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Historical Development of Technology Integration in Teaching Learning: From PCK to TPACK

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Abstract
Technology plays a crucial role in almost every aspect of our lives, including education. During the first two decades of 21st century, there is a paradigm shift in educational practices where technology became instrumental in increasing access and improving the quality of education with new models of educational environments. The aim of this study is to look at the historical development of technology integration in teaching learning from Shulman's pedagogical content knowledge (PCK) to technological pedagogical content knowledge (TPACK) by Mishra and Koehler, 2006. Technology integrated learning environment has been regarded as the prerequisite for active, authentic, collaborative, and constructive learning (*Howland*, David *Jonassen*, *and* Rose M. *Marra*, 2013). Teachers' knowledge of content and pedagogy separately is not sufficient for effective teaching. A fine interplay between pedagogy and content knowledge formulates new type of competencies i.e., pedagogical content knowledge (PCK), that are exclusive to teachers, rather than subject area experts or experts having an unquestionable understanding of students' psychology (Shulman, Knowledge and Teaching: Foundations of the New Reform, 1987). After twenty years, Mishra and Koehler (2006) extended the model of Shulman to incorporate technology as the third domain and shaped technological pedagogical content knowledge (TPACK). TPACK combines teachers' knowledge of general pedagogy, subject matter content, and technology (Harris and Hofer, 2009). This study tries to trace Historical Development of Technology Integration in Teaching Learning: From PCK to TPACK.

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Keywords: Technology integrated teaching learning, information and communication technology, pedagogical content knowledge (PCK), technological pedagogical content knowledge (TPACK)

Introduction

Educational research has been centered round the knowledge that educators should have for effective teaching learning. The primary objective of teacher education programmes has been either the development of a teacher candidate's subject-matter expertise for overall pedagogical growth in classroom practices. In the 1980's and 1990's different epistemological perspectives were used in research on knowledge for effective teaching bringing significant changes in how we perceive teachers' knowledge to be specialised. Shulman with his rigorous work (1986a; 1986b; 1987) made a balance between pedagogical knowledge and content knowledge. He presented one of the most cited and influential notion of pedagogical content knowledge (PCK) setting up the base/laid the foundation for a line of study in the field of teacher education prompting a large number of research studies. From the outset, numerous researchers have examined Shulman's PCK framework using various techniques in various areas of education. It prompted a large number of studies with several new dimensions. The early 2000s saw the emergence of technology in the literature on educational technology (Niess, 2005; Angeli & Valanides, 2005) [14, 1]. With Mishra and Kohler's presentation of TPACK framework in 2006 it dragged the attention of several researcher.

Rationale

In India, a large number of the teacher education institutes have been running 2-year teacher education programmes till now. Student teachers, after completing their graduation or master's degrees with content knowledge, take admission in a teacher education programme where they mainly learn about pedagogy, including a course on ICT. It is one of the foremost reasons behind the less effective teacher education system in India as the student teachers learn content, pedagogy and ICT in isolation. The National Education Policy 2020 proposed the four-year Integrated Teacher Education Programme (ITEP), where everything related to teachers' knowledge would be taught in integration. Therefore, the present study may have its significance for the curriculum designer to prepare integrated teacher education programme where content, pedagogy, and technology would be taught simultaneously in integration not in separation. The teacher educators and student teachers will also get insights about the knowledge teachers need to have.

Statement of the Problem

As mentioned in the abstract of the study: **"Historical Development of Technology Integration in Teaching Learning: From PCK to TPACK**."

Objective of the Study

The primary objective of this study is to trace development of technology integration in teaching learning from PCK to TPACK.

Methodology

Based on the objective of the study this study is a qualitative investigation critical analysis of related studies. In this study, a number of related works which are in line with PCK model (more than 70) have been assessed in chronological sequence from 1986 to 2008, i.e., from Shulman's PCK to the TPACK studies of 2008.

Shulman's PCK Model

Shulman identified the ambiguity that while by the late 1800s, content was prioritized and pedagogy was weak, or by the middle of the 1980s, pedagogy was prioritized while content was ignored. Considering these two knowledge areas separately was viewed as a challenge by Shulman (1986) [17]. According to Shulman, having a general understanding of pedagogical principles and subject-matter expertise are not sufficient for effective teaching. He proposed that in the heart of good teaching lies pedagogical content knowledge. According to Shulman, content knowledge and pedagogical knowledge are interrelated, the point at which they converge is where teachers' pedagogical content knowledge lies. Pedagogical Content knowledge is the understanding that teachers gain with time and via experience on how to teach a certain material in specific methods to improve students' learning. Shulman discusses three sorts of knowledge in his studies:

(a) Content Knowledge

Content knowledge is defined as the quantity and arrangement of knowledge as such in a teacher's mind. A teacher with subject-matter expertise, according to Shulman (1986) [17], must not only be able to truths pertaining to a specific field, but also justify why they are true and important to know and how they relate to other domains. Shulman categorizes (1986) [17] content knowledge in two structures; substantive and syntactic, for better comprehension. Some fundamental ideas and guiding principles of the discipline are included in the substantive framework. Validity and invalidity are both parts of the syntactic structure.

