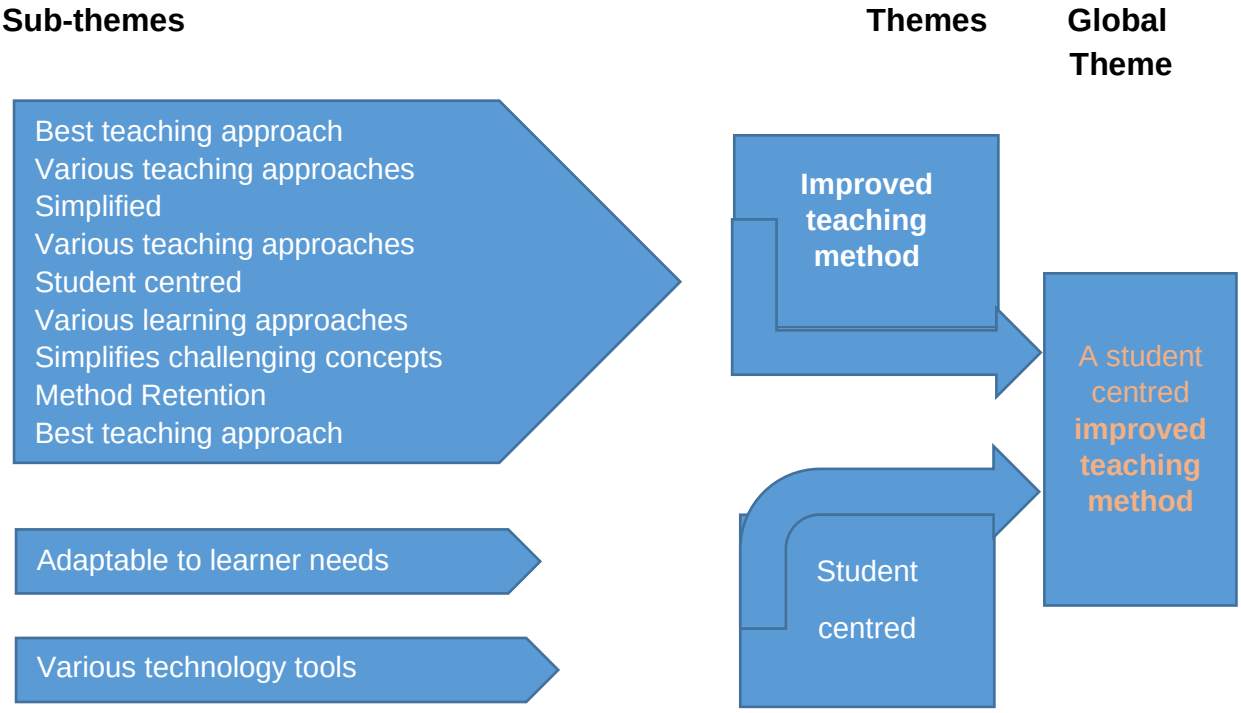
Conclusion

Participant's responses show that learners were exposed to a student centred and motivational learning during their exposure to TPACK technology based integration approach. This finding is similar to Hanewicz et al. (2017) who found that virtual learning allows for collaboration amongst learners, the term collaboration is an accepted term for a student-centred learning environment.

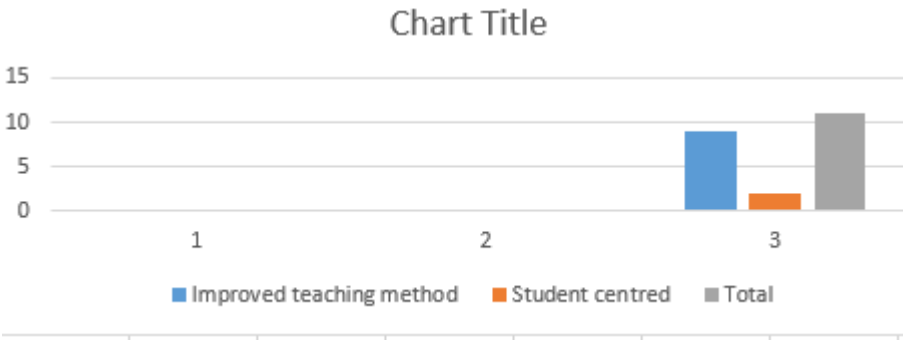
Table 9: Analysis of question (e) participant's responses

