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Enhancing engineering education through technological pedagogical and content knowledge (TPACK): A case study

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ABSTRACT

This study analysed the status of TPACK knowledge and its impact on the quality of technical and engineering education. The research was a case study of 20 lecturers who were purposefully sampled from the School of Engineering and Technology at a university in Zimbabwe. The lecturers had no prior training in pedagogy. The purpose of the study was to establish the level of appreciation of TPACK among the lecturers and how they were integrating it in their teaching. Mixed research methods were employed. A questionnaire on Likert scale was used and descriptive statistics performed on the data to get frequencies and means. Follow-up interviews were done to triangulate questionnaire data in the determination of lecturers' views on the use of TPACK to enhance understanding as effective strategies to use it in teaching engineering students. The study found out that most lecturers (70%) were confident of their pedagogical competencies. However, on the adoption and use of technology in their teaching, 60% agreed that they could adopt whilst 55% were still thinking about how technology could be used in teaching. The frequency of use of ICT technologies among lecturers is quite high (80%) besides the lack of technology use to support students with disabilities. The lecturers (70%) viewed TPACK as an enhancement to improved quality of technical and engineering education. ICT use has been perceived as to improving the quality of engineering teaching and learning. It can be concluded that engineering lecturers are competent in their knowledge about individual components of TPACK but not on the integration of these components for effective teaching besides them agreeing that it is important to have a balanced combination of knowledge with respect to content knowledge, methods, and technologies. The research recommends TPACK capacitation of lecturers through in-service training.

Keywords: *Engineering education, technical education, TPACK, quality teaching and learning*

INTRODUCTION

Teaching is a complex practice which requires a combination of many types of specialized areas. Teachers work in complex and dynamic contexts (Leinhardt & Greeno, 1986) which require continuous evolution of their knowledge an understanding. To this end, for teachers to be able to teach effectively there is need for flexible access to high quality and integrated knowledge from a variety of domains (Putnam & Borko, 2008). This includes knowledge about how students think and learn, knowledge about content of a particular subject matter and lately knowledge about technology.

Technology is rapidly changing and this presents challenges to teachers who use it in their classrooms. Whilst traditional technologies are characterized by stability, specificity and transparency of function (Bruce & Hogan, 1998) new technologies are protean, unstable and opaque (Koehler & Mishra, 2008). This therefore presents challenges to teachers who attempt to integrate technology in their teaching. To make matters worse for teachers, technologies are neither neutral nor unbiased (Koehler & Mishra, 2008). Rather each particular technology has its own propensities, affordances and constraints which render them more appropriate for particular task than others (Koehler & Mishra, 2008). Contextual issues also complicate the integration of technology in teaching. Educational institutions do not always give the necessary support for effective integration of technology in teaching. The teachers sometimes do not have the experience for using technology. Many of them earned their degrees when educational technology had not advanced to where it is at present. As such teachers lack confidence in integrating technology in their teaching.

In Zimbabwean universities most of the lecturers are highly qualified experts in their academic fields. However most of them have no formal qualifications in pedagogy (Chabaya, 2015). This means that even though their knowledge about content is good their pedagogical knowledge and practices may be compromised by their lack of formal training in pedagogy. This lack of pedagogical skills as well as the challenges faced in integrating technology in teaching complicates their ability to adapt to the new demands of the teaching profession.

The TPACK Framework

The TPACK framework was introduced in 2005 by Punya Mishra and Mathew Koehler (Cox, 2008). The theoretical framework basically suggests that a teacher has to have a balanced combination of knowledge with respect to technology, pedagogy and content. The TPACK framework is an extension of the pedagogical content knowledge (PCK) that was suggested by Schulman in 1986. The basis of the PCK was that knowledge about content and knowledge about pedagogy exist independently but their overlap creates a new form of knowledge, that is, knowledge about how to teach content of a particular subject matter.