(b) Curricular Knowledge

Curricular knowledge is the understanding of courses and learning resources regarding certain subjects at a specific level. Curriculum is the entire range of programmes that comprises a variety of instructional resources for these disciplines to teach particular subject at a certain level, (Shulman, 1986) [17].

(c) Pedagogical Content Knowledge

Shulman defined pedagogical content knowledge (PCK) as "the most useful forms of [content] representation the most powerful analogies, illustrations, examples, explanations, and demonstrations -- in a word, the ways of representing and formulating the subject that makes it comprehensible for others" (1986b, p 9).

In the subsequent development of pedagogical content knowledge (PCK) in 1987 Shulman and his companion researchers listed PCK as categorises 7 knowledge bases or effective teaching and listed PCK as one of them with equal emphasis and importance with other bases of knowledge. The seven knowledge bases are content Knowledge, general pedagogical knowledge, curricular Knowledge, knowledge of learners, knowledge of educational contexts, and knowledge of the philosophical and historical aims of education. Pedagogical content knowledge is a special blending of pedagogy and content and teachers' exclusive field (Shulman, 1987) [18]. PCK was described by Shulman as "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to diverse interests and abilities of learners, and presented for instruction. Pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue." (Shulman, 1987, p. 8) [18]. The ability to structure content knowledge to meet the diverse needs of learners distinguishes an educator from a subject specialist and validates pedagogical content knowledge as knowledge of teaching (Shulman, 1987) [18].

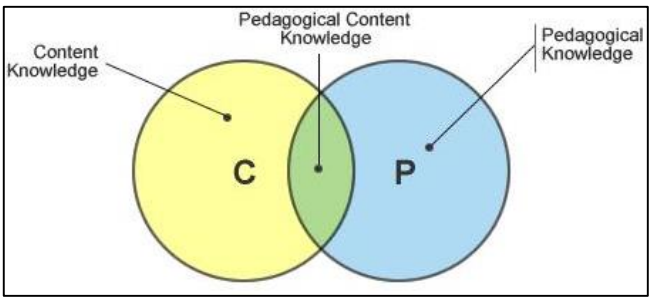

Fig 1: Shulman's PCK (Adapted from Gess-Newsome, 1999) [4]

Grosmann's Framework of Teacher Knowledge (1990)

Grossman (1990) [5] considered PCK as representations of content and difficulties related to comprehension of content. Grossman (1990) [5] stated that there are "four general areas of teacher knowledge. As the cornerstones of the emerging work on professional knowledge for teaching: general pedagogical knowledge, subject matter knowledge,

pedagogical content knowledge, and knowledge of context" (p. 5).