Questions to participants	Participant 1 responses (P1)	Participant 2 responses (P2)
(e) How has teaching with technology influenced your teaching method?	*'The use of technology helps me to choose the relevant method of teaching.. E.g. students will have to answer a quick quizzer then I give them their results immediately using plickers, students will choose a correct answer then lift their plickers so that I can scan them, then automatically the results will be shown on my phone as each plickers card do have a number and its linked to a specific student'.*	*'This enabled myself to use more blended learning techniques, it also created ways for me to better understand my students as student do learn differently. By using notes, pdf file (visual), and Voice-notes (auditory), trying to get include as much students as possible. This was also a way of teaching them using building blocks from lower order thinking. I will be using these techniques from now on as this will be available for students to go back. This is an excellent way of teaching as most students. The use of Socrative helped me with understanding the students' application of the content. Reading and interpretation is critical in my subject'.*

Figure 7: The sketch below shows sub-themes and themes that emerged from participant's responses of question (e)



Themes analysis	
Improved teaching method	9
Student centred	2
Total	11



Findings

Improved teaching method had a dominant meaning with nine sub-themes, participants still felt that technology-based method is student centred, the 'student-centred' theme had two sub-themes.

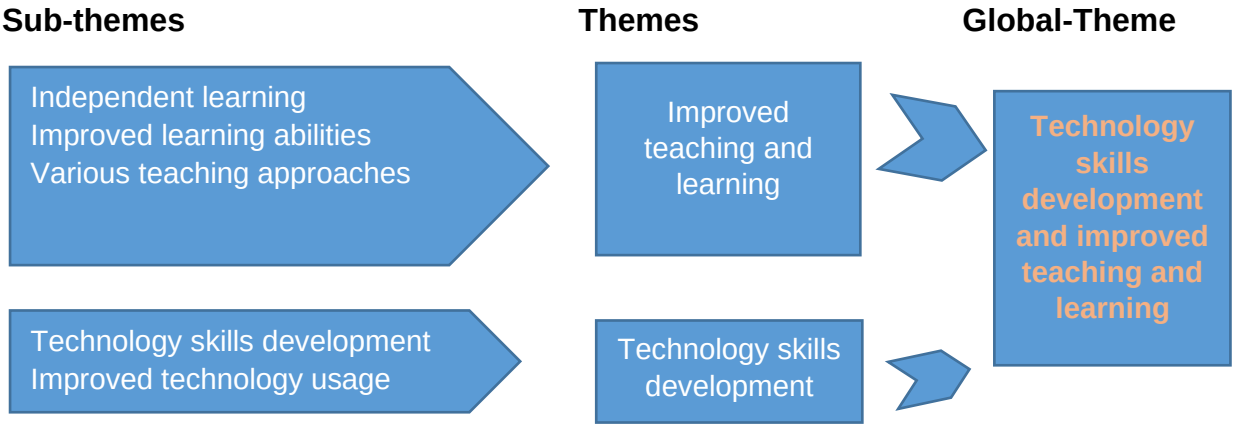
Conclusion

With an 82% response, participant's felt that TPACK technology integration approach improves teaching method significantly.

Table 10: Analysis Question (f) participant's responses

Questions to participants	Participant 1 responses (P1)	Participant 2 responses (P2)
(f) Provide practical examples of how learners were influenced by technology method of teaching.	*'My learners are now being exposed to be able to work/study independently. My learners now know how to answer and submit online. They are also able to follow instructions and respond according to instructions'.*	*'Using the building blocks – starting with understanding and comprehension – breaking down the content for students to understand before testing them on application".* There is now usage of technology by learners, even when submitting tasks'.

Figure 8:The sketch below shows sub-themes and themes that emerged from participant's responses of question (f).



Findings

Participant's responses showed a closely contested meaning on this question, with a both themes having marginal gap of one.