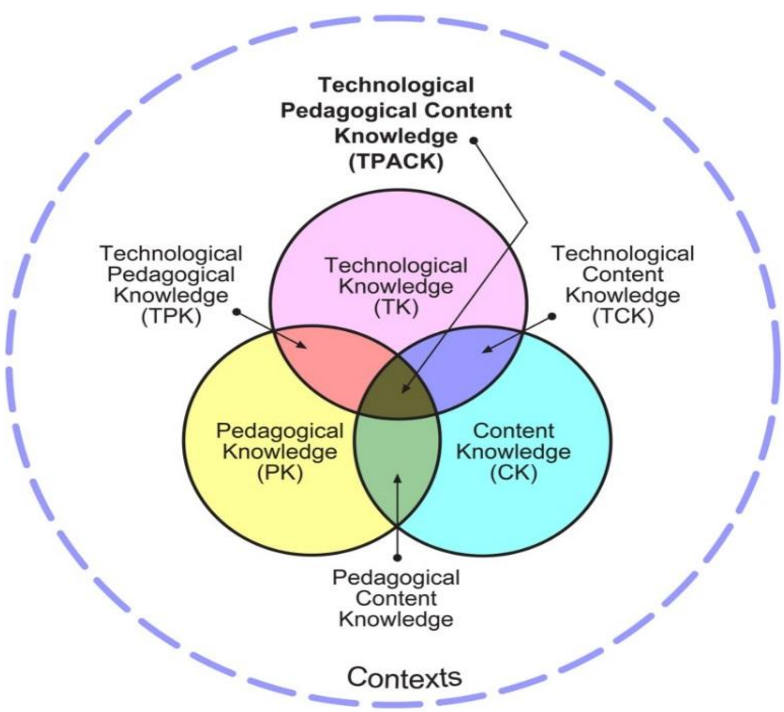

Figure 1: *The TPACK framework*

The advent of technology provided another dimension to teachers' knowledge, which is how a teacher's understanding of technology interacts with his or her PCK for effective teaching (Koehler & Mishra, 2008). In this framework emphasis is placed on the interactions between, as well as among content, pedagogy and technology. These interactions are represented as PCK (pedagogical content knowledge), TPK (techno logical content knowledge) and TCK (technological content knowledge) as shown in Figure 1.

Content Knowledge

Content knowledge refers to the teachers' understanding about the subject matter to be taught and learned. The content is dependent on various factors such as the age of the learners, the area of specialisation, the level of the learner etc. As such the content covered at undergraduate level will be different from the content covered at postgraduate level and the content covered in a biology course differs from that cover in a history course. As noted by Shilman (1986) content knowledge includes knowledge about theories, concepts, organisational frameworks, practices, and approaches towards knowledge generation in a specific subject area. In the science field in particular this will include the scientific theories and facts as well as the scientific process of investigation. Lack of proper content knowledge can have dire consequences on the learner. Students may receive the wrong information and end up developing serious misconceptions about the subject (National Research Council, 1999).

Pedagogical Knowledge

Pedagogical knowledge (PK) refers to the teachers' knowledge about the processes, practices and approaches to teaching and learning (Koehler & Mishra, 2008). This includes an understanding of how students learn, planning lessons, knowledge about student assessment and classroom management. Such knowledge helps teachers to tailor make their lessons to suit individual students' prior knowledge, motivation and level of ability. Teachers' pedagogical knowledge is not static but rather changes as a result research and experiences (Guerriero, 2017). As new knowledge emerges it is shared through professional communities and may lead to changes in teachers' pedagogical practices.

Technology Knowledge

Of the three knowledge domains of TPACK, technology knowledge (TK) is the most difficult to describe. This is because it is in a state of flux (Koehler & Mishra, 2008). Technological changes occur very fast hence individuals need to adapt to these changes so that they can remain relevant over a lifetime of open-ended interaction with information communication technology.