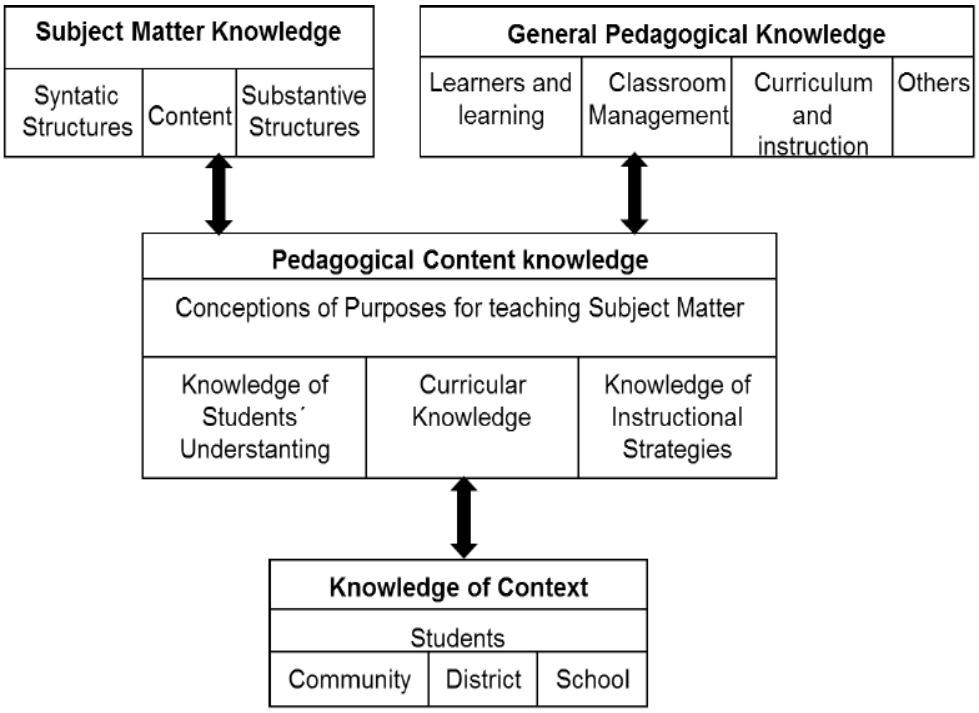

Fig 2: Model of Teacher Knowledge. (Grossman, 1990, p. 5) [5]

(1) Knowledge and beliefs
Knowledge and beliefs pertain to understanding and beliefs regarding the goals of teaching a subject at various grade levels. It covers teachers' ideas about the subject's importance for pupils, as well as teachers' goals for teaching the subject.

(2) Subject matter knowledge
Grossman defines subject matter knowledge as mastering the key concepts and facts of a certain area. This component includes knowledge on students' comprehensions, conceptions, and delusions about specific content that is to be taught.

(3) Curricular knowledge
Curricular knowledge is a comprehension of the materials for teaching a subject as well as understanding about curricula for that subject. Curriculum knowledge includes knowledge of the curriculum of a certain subject as well as comprehension of the general goals for education at a particular level. Grossman's curricular knowledge is similar to Shulman's idea.

(4) Pedagogical content knowledge
Grossman described pedagogical content knowledge, as the knowledge of instructional strategies and representations for teaching particular subjects (pp. 8-9). According to Grossman (1990) [5] "experienced teachers may possess rich repertoires of metaphors, experiments, activities, or explanations that are particularly effective for teaching a particular topic" (p. 9). Of the four knowledge bases, it was anticipated that pedagogical subject knowledge would have the greatest impact on a teacher's classroom behaviour.
The definition of PCK and the component of belief varies between Grossman's and Shulman's teacher knowledge. While The value of multiple representation repertoires in PCK is emphasized by Grossman, for Shulman PCK includes pedagogical reasoning development also.

Cochran, DeRuiter, & King (1991 &1993) [2]
Cochran, DeRuiter, & King (1993) [2] tried to better align Shulman's PCK model with a constructivist approach to teaching and learning. Modifying Shulman's PCK concept Cochran, DeRuiter, & King (1993) [2] defined Pedagogical Content Knowledge as 'a teacher's integrated understanding of four components, namely, pedagogy, subject matter content, student characteristics, and the environmental context of learning' (p. 266). Considering Shulman's idea of PCK as segregated and static, they advocated that educators' knowledge should be dynamic, always expanding and developing. They titled their improved version of PCK pedagogical content knowing (PCKg) that signifies dynamic teaching competence. PCKg is an combination of four categories of teacher knowledge: pedagogical knowledge, content knowledge, student knowledge, and environmental context knowledge. Emphasizing the last two components they opined that all four components develop in an integrated manner resulting from countless hours of instruction, observation, and reflection on one's own and others' teaching.

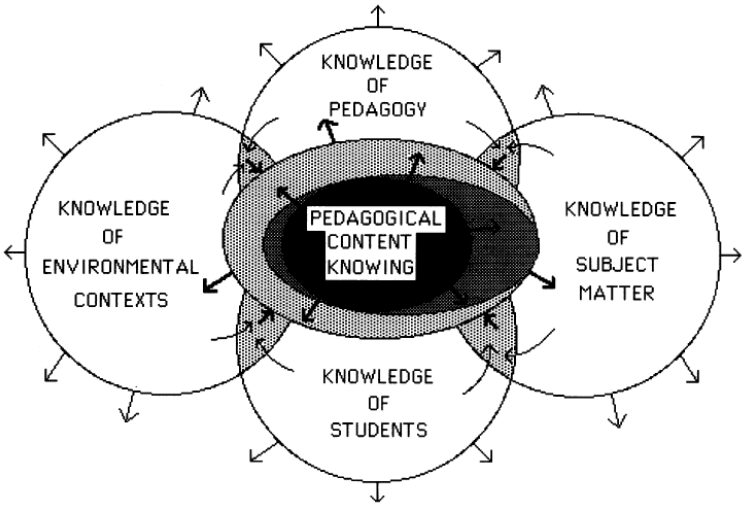

Fig 3: Model of PCKg. (Cochran, King, & DeRuiter, 1993, p. 268) [2]