Conclusion

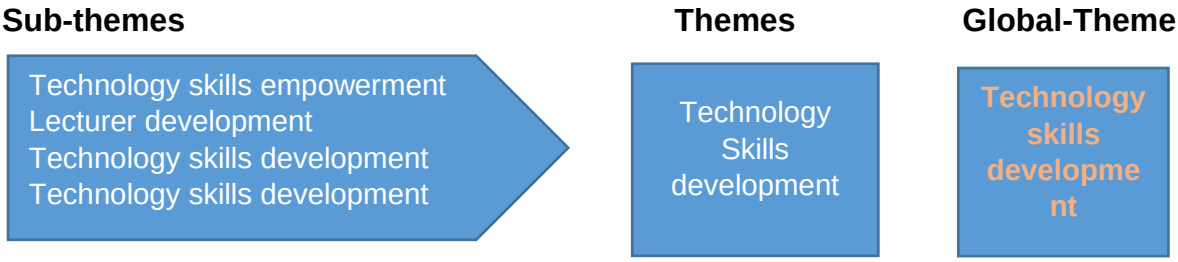
So, both themes represent's the importance of teaching method examples learners reflected upon. That learners felt TPACK learning approach improves teaching and learning and technology skills development is critical for this method.

Table 11: Analysis of question (g) participant's responses

Questions to participants	Participant 1 responses (P1)	Participant 2 responses (P2)
(g) Are there areas of development you can suggest for ITC integration on pedagogical knowledge?	*'Student's teachers are expected to be skilled users of ICT for their daily activities.*	*'Development of Lecturer to further their knowledge of using of Technology in the space of ICT and online teaching. This was*

		just a drop in a bucket, there is much more that can be done with online teaching in the space of TVET colleges'

Figure 9:The sketch below shows sub-themes and themes that emerged from participant's responses of question (g).



Findings and Closing

Technology skills development is viewed as a critical requirement for technology-based method of teaching to be successful.

5.3 Main Conclusion

The main question of this study asked, what kind of technology integration framework is required within TVET sector? This study adopted Technological Pedagogical Content Knowledge (TPACK) framework because it is challenging, since new skills have to be learned of technology, but the framework also provides advantages of creating an improved teaching method for educators and a student-centred learning experience. The core message of analysed data from participant's responses is that Technological Pedagogical Content Knowledge technology integration framework improved teaching and learning method significantly and it is student centred. Analyzed data from participants' show that TPACK framework improves teaching and learning method and also it is student centred. This finding is confirmed through analyzed data which showed both themes had 40% (30 sub-themes) and 38% (28 sub-themes) sub-themes contributions.

The importance of triangulation was important in how we got to the findings, learners were asked in class, on their overall experience of the technology- based method. Ten responses from level 2 learners said the approach make learning easy and it is convenient. Nine responses from level 4 learners on the same question also said method makes learning easy and it is convenient. This points to a student-centred learning experience.

TPACK can assist TVET colleges to find true expression to the purpose of a TVET institution in assisting young people to develop skills to ensure that they enter the labour market. Since TPACK method of teaching assist to improve learner technology skills, these skills are a requirement for the 21st century economy. This finding aligns well with the purpose of TVET sector as described by UNESCO (2015), which is to find solutions to the unskilled persons to equip them with relevant skills, for entry to the labour market as well as to ensure that learners become life-long learners.

Technology integration with method of teaching enable learners to collaborate outside the classroom, in a flexible way at their convenience. Student further develop problem solving skills (Delialioglu et al., 2007), which is an important skill in the 21st century. Using technology to teach can free up teaching time for educators (Hanewicz et al., 2017), thereby allowing them to focus on the development of TPACK.

Another important finding is that TPACK can bring a solution of dealing with outdated curriculum to the TVET sector. The issue of outdated curriculum has been highlighted by Terblanche (2017). When most educators have integrated technology within their methods of teaching, the development of TPACK will provide solutions to the challenge of outdated curriculum.

5.4 Recommendations

This study provides an additional option on the existing technology integration knowledge, with a focus on TVET sector where most educators have traditional teaching method without technology method. The Technological Pedagogical Content Knowledge (TPACK) will be able to address this gap, helping educators to integrate already existing teaching methodology with technology method.

Various campuses within a TVET colleges can identify a few educators who can enrol for technology-based method of teaching at a university, with a purpose of developing their method of teaching using technology. Then, they can then take the responsibility as experts or coaches who can assist other educators with the process of integrating their method of teaching with technology using TPACK and its two pathways (from TPCK to TPACK and from PCK to TPACK.

The idea would be to grow a tree of many educators with technology-based method of teaching, specifically TPACK to enhance the delivery of an exciting and relevant curriculum in the 21st century.

