

Integrating Technological Pedagogical Content Knowledge Among Pre-Service Science and Mathematics Teachers in Nigerian Universities

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Abstract

This paper explored the ways in which pre-service teachers at the Universities and Colleges of Education can develop the knowledge of integrating technology pedagogy and content in Science and Mathematics teaching because it is not learning how to use technology which improves an understanding of Science and Mathematics but the manner in which technology is used to support learning. Teachers can develop technological pedagogical content knowledge (TPACK) when they engage in learning activities which reflect the real teaching process. This implies that teachers' TPACK can be developed by engaging them in a real-life learning process which involves hands-on activities rather than the theoretical learning and there is need to pay more attention on preparing pre-service teachers for integrating technology in classroom practice lesson delivery because most science teachers in Nigeria have not shown adequate knowledge in TPACK. This paper tried to identify and examined the problems and prospects of integrating technological pedagogical content knowledge among pre-service science and mathematics teachers and some of its prospects in Nigeria universities. Recommendations were proffered and conclusion drawn.

Keywords: Integration Technological Pedagogical Content Knowledge, pre-service teachers.

Introduction

Technology integration in teaching is currently attracting the attention of educators, curriculum developers and policy-makers. Governments in both developing and developed countries are investing in research on how students' learning outcomes can be maximized through the use of technology (Graham, 2011). Previously, the attention was on how to bring technology into education and studies were more focused on the importance of technological tools' availability, teachers' technological skills and teachers' attitude towards technology (Christensen & Fluke, 2003). However, studies by Graham (2011) and Niess, Ronua, Shafer and Johnson (2009) have shown that bringing technology into education does not improve students' learning outcomes; thus what matters is how technology is integrated with pedagogy and content. Researchers (Keong, Horani & Daniel, 2005; Tilya, 2008; Niess et al, 2009;) have indicated the ways through which effective integration of technology in teaching and learning can enhance students' understanding of basic concepts in Science and Mathematics. According to Keong et al (2005), when Information Communication Technology (ICT) is properly integrated in Science and Mathematics classrooms, it can help improve learning through increased collaboration and a high level of communication and sharing of knowledge among students. Teachers can also provide rapid and accurate feedback to students and allow them to focus on strategies and the interpretation of answers rather than spending time on tedious computational calculations. Tilya (2003) and Voogt (2003) assert that the constructivist learning approach is enhanced when technology is used in teaching. In constructivist learning, students use technology to explore and reach an understanding of mathematical concepts by concentrating on the problem-solving process rather than on calculations related to the problems. Kohler and Mishra (2009), indicate that it is not learning about how to use technology which improves an understanding of Science and Mathematics, but the manner in which technology is used to support learning.

Thus, Meagher and Edwards, (2010) Niess et al (2009), Ozgun-Koca, and Webb (2008) propose that when teachers decide to use technology, they need to consider the Science or Mathematics

content they will teach with the technology and the pedagogical methods they will employ. Niess (2005) sees the existing failure in Science and Mathematics teaching as resulting from the teachers' poor knowledge of the subject content and instructional strategies and their poor representation of particular science or mathematical topics supported by digital technology to demonstrate and verify, drill and practice. According to Kafyulilo (2010), access to technology without the necessary knowledge of related Science and Mathematics curriculum materials does not have an impact on students' learning outcomes. As a result, Mishra and Koehler (2009) insist on the need for teachers to know, not only the subject matter they teach or the technology, but also the manner in which the subject matter can be changed by the application of technology in a given pedagogical approach. Teachers are, therefore, required to develop the knowledge of various technologies and in addition to know how Science and Mathematics teaching might change as the result of using particular technologies (Koehler & Mishra, 2009). Studies by LeBaron, McDonough and Robinson (2009), and Niess et al (2009) have revealed the overarching conception that teachers' beliefs about how to teach Science and Mathematics are generally aligned with how teachers learned the subjects at the teacher training college. Teachers who learned to solve Science and Mathematics problems by using graphing calculators, spreadsheets and some learning software are among the few who can embrace the use of those tools in teaching these subjects (Niess et al, 2009). Researchers (LeBaron, McDonough & Robinson, 2009; Kirschner, Wubbels & Brekelmans, 2008) are questioning the efficacy of teacher preparation for effectively using technology in schools.

Angeli (2005) report that pre-service teachers are still learning about technology, pedagogy and content as independent subjects, not as integrated knowledge. In this way, teachers have been prepared to teach technology as a discipline rather than use it as a tool with which to enhance students' learning (Jimoyiannis, 2010; Schmidt et al, 2009). According to United Nations Educational, Scientific and Cultural Organization (UNESCO 2008), teachers should not only learn how to teach Information and Communication Technology (ICT) but also how to apply it in teaching to enhance students' learning. In fact, teachers should be prepared to change their orientation from thinking they would teach technology to thinking they would use technology to support students' learning (Kirschner et al, 2008 & Webb, 2008). To develop this thinking among teachers, technology integration in teacher education should provide pre-service teachers with hands-on experiences as they explore how to use ICT and its applications in their teaching and learning. Education courses should, therefore, model technology integration and field experiences in technology-rich classrooms.