Technological Content Knowledge

The relationship between technology and content date many years back. Developments in fields like science and medicine have been influenced, and have influenced the development of technology. It is therefore important to understand the impact of technology on the knowledge of a given subject in order to develop appropriate instructional tools. TCK is therefore an understanding of the relationship between technology and content and how the two knowledge domains enhance and constrain each other. It is therefore necessary for teachers to not only know about their subject matter but to also understand the technological tools that are appropriate for effective delivery.

Technological Pedagogical Knowledge

Technological Pedagogical Knowledge (TPK) is an understanding of the changes in teaching and learning that occur as a result of changes in the way technology is used. Most popular technological software is not ordinarily made for educational use. There is therefore need for teachers to look beyond the traditional uses of computer software and re-configure them for pedagogical purposes. They need to be creative and open minded as they seek to innovate around how they can use the existing technologies to enhance the understanding of concepts within their subject area.

Technological Pedagogical Content Knowledge

Technological Pedagogical Content Knowledge (TPACK) encompasses and goes beyond the three components (technology, pedagogy and content). It's a concept that arises from the interaction among the three components. Therefore TPACK does not only entail having a deep understanding of the components individually but the simultaneous integration of the knowledge of technology, pedagogy and content (Koehler & Mishra, 2008). Each teaching situation is unique and there is no technology that can be applied in all contexts. Therefore teachers need to be flexible in terms of their understanding of the dynamic interactions that occur among content, pedagogy and technology. The emergency of new technologies therefore requires teachers to reconstruct the dynamic equilibrium that exist among these elements.

Impact of TPACK on teaching and learning

TPACK enhances effective teaching and learning of all school subjects from primary up to university level. Abisamra (2010) outlines the following advantages of applying TPACK in teaching and learning purposes:

- Teachers and students to access accurate information quickly as well as applying it appropriately. Distance education becomes easy to conduct. Students learn at their own pace and teachers do more of remote facilitation and less of face to face teaching. There is maximum utilization of time, less physical space and money needed.
- Several educational technologies used in TPACK provide audio, visual, motion, colour and texture enhancement. Such electronic enhancements have a multiple sensory arousal effect on learners which results in long time retention of learnt ideas, quick understanding and easy application where necessary.
- Knowledge and application of several smart devices for teaching and learning purposes allows collaborative learning and research at global level among students or teachers.
- Teaching and learning through virtual libraries, laboratories and internships are enhanced by TPACK practice (Potkonjak, Gardner, Callaghan, Mattila, Guetl, Petrovic and Javanovic, 2016). Virtual laboratories provide hazard-free learning environments where experimenters cannot be hurt. Students and teachers can repeat virtual laboratory experiments at no cost. The chemicals and or tools used in virtual laboratory experiments do not depreciate.

TPACK is by nature an integrative process that combines knowledge from three domains of technology, pedagogy and content (subject matter) hence it culminates to interdisciplinary teaching and learning. Integration brings about deeper and richer understanding of subject(s) in question. New understandings that emerge from subject integrations lead to the development of new skills and values. TPACK therefore equips teachers with new skills and values that promote effective teaching and general management of their classes. According to Mansilla & Gardner (1996), TPACK's interdisciplinary teaching is the use of a method(s) to teach a concept across several disciplines of a curriculum. Interdisciplinary teaching enables teachers to teach a complex concept easily by leveraging it from different angles. On the other hand, interdisciplinary learning is a planned approach that uses links across different subjects to enhance learning. It enhances development and transfer of previously taught or learnt ideas to new situations. Examples of personal qualities that it cultivates are originality, risk taking, critical and creative thinking. Such qualities are desirable among current and future global citizens.

Impact of TPACK on teaching and learning of technical and engineering education

Increased usage of information and communication technology tools in the home and wider social community is forcing school teachers to use Technological Pedagogical and Content Knowledge (TPACK) in their jobs. Research by the Department of Education and Communities in Australia showed that primary school teachers used TPACK in their teaching. Goodwin (2012) in Maher (2013) further acknowledges that the results for the same study showed that both students and teachers agreed that I pads improved teaching and learning activities. Ndongfack (2015) and Maher (2013) agree that primary school teachers in Singapore, Australia, South Africa and the United States of America used TPACK successfully in their classroom teaching work.