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APPENDIX A: Participant 2's Lesson designs

L4 MATHS LITERACY

SUBJECT OUTCOME/S

At the end of this lesson we want to accomplish the following:

1. Manipulate given formulae to calculate the UNKNOWN values when the perimeter/circumference, area and volume of the following shapes are given:

- square;
- rectangle;
- triangle;
- circle;
- semi-circle;
- cube;
- rectangular prism;
- triangular prism;
- cylinder;
- sphere;
- cone

compiled by B Adams

In order for us to understand the above outcome, we must first make sure that we know our formulas. You will find this in your textbook on pg 111.

This means that when we have our formula (Halleluja) we can then substitute the values that they have given us into the formula. Look at the examples on the following slides:

Summary of formulae for three-dimensional shapes

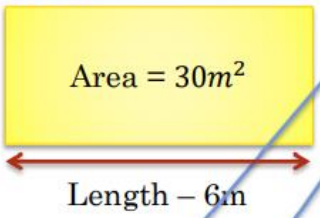
Shape	Surface area	Volume
Rectangular prism	Add the areas of the 6 sides or $2lb + 2lh + 2bh$	Area of base × height or length × breadth × height
Cube	6 × area of a side or 6 × side length × side length or $6(\text{side length})^2$	Area of base × height or side length × side length × side length or $(\text{side length})^3$
Cylinder	2 × area of base + height × circumference of base or $2\pi r^2 + 2\pi rh$	Area of base × height or $\pi r^2 h$
Sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$
Cone	pi × radius × side + pi × radius × radius or $\pi rs + \pi r^2$	$\frac{1}{3}$ × pi × radius × radius × height or $\frac{1}{3}\pi r^2 h$
Triangular prism	2 × area of base + length × base + 2 × side × length or $bh + bl + 2sl$	Area of base × length or $\frac{1}{2}bhl$

compiled by B Adams

LET'S LOOK AT SOME EXAMPLES:

- Example 1:

The area of a rectangular room is $30m^2$. The length of the one side is 6m. What is the breath?



Step 1 – What did the question ask?
Step 2 – What shape do you see/or did the question mentioned?
Step 3 – What is the related formula (look at step 1 and 2)
Step 4 – Write the formula down and substitute what was given in the Question.

1. Work out the breath
2. A rectangle was mentioned in the question (if you are unsure draw the shape for yourself)
3. *Area of a rectangle = lenght × breath*
4. Substitute what was given in the question

$$30m^2 = 6\text{m} \times breath$$

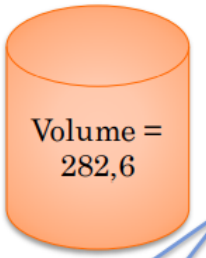
$$\frac{30m^2}{6m} = \frac{6\text{m} \times breath}{6m} \quad (divide\ both\ sides\ by\ 6m)$$

$$5m = breath$$

compiled by B Adams

CONTINUE: EXAMPLE 2

The Volume of a cylinder is $282{,}6cm^3$. Calculate the radius of the cylinder if the height is 10cm.



Step 1 – What did the question ask?
Step 2 – What shape do you see/or did the question mentioned?
Step 3 – What is the related formula (look at step 1 and 2)
Step 4 – Write the formula down and substitute what was given in the Question.

1. Work out the radius
2. A cylinder
3. *Volume of cylinder* $= \pi \times r^2 \times h$
4. Substitute into the formula:

$$\textit{Volume of cylinder} = \pi \times r^2 \times h$$
$$282{,}6cm^3 = 3{,}14 \times r^2 \times 10cm$$
(You are allowed to swapped both sides of the equal = sign)
$$3{,}14 \times r^2 \times 10cm = 282{,}6cm^3$$
$$31{,}4cm \times r^2 = 282{,}6cm^3 \textit{ (divide both sides with 31,4cm)}$$
$$r^2 = 9cm^2$$
$$\sqrt{r^2} = \sqrt{9cm^2}$$
$$r = 3cm$$

LET'S DO A FEW NOW TO PRACTICE:

- Go to page 116 Exercise 2.5
- Do the following Questions

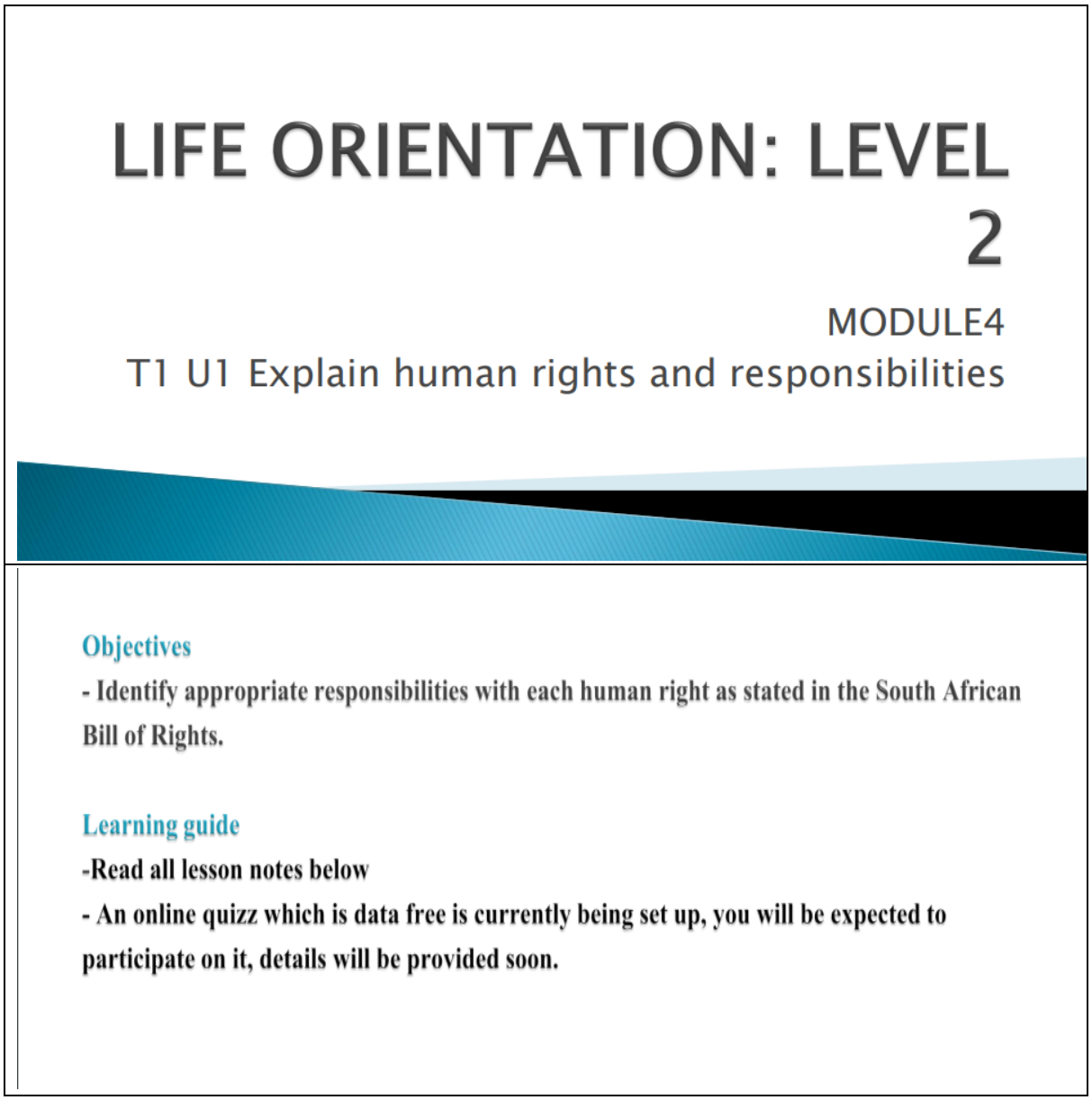
1, 2,3,4 ,5, 8, 9 and 10.

Please use the steps as given above for each question. After substitution you need to work out the answer.

You can do this guys. If there were No picture with the question – draw it, visualise it for yourself and write the dimensions in.

Good luck and shout if you are stuck!

APPENDIX B: Participant 1 lesson designs



1.2 The Right in the Bill of Rights

The Bill of Rights provides over 25 basic rights and freedoms to all people in South Africa and is based on the Universal Declaration of Human Rights.

1.2.1 THE SOUTH AFRICAN BILL OF RIGHTS

Chapter 2 sets out the human rights which are protected by the South African Constitution. Study these rights to understand what they mean in practice for you as citizen.

EQUALITY

- Everyone is equal and has the right to equal protection and benefit of the law. No-one, including the government is allowed to treat you less well than other people (Discriminate against you) because of your race, gender, sex, pregnancy, marital status (whether you are married or single), ethnic or social origin, colour, sexual orientation, age, disability, religion, conscience, belief, culture, language or birth. But **fair discrimination** and **affirmative action** are allowed.

