How important is technological, pedagogical, content knowledge? A literature reviews

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Abstract. Technological, Pedagogical, Content Knowledge (TPACK) is a conceptual framework that teachers can effectively incentivize as technology is ubiquitous. Technology infusion in a specific educational context is beneficial if pedagogy and content are effectively aligned it. Educators need to be competent in all three domains for optimum output. This study was limited to 10 peer reviewed journal articles published between 2015 and 2018. The purpose was to review the theoretical foundations and applicability of TPACK. The results revealed different understandings of TPACK. Educators’ perception about Content knowledge, Pedagogy knowledge and Technology knowledge imply that the three domains are inseparable. For optimum development of TPACK in educators, educators should be engaged in designing technology supported lessons. This implies educators should adjust to the needs of industrial revolution 4.0 in the classroom.

1. Introduction
The technology pedagogical content knowledge (TPCK) conceptual framework was first designed by Koehler and Mishra in 2005 [1]. Its development was meant to explain knowledge foundation for teachers to integrate technology during the teaching process. The concept TPCK was developed from the work of Shulman’s PCK work [2]. PCK was considered a necessary ingredient for a teacher’s professional development, that is teachers are expected to infuse the content domain together with the pedagogical strategies so as to enhance subject understanding by learners. The addition of technological knowledge (TK) is invaluable to teacher’s profession.

The TPCK was later changed to TPACK which means ‘Total PACKage” for adequately teaching with technology [3]. TPACK shows the vital forward and background linkages of three fundamental knowledge domains namely content knowledge (CK), Pedagogical Knowledge (PK) and Technological knowledge (TK).
Figure 1. Linkages of PK, CK and TK.

However, Mishra and Koehler discovered lack of logical and world-wide definition of knowledge amongst Technology, Pedagogy and Content [1]. Furthermore, related criticism was centered on the difficulty associated with distinguishing pedagogical knowledge and content knowledge [4].

There are some already existing literature reviews that focused on TPACK for instance Wu (2013) study of 24 articles. Chai et al (2013), study of 74 articles, Voogt et al (2013) study of 56 journal articles and Willermark et al (2017) study of 107 peer-reviewed to mention a few [4] [5]. The TPACK framework is still attracting interest of both emerging and seasoned researchers as evidenced by the latest publications. The purpose of this study is to add to the existing TPACK body of knowledge through reviewing TPACK articles published from 2015-2018.

1.1. Research questions
- What are the basic characteristics of latest TPACK articles?
- How is the TPACK framework incentivized in knowledge evaluation?

1.2. Theoretical view
TPACK is very instrumental in the teaching field as justified by many studies on its relevance. Previous studies dwelt on pre-service and in-service teachers’ abilities to deliver within the TPACK context following inventions and professional development programs [6] [7]. According So and Kim (2009), having technological knowledge does not imply ability to apply technology skills [4] [8] [9]. Knowledge is concerned with teachers’ possession of concepts, rules and procedures while TPACK competence focuses on teacher action which can be continuously developed. Competence develops through planning, implementing and evaluating teaching activities. TPACK can be classified as knowledge or competence.

2. Method
The first step involved searching of TPACK in several reliable, high quality databases namely Elsevier, Sage Publication, IEEE and John Wiley and Sons. The search was confined to articles accepted between 2015 and 2018. They were mainly from Computer and Education journal, Journal of
Computer Assisted Learning, Journal of Education Computing and British Journal of Educational technology. Both theoretical and empirical based articles were deliberately selected and downloaded for review purpose. Selected articles were screened on the basis of TPACK tittles, content and abstracts. The final list of screened journals was 10 after full-text reading and analysis. For this review, selection of articles was limited to:

- Alignment of research question/objectives with data sources and data analysis
- Discussion of instruments and data collection
- Discussion of data analysis and procedures

Articles which satisfied all the three conditions were regarded as good quality and dropped were articles which failed on one or all the conditions. A spread sheet was incentivized to analyze the articles and retrieve data to do with study characteristics. All articles were solely analyzed by the reviewer. For this analysis the following sub-themes were opted to explain TPACK theoretical understanding: Participants, Context, Types of data and basic findings. The research topic was not predetermined prior to the review but emerged ground-up from the data.