According to Goodwin (2012) in Maher (2013), primary school teachers' application of TPACK led to the use of Ipad in teaching many subjects like Mathematics, English, Drama, Geography, History, Environmental studies, Art and Physical education in South Africa. Among many other uses teachers in Botswana applied TPACK effectively in classroom management and self-reflection.

Gluck, et al. (2014) state that secondary school teachers in the United States of America used TPACK to motivate students to like Chemistry. Use of TPACK helped students to understand and retain several concepts of Chemistry. ICT tools used by the same secondary school Chemistry students include digital library, virtual chemistry laboratory, cloud on, u pad, iPad and Iphone. Saini, et al. (2014) cite increased use of internet and web- based instruction system among undergraduate and graduate education and training programmes in India. Mosalanejad, et al. (2012) further state that internet based learning methods are fast substituting the traditional classroom methods and they promote virtual network learning environment. An experiment conducted with 86 undergraduate nurses in Turkey showed that theoretical and practical courses were taught successfully using virtual learning systems. Furthermore, Tai, Pan and Lee (2015) state that TPACK model was successfully used to teach online English lessons for foreigners to student nurses at a University in Taiwan. Several clinicians and medical doctor students were reported to be increasingly using smart phones and tablets for classroom and laboratory learning purposes. Application of TPACK in university technical and vocational education is at a lower level when compared with that of Malaysia and Singapore (Shu'aibu, et al., 2013). Most technical and vocational education teachers used ICT tools mainly for managerial purposes but their use in teaching safety rules and workshop practice skills is increasing. In Nigerian higher education institutions TPACK is being used to teach technical and engineering related fields (Mumcu and Usluel in Shu aibu et al., 2013).

RESEARCH QUESTIONS

1. What is the status of technological pedagogical and content knowledge among engineering educators?
2. How do engineering educators view technological pedagogical and content knowledge with respect to improvement of quality of technical and engineering education?
3. What are engineering educators perceived usefulness of ICTs in teaching and effective strategies for integrating technological pedagogical and content knowledge in technical and engineering education

METHODOLOGY

Twenty engineering lecturers from the School of Engineering and Technology at a university in Zimbabwe were purposefully sampled for the case study. The university's niche area is in the fields of engineering. Therefore, purposive sampling used in this case entailed selecting information rich participates (Cohen, et al., 2011) thereby increasing data utility (Gray, 2011). The lecturers were selected from the fields of chemical processes and systems engineering, electronic engineering*,* polymer engineering and technology and industrial manufacturing and engineering.

Mixed research methods, where both quantitative and qualitative data are collected and analysed (Nyawaranda, 2014; Gray, 2011; Leech & Onwuegbuzie, 2009) to bring out detailed and insightful explanations (Denscombe, 2008) into the status of TPACK knowledge among technical and engineering educators and how it impacts on the quality of engineering education, were used for the case study. As a case study, the researchers aimed at bringing forth the nature of engineering educators' view with regard to technological pedagogical content knowledge at university where this study was carried out. However, though it might have been necessary, statistical comparisons among lecturers in the various engineering fields was not part of the scope of this particular research but left out for future studies.

The mix of methods for this study was in the form use of a self-designed and administered questionnaire with closed items which generated quantitative data in the form of frequencies of participants' responses for each aspect investigated. Follow-up interviews generated qualitative data. In the use of a mix of different research methods and modes of analysis, we concur with Feilzer (2010) that it aims at producing meaningful knowledge.

The questionnaire with three sections with items on Likert scale was used. However, each of the investigated aspects (1) status of TPACK, (2) perceived impact of TPACK on quality of technical and engineering education and (3) perceived effective methods of integrating TPACK in engineering education among engineering educators, had its own specific measurement scale. Descriptive statistical analyses were performed using SPSS to determine the prevalence of the afore-mentioned attributes among the lecturers using frequencies and means.