Example

If a bus company wants to employ bus drivers, it would be fair for it to refuse to employ who are blind.

HUMAN DIGNITY

- You have dignity because you are a human being, and your dignity must be respected and protected.

FREEDOM AND SECURITY OF THE PERSON

- You can only be imprisoned if there is a good reason.
- You cannot be detained without trial.
- Torture is not allowed.
- You cannot be treated or punished in a cruel, inhuman or degrading way.
- You have the right to be free from all forms of violence, even in your own home. This is to stop people *abusing* their wives, husbands and children
- You have the right to make decisions about whether you want to have children.
- You have control over your body.
- You cannot be forced to undergo medical or scientific experiments against your will.

PRIVACY

- You cannot be searched nor could your home or possessions.
- The government cannot take your things, open your mail or listen to your telephone calls.

CITIZENSHIP

- Your citizenship cannot be taken away from you.

APPENDIX C

TPACK Training plan and exposure / Pre-data collection

Point of discussion	Guidelines	Proposed meeting dates	Meeting times	Next steps
- ICT learning design model (TPACK framework) meeting	- An overview meeting of the TPACK framework. Presentation of literature around this concept.	20 February March	15H00 - 16H00	- Participants to arrange their technology tools and ensure they are in proper use. Laptop, internet connectivity etc.
- Practical technology exposure and training	Participants are exposed to mobile technology and open educational resources training and integration. (cellphones, whatsapp, socrative etc). The alignment of technology, pedagogy and content are fully discussed. Literature is then shared as an additional resource to participants.	Wednesday 22 April 2020		Participants to design one unit of technology integrated lesson
- Technology design and development feedback	- Participants to present their lesson designs and the technologies they used. Or send these to the researcher on	Thursday 20th May 2020	15H00 - 17H00	- Participants to work on their lessons and incorporate feedback provided by

	email or whatsapp.			the researcher.
- Group interviews	**- Participants to answer questions for data collection purposes**	**30 July 2020**	**15H00-17H00**	**- Data analysis process follows**
- Data analysis	- Application of data analysis procedures	31 July 2020 - 31 September 2020		
- Findings and conclusion	- Compilation of findings and conclusion	1 October - 30 November 2020		
- Overall final touch ups to report	- Work on entire report for submission	December 01 - December 15/ 2020		

APPENDIX D: Ethics certificate

Research Office

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

ACKNOWLEDGEMENT OF RETROSPECTIVE APPLICATION FOR ETHICS CLEARANCE
R14/49

CERTIFICATE OF RETROSPECTIVE ACKNOWLEDGEMENT
PROTOCOL NUMBER H19/11/04

PROJECT	An investigation of a technological integration framework to best align with the Technical Vocational Education Training sector (TVET)
INVESTIGATORS	Mr C Chaka
DEPARTMENT	Education
DATE CONSIDERED	15 November 2019
EXPIRY DATE	13 February 2023
DECISION OF THE COMMITTEE*	Retrospective Acknowledgement

NOTE:

- **The HREC (Non-Medical) acknowledge receipt of this retrospective ethics clearance application.**
- **The HREC (non-medical) found no ethics problems.**
- **This acknowledgment is valid for three (3) years.**

DATE 14 February 2020

CHAIRPERSON
(Professor J Knight)

cc: Supervisor: Prof A Dewa

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.

I/We acknowledge that appropriate permission should have been sought, this acknowledgement does not entitle the applicant to conduct further research under this protocol number.

Signature

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX E

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG | WSoE

Declaration of Original Work

I, (Name and surname) Charles Mbele
Student number: 2287903

know and accept that plagiarism (i.e., to use another's work and to pretend that it is one's own) is dishonest.

Please confirm the following:

☑	I declare that the assignment entitled See Cover Page and handed in on the date below is my own work.
☑	I have acknowledged all direct quotations and paraphrased ideas.
☑	I have provided a complete, alphabetised reference list, as required by the APA method of referencing (described in the Referencing Handbook).
☑	I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.
☑	I understand that the University of the Witwatersrand will take disciplinary action against me if evidence suggests that this is not my own unaided work or that I failed to acknowledge the source of the ideas or words in my writing

Signed: C Mbele

Date: 16/11/2021

Course Code: EDUC7030A

Tutor Name: Dr J Moll