Over the last decade, in light of rapid technological advancement, traditional educational practices in teacher education no longer provide prospective teachers with all the necessary skills for teaching students to cope with society in the 21st century. As a part of the change, there is need for high quality teaching competency. To this end, there is a growing body of research to find ways to enhance pre-service teachers' preparedness in integrating technological tools into their classroom teaching practices for specific subject domains. The challenge for teacher education this century is to discover effective ways to prepare literate pre-service teachers and also to professionally develop in-service teachers. For science education, the current educational reforms encourage science teachers to integrate educational technology and inquiry-based teaching into their instruction for adding efficiency and value to both teaching and learning (Guzey & Roehrig, 2009, 2012). In the science education community of practice, there is a wide range of efficient technological environments and applications that can serve science teaching and learning (e.g. animations, simulations and modeling tools, microcomputer based laboratories (MBL), intelligent tutoring systems, web resources and environments, spreadsheets, scientific databases, etc.) for both students and teachers. Many researchers have advocated the educational potential of ICT-based learning environments in science education, arguing that they provide opportunities for active learning, enable students to perform at higher cognitive levels, support constructivist learning, and promote scientific inquiry and conceptual change (Jimoyiannis, 2010). It is however, still not clear how best to prepare science teachers who are competent in using and managing educational technologies to support their teaching practice and

enhance students' understanding of science concepts. The existing research reports suggest that experienced teachers seem reluctant to incorporate educational technology in schools, while pre-service teachers and newly qualified teachers are more confident users of educational technology in classroom and are more willing to learn and adapt educational technology in their classroom practices. A major obstacle of experienced teachers for using technology in the classroom is the lack of sufficient knowledge and skills of information and communication technology (ICT) (Efe, 2011). To overcome this obstacle, Smarkola (2008) has suggested training pre-service teachers in educational technology during their initial teacher education. In addition, they can gain more confidence in using technology in their classroom teaching. To do so they will require a reasonable level of generic skills for integrating technology into classroom teaching in order to use computers as a part of the curriculum and a tool for authentic students engagement and learning (Sime &Pristley, 2005; Smarkola, 2008).

The concept of TPACK

Effective teaching with technology requires that teachers understand the content they want to teach, the pedagogy which is concurrent with the content of the subject to be taught and the technology that can support students' learning in a certain context. According to Koehler and Mishra (2009), teachers' knowledge of content, pedagogy and technology forms the heart of good teaching with technology, a process that has come to be known simply as TPACK, standing for Technological Pedagogical Content Knowledge.

TPACK has been touted as *“the basis of effective teaching with technology, requiring an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones”* (Koehler and Mishra, 2009).

The term TPACK, which was previously known as TPCK (Koehler & Mishra, 2005), provides the knowledge base needed by teachers to incorporate technology in their teaching (Guzey & Roehrig, 2009). According to Niess (2005), for technology to become an integral component in the teaching and learning process, pre-service teachers must develop an overarching conception of their subject matter with respect to technology and teaching approaches. The interplay between the various components of TPACK—technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and pedagogical content knowledge (PCK), as indicated in Figure what makes effective teaching with technology possible (Mishra & Koehler, 2006; 2009).

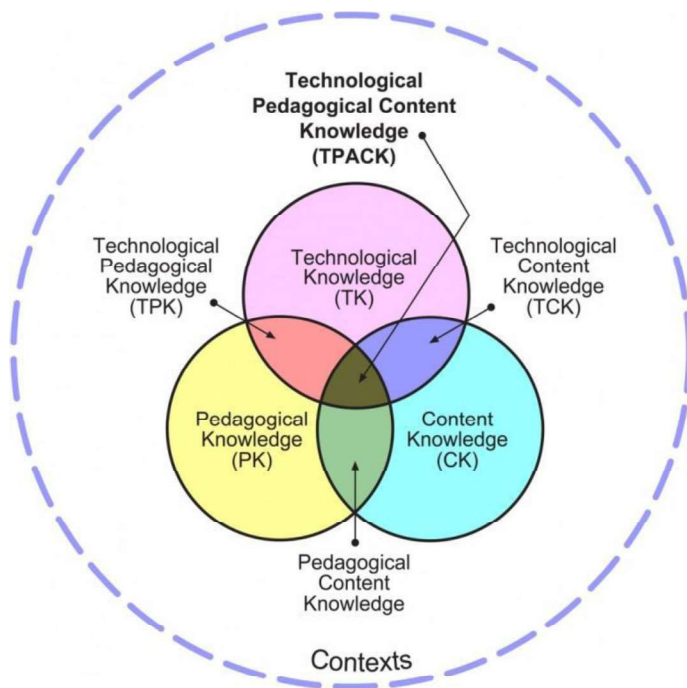


Figure 1: TPACK framework (Koehler & Mishra, 2009)

The different components of TPACK are described as follows:

Technological Knowledge: Technological knowledge is the knowledge of various technologies, ranging from low-tech technology, such as pencil and paper, to digital technology, such as the internet, digital video, and interactive whiteboard (Schmidt et al, 2009). Technological knowledge is related to the ability of the teacher to use hardware and software to deal with learning problems (Harris, Mishra & Koehler, 2009). However, Koehler and Mishra (2009) argue that technology is always more in a state of flux than content and pedagogy. What is seen as new technology today may become old technology soon after or in subsequent years; thus, it is difficult to provide a clear definition of technological knowledge.