Follow-up interviews with engineering educators were also conducted to triangulate questionnaire data. According to Nyawaranda (2014) triangulation of methodological techniques can be done at different levels, and of these levels, this research made use of multiple data sources (questionnaires and interviews) and analysis (quantitative and qualitative) methods in a complementary manner.

RESULTS AND DISCUSSION

Engineering educators' general knowledge about pedagogy and technology

The results of the study show that most of the lecturers were confident of their pedagogical competencies. 70% of the respondents agreed that they knew how to select effect teaching approaches to guide students thinking and learning in science and mathematics. Only 20% were not sure about how to select effective teaching approaches. On the use of technology to enhance students understanding, 75% of the respondents agreed that they were able to choose technologies that enhance students' learning whilst 10% were not sure. 55% responded that they were critically thinking about how they can use technology in teaching while 60% agreed that they could adapt the technology they were using to different learning styles.

Table 1: *The results of the lecturers' knowledge about pedagogy and technology (N=20).*

Statement	Not sure *f (%)*	Agree *f (%)*	Strongly agree *f (%)*	Disagree	Strongly Disagree
I know how to select effective teaching approaches to guide students thinking and learning in science/mathematics	4 (20)	14 (70)	2 (10)	0 (0)	0 (0)
I can easily select the suitable teaching approach for a given topic	3 (15)	13 (65)	4 (20)	0 (0)	0 (0)
I can choose technology that enhances content for a lesson I teach	5 (25)	12 (60)	3 (15)	0 (0)	0 (0)
I can choose technologies that enhance students' learning for a lesson	2 (10)	15 (75)	3 (15)	0 (0)	0 (0)
I know about the technology I can use for students' understanding and doing science/mathematics	3 (15)	13 (65)	4 (20)	0 (0)	0 (0)
I am thinking critically on how I can use technology in teaching	6 (30)	11 (55)	3 (15)	0 (0)	0 (0)
I can adapt the use of technology that I am using to different learning activities	6 (30)	12 (60)	2 (10)	0 (0)	0 (0)

Frequency of using technology

Table 2: *Lecturers' use of technology (N=20)*

Statement	Never	Less than half the time	About half the time	More than half the time	Almost always
	f (%)	*f (%)*	*f (%)*	*f (%)*	*f (%)*
to facilitate teaching specific concepts or skills	1 (5)	2 (10)	4 (20)	9 (45)	4 (20)
to support various students learning styles and personalise learning	2 (10)	3 (15)	6 (30)	4 (20)	5 (25)
to facilitate teaching pupils with disabilities (cognitive, physical, etc)	8 (40)	1 (5)	3 (15)	6 (30)	2 (10)
to support activities that facilitate higher order thinking	3 (15)	3 (15)	2 (10)	6 (30)	6 (30)
to support creativity	2 (10)	3 (15)	1 (5)	8 (40)	6 (30)
to foster pupils' ability to use technology in their learning	2 (10)	2 (10)	4 (20)	4 (20)	8 (40)
support students' interest in science and mathematics	3 (15)	1 (5)	1 (5)	8 (40)	7 (35)
enhance students' interest in science and mathematics	1 (5)	2 (10)	2 (10)	9 (45)	6 (30)
Use of technology for communication and or networking (colleagues and students)	1 (5)	4 (20)	1 (5)	4 (20)	10 (50)
Use of technology for own development and learning	1 (5)	1 (5)	4 (20)	4 (20)	10 (50)
for organising your work and keep records	1 (5)	3 (15)	3 (15)	5 (15)	8 (40)
for digital learning resources	2 (10)	1 (5)	4 (20)	1 (5)	12 (60)
for preparing lessons	1 (5)	1 (5)	4 (5)	3 (15)	11 (55)
for designing your own digital learning resources	2 (10)	4 (20)	3 (15)	2 (10)	11 (55)

The results show that the use of technology for various teaching and learning activities was very high among university lectures as shown in Table 2.