3. Results

3.1. Pre-service teachers

The identified research topics appeared to cluster into two main categories namely pre-service perception and in-service perception of TPACK. Previous research alluded that, there was a significant positive correlation of self-reporting (SR) TPCK and reported personal computer use frequency r (82) =0.82, p=0.04. According to the regression results, there was significant amount of explained variance 41% (adjusted R^2) in the final regression model [10]. The data was harnessed from 82 pre-service teachers (mean=24.85, SD=4.36). Three online questionnaire surveys were administered after every two weeks. Student teachers were able to construct teaching videos and they were enthusiastic to integrate technology.

Another research was conducted on 215 pre-service teachers in their final year in three universities in Turkey (146 males and 69 females), it was found that educators were instrumental in motivating the pre-service teachers’ attitude on ICT integration in the classroom. The more lecturers (teacher educators) applied the SQD-model strategies (role model, collaboration, instructional design, reflection), the more TPCK-practical levels increased [11]. This was consistent with several similar TPACK research findings.

A similar research was also conducted on 54 pre-service biology teachers (21 males, 33 females). Data was collected in 4.63 months. It was found that most pre-service teachers incentivized the Just in Time support materials. Provision of additional support for integration of technology with pedagogy and content was found to be highly beneficial [12]. If teachers are aided with technological tools, they are compelled to utilize them.

Another research on 51 first semester nursing students taking nursing course at Taiwan University revealed that TPACK model was exhaustive and enhanced nursing students’ English writing performance. All post-test averages (mean) were higher than pre-tests and it showed technology aided learning was essential. Learning progress was statistically significant [F(6,45)=158.37, p<0.000] [13]. The findings are consistent with most TPACK research findings conducted on pre-service teachers.

A similar study on 99 teachers( 52 pre-service and 47 in-service) science teachers revealed that there was no much difference between in-service and pre-service teachers’ TPACK-Practical skills in terms of simple adoption and infusive application [14].

3.2. In-service teachers

A study from 86 responses was sought from K-12 teachers and tertiary instructors (47 teaching in the USA, 39 in Saudi Arabia). It was found from SR (self-reporting) that both teachers from the two countries highly rated Pedagogy knowledge, and Saudi Arabia teachers highly rated TPACK more than their American counterpart [15]. There was an overall agreement that a vibrant teacher should not
only have the Technological, Pedagogical and Content knowledge but should be competent in all three domains.

A learning environment was co-designed, enacted and refined by 4 Chinese University language teachers. It was applied to 259 primaries 3 students between August 2011 and November 2012. The findings from the user acceptance tests proved that MyCloud 1.1 environment was easy to use and the general efficacy of the platform was supported [16].

A similar study was limited to 25 fifth graders, 1 principal, 4 parents and 4 female experienced teachers (9-12 years) aged 36-45 in an Israeli primary school. Results revealed that tablet use is ideal in out of school setting due to tablet technical limitations. Tablets were found to enhance “learning by doing” and student interest but in an out of school set up [17]. This was inconsistent with other findings from similar researches which concur with the incremental effect of e-gadgets on the performance of learners when used in the school [16].

Another study made up of 37 Singapore primary school teachers (30 females, 7 males) who were put into 7 design teams. 5 out of 7 design teams confirmed that they learned new technological tools that enhanced student learning process [18]. This is consistent with other similar research work which revealed that teacher’s technological competence pave way for virtual learning and result in improved output [10] [11] [12] [15] [16][17].

A study conducted on 32 mathematics teachers before training revealed that there was minimal use of technology and dropouts were extremely high. A subsequent study of 6 tutors showed that messages of encouragement, praise, comfort, correction were invaluable in mitigating course dropouts and integration of technology can motivate student in addition to making the duties of teachers easy as revealed by similar TPACK research findings [19].

4. Discussion and conclusion
The purpose of the paper was to present a review of hitherto published empirical studies focusing on the importance of TPACK to both in-service and pre-service teachers with the intention of summarizing several study results and refocusing future research direction. The conducted review suggests that the past researches dwelt on the impact of TPACK on students, pre-service and in-service teachers. Overall previous findings show that all make up components of TPACK are vital for optimum outcome in the classroom. The review also found that most studies to date have focused on Anglo-American and Singaporean pre-service and in-service teachers.

The use of technology knowledge (TK) is increasingly ubiquitous in schools, colleges and universities. There is therefore great need for more research on TPACK so as to optimally infuse technology in the learning systems. Pedagogy Knowledge, Content Knowledge and Technological Knowledge should be aligned through administering refresher courses for in-service teachers and technology aided training of pre-service teachers [18].

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