Content Knowledge: This is the knowledge of the actual subject matter that is to be learned or taught (Mishra & Koehler, 2009). Content knowledge is about the knowledge a teacher possesses in the Mathematics or Science subjects he/she teaches. Kohler and Mishra (2009) describes this as including the knowledge of concepts, theories, ideas, organizational frameworks, scientific facts and theories, knowledge of evidence and proof, as well as established practices and approaches for developing such knowledge.

Pedagogical Knowledge: This describes the knowledge of the teacher on the processes and practices of teaching and students' learning, encompassing educational purposes, goals, values, and strategies (Koehler & Mishra, 2009). According to Koheler and Mishra, pedagogical knowledge encompasses the broad spectrum of teaching approaches, from planning the lesson to students' assessment. It includes knowledge about the techniques or methods used in the classroom, the nature of the learners' needs and preferences, and strategies for assessing students' understanding (Harris, Mishra & Koehler, 2009).

Pedagogical Content Knowledge: This refers to the content knowledge that deals with the teaching process. Pedagogical content knowledge blends both content and pedagogy, with the goal of

developing better teaching practices in the content area (Schmidt et al, 2009). Koehler and Mishra (2009), adopting the idea of Shulman, describe PCK as the transformation of subject matter for teaching, which occurs when a teacher interprets the subject matter and finds various ways of presenting it, and adapts and tailors the instructional materials to alternative conceptions and the students' prior knowledge.

Technological Pedagogical Knowledge: This is about the teachers' understanding of the way teaching and learning can change when particular technologies are used in particular ways (Koehler & Mishra, 2009). It is the knowledge of how various technologies can be used in teaching as well as an understanding that using technology may change the way teachers teach (Schmidt et al, 2009). A teacher should know where and how a particular technology can be used to enhance teaching given subject matter (Koehler & Mishra, 2009; Niess, 2005). An example of technological pedagogical knowledge may include the use of an interactive whiteboard to engage students in the process of interacting with the materials in the process of learning.

Technological Content Knowledge: This is the knowledge of how technology can create new representations for specific content. According to Koehler and Mishra (2009), "understanding the impact of technology on the practices and knowledge of a given discipline is critical to developing appropriate technological tools for educational purposes". It is also about understanding the manner in which technology and content influences and constrains one another. Teachers tend to master not only the subject matter but also the manner in which the subject matter can be changed by the application of particular technology (Koehler & Mishra, 2009).

Technological, Pedagogical and Content Knowledge: This refers to the knowledge required by teachers for integrating technology in their teaching and content area (Schmidt et al, 2009). Koehler and Mishra (2006, 2009) argue that, by simultaneously integrating knowledge of technology, pedagogy and content, expert teachers bring TPACK into play whenever they teach.

They also argue that "*there is no single technological solution that applies for every teacher, every course, or every view of teaching. Rather, solutions lie in the ability of a teacher to flexibly navigate the space defined by the three elements of content, pedagogy and technology and the complex interactions among these elements in specific contexts (p. 66)*".

Schmidt et al (2009) describe TPACK as a useful framework for thinking about what knowledge teachers must have to integrate technology into teaching and how they might develop this knowledge. They further argue that measuring teaching knowledge could potentially have an impact on the type of training and professional development experiences that are designed for both pre-service and in-service teachers.

Conclusion

In conclusion, in order to provide a better and effective science and mathematics teaching, firstly the pre-service science and mathematics teachers should be equipped with the required skills for integrating technological pedagogical content knowledge for teaching science. This can be achieved by devoting more time and effort for professional development for technology integration. In addition, teaching education programs should offer pre-science teachers with courses teaching technology in contexts that focus on the relationship among technology, content and pedagogy, mainly rather than giving superficial theoretical knowledge of technology integration, the pre-service science and mathematics teachers should be provided more practice both in class and in practicum at schools. By having the sufficient knowledge and skills for technology integration, the teachers will have high self-confidence and motivation which will enable them to integrate technology more into their lessons. Finally, the technological infrastructure and facilities at schools and faculties should be improved so that teachers can apply their knowledge and skills for a better and effective learning environment.

Recommendation

Teachers play a critical role in education development. Thus, they are demanded to master the required knowledge for successful teaching and learning process. The findings revealed that teachers seem to have some problems in technology mastery. Therefore, it is recommended for authority and technology experts to cooperate in facilitating teachers to acquire such knowledge. And secondly pre-service science and mathematics teachers should be adequately and effectively trained on how to integrate technology in teaching and learning of science.

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