The results show that there is a very high frequency in the use of technology for digital learning resources, lesson preparation, communication and networking, record keeping as well as for personal learning and development. There is however, low use or the use of technology to support students with disability.

Confidence in the use of technology for various teaching and learning activities

As shown in Table 3 most of the lecturers show high levels of confidence in the use of technology for the various aspects of teaching and learning.

Table 3: *Levels of lecturers' confidence in working with technology (N=20)*

Statement	Not Confident	Somewhat confident	Confident	Very confident
	f (%)	*f (%)*	*f (%)*	*f (%)*
Use technology for communication and/networking with students	3 (15)	3 (15)	8 (40)	6 (30)
Use technology for communication and/networking with parents	3 (15)	3 (15)	7 (35)	7 (35)
Use of technology for own development and learning	2 (10)	1 (5)	5 (5)	12 (60)
for organising your work and keep records	1 (5)	1 (5)	8 (40)	10 (50)
for preparing lessons	1 (5)	1 (5)	9 (45)	9 (45)
for finding digital learning resources	1 (5)	3 (15)	7 (35)	9 (45)
for designing and producing own digital learning environment	1 (5)	4 (20)	6 (30)	9 (45)
Your future integration of technology to facilitate teaching specific concepts or skills	1 (5)	2 (10)	8 (40)	9 (45)
Your future integration of technology to support various students' learning styles and to personalise learning	2 (10)	3 (15)	7 (35)	8 (40)
Your future integration of technology to facilitate teaching pupils with disabilities (cognitive, physical, etc.)	3 (15)	4 (20)	6 (30)	7 (35)
Your future integration of technology to support activities that facilitate higher order thinking	3 (15)	2 (10)	9 (45)	6 (30)
Your future integration of technology to support creativity	3 (15)	2 (10)	8 (40)	7 (35)
Your future integration of technology to foster pupils ability to use technology in their learning	1 (5)	3 (15)	9 (45)	7 (35)
Your future integration of technology to access web information sources e.g. Google & ERIC Educational resources, etc.	1 (5)	1 (5)	8 (40)	10 (50)

The responses show that lecturers' confidence in the use of technology for various aspects of teaching was high. For example 90% of the respondents expressed confidence in the use of technology for record keeping (40% and 50% confident and very confident respectively). Another 90% expressed confidence in the use of technology for lesson preparation whilst as well as for accessing web information. A high number of respondents (85%) expressed confidence that they would use technology in their future teaching endeavors whilst 80% were confident they will use technology to foster student ability to use technology as well as finding digital learning material.

Ability to integrate technology, pedagogy and content

Table 4 shows the lecturers' ability to integrate the three elements of TPACK

Table 4: Educators' integration of technology, pedagogy and content

	Strongly agree	Agree	Not sure	Disagree	Strongly Disagree
I can teach a lesson that combine science/mathematics, technology and teaching approaches	3 (15)	10(50)	7(35)	0 (0)	0 (0)
I can use strategies that combine content, technology and teaching approaches that I learnt at college in my own teaching	2 (10)	11 (55)	7 (35)	0 (0)	0 (0)
I can choose technology to use in my classroom that enhances what I teach, how I teach and what students can learn	2 (10)	12 (60)	6 (30)	0 (0)	0 (0)
I can provide leadership in helping others to coordinate the use of content, technology and teaching approaches at my school	4 (20)	8 (40)	8 (40)	0 (0)	0 (0)

Whilst most lecturers agreed that they could integrate the three components (technology, pedagogy and content) a significant number was not sure. For example 40% of the respondents were not sure if they could help other to coordinate the use of TPACK.

Engineering lecturers view Technological Pedagogical and Content Knowledge with respect to improving of quality of technical and engineering education

Engineering educators viewed TPACK as an enhancement to the improvement of quality of technical and engineering education. The results show that 70% of the engineering educators expected to integrate technology in their teaching. Also 55%of them stated that technology has a very high contribution towards students' learning. Evidence to this effect is seen among the following responses made by some of the engineering educators:

> *I expect to integrate technology to support students in learning complex concepts almost always (lecturers 14, 16 and 18 - 20).*
> *I expect to integrate technology to enhance students' interest in science and mathematics almost always (lecturers 16 and 18 - 20).*
> *I expect to integrate technology to support creativity almost always (lecturers 14 and 17 – 20).*
> *Technology has a very high contribution to learning (lecturers 4, 6 – 7, 12 – 14 and 17 – 20).*

Engineering lecturers' expectation to integrate technology in several teaching activities for almost always suggests their understanding TPACK's effectiveness.

Engineering educators' perceived usefulness of ICTs in teaching and effective strategies for integrating technological pedagogical and content knowledge in technical and engineering education

The study revealed that lecturers (85%) perceive ICT use in their teaching as contributing to the quality of engineering teaching and learning as it both capacitates lecturers and students. This is evidenced by the responses from some lecturers as follows:

> *I have noticed an improvement of use of online resources among my students. (Lecturer 10)*
>
> *ICT promotes independent learning and develops among students higher order thinking skills, cooperative learning through improved information sharing ICT tools such as e-mails and social media platforms. (Lecturer 16)*

However, the lecturers think that continuous in-service training on new technologies for teaching enhances uptake of use in their teaching as well as among learners.

> *I think professional programmes such as the Postgraduate Diploma in Tertiary Education may be appropriate for us who have no education background. (Lecturer 3)*

Such programmes as mentioned by one of the lecturers as above capacitate lecturers' integration content knowledge, methods, and technologies for improved quality of technical and engineering pedagogies that promote creativity and innovation among learners.

Lecturers also perceive that increased use of ICT for learning among learners may be achieved through infusing information literacy skills in courses such as communication skills and educational technologies or IT courses.

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

The engineering educators' general appreciation of TPACK was satisfactory. Most of them are quite competent in the individual components of TPACK especially on content and technology. Their pedagogical knowledge was lagging behind knowledge of content and technology. Engineering educators' lag in pedagogical knowledge implies that they lack training in pedagogy which is tenable at teachers' training colleges. Engineering educators' high competency in content and technology components implies that they are highly trained in their own field of specialization and have been using technology for most of their teaching. Whilst engineering educators' knowledge about the individual components of TPACK was good, there was a general lack of understanding of the dynamic equilibrium that exists among technology, pedagogy and content. Lack of understanding of the dynamic equilibrium among technology, pedagogy and content by engineering educators is further evidence of their lack of hands-on practice in pedagogy (teaching practice that is done during teacher training).

Engineering educators' intention to integrate technology in future ranked highest in things like record keeping, communication with students and finding e-resources, whilst critical ones like higher order thinking and creativity ranked low. This implies engineering educators' limited knowledge and skills of using technology to develop students' cognition. Engineering educators indicated that technology can be used to facilitate learning of students with physical and cognitive deficiencies. However, there was low percentage of educators who intended to use technology in facilitating learning of students with physical and cognitive deficiencies. This scenario implies a lack of pedagogical skills and knowledge to deal with challenged students on the part of engineering educators.

The aforementioned research findings and implications lead to the following recommendations:

- Whilst this research study focused on status of TPACK at a selected university in Zimbabwe, statistical comparison of findings from engineering educators elsewhere may guide the current and future global education leaders.
- Certified old school engineering educators and the new but uncertified engineering educators need training in pedagogy, especially of higher education learners. This can be done either by full time or part time studies with teacher training colleges.
- Teacher training colleges' curricula must include innovative teaching methods and software development skills that enhance a culture of educational technology.
- Teacher training colleges' curricula must train engineering educators in pedagogy for the challenged students. Studies on inclusive education courses can equip the learner educators with moderate skills.

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