Considering unified nature of pedagogical content knowledge, they stated that the 4 parts of PCK be developed simultaneously rather than being acquired separately and then put together in some way. The line between the various components will become less clear as PCKg grows and spreads. In order to ensure that future teachers have a thorough understanding of all the PCK components and their intricate relationships, the integration of these elements should be encouraged in teacher education programmes.

Gess-Newsome (1999) [4]

Gess-Newman presented two different perspectives on PCK-integrative model, i.e., PCK develops as a result of the integration of other domains; and ―transformative model, i.e., pedagogical content knowledge is a unique category (Gess Newsome, 1999, p.12) [4]. Gess-Newsome (1999) [4] defined a viewpoint in PCK research in addition to these two extremes. Gess-Newsome (1999) [4] states that, "New knowledge gained through preparation programmes and teaching experiences increases the organization and depth of both foundational knowledge domains and PCK, though changes in one knowledge base will not necessarily result in changes in others" (p. 13).

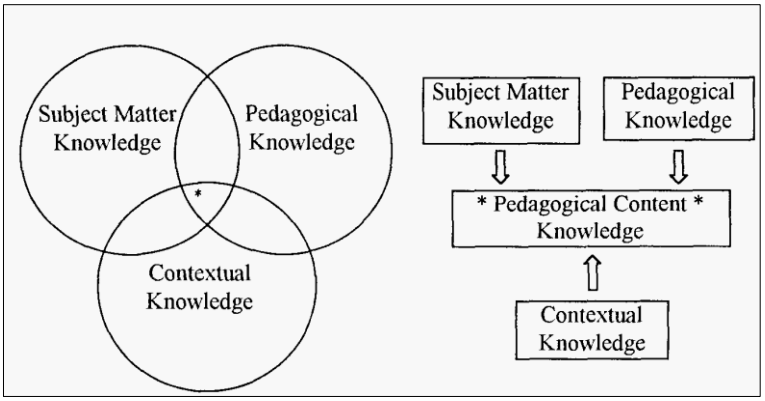

Fig 4: Integrative and transformative model of teacher knowledge. (Gess-Newsome 1999, p. 12) [4]

Based on Shulman's original notion on PCK Gess-Newsome (1999) [4] proposed five interlinked/interrelated categories of knowledge: conceptual knowledge, subject matter knowledge, knowledge about the nature of the discipline and knowledge about teaching strategies that are focused on a particular subject and the environment.

During the 90s technology became more affordable, and came to be in aid of teaching learning, educators and investigators began to understand the significance of using technology in the field of education and the effect it has on pedagogy and content respectively. In the beginning of the 2000s the technological aspects were being explored by many researchers. They suggested expanding Shulman's concept of Pedagogical Content Knowledge by including the technology construct due to the increasing necessity for technology integration in education.

Keating and Evans (2001) [8]

Keating and Evans (2001) [8] examined survey results and interviews with a small group of prospective teachers using the grounded theory methodology to examine how the student teachers' increasing pedagogical content knowledge integrates with teaching using technology. They found that pupils were at ease using technology for a variety of daily tasks. However, this individual use of technology did not simply transition into a technology integration into teaching and learning Keating and Evans defined TPCK construct as knowledge that "extends beyond proficiency with technology for personal use to an understanding of how technology can be integrated with subject matter in ways that open new avenues for student understanding of the subject matter and the technology itself" (p. 1671).

Pierson's Framework of Teacher's TPACK (2001)

A number of researchers have attempted to combine Shulman's notions of pedagogical content knowledge with technology over the years (PCK). A theoretical model of technology integration called "technological-pedagogical-content knowledge" was presented by Pierson based on her analysis to incorporate knowledge of technology with Shulman's pedagogical content knowledge model (p. 224). Pierson (2001) [15] asserted that the only way technology can be used in a meaningful way in the classroom is if the teacher sees it as an essential component of the learning process. Similar to Shulman's description of PCK, she added a fourth element, technological knowledge, to PCK. Aspects of technological knowledge include teachers' technological proficiency and awareness of the features of specific kinds of technologies utilized in teaching and learning procedures (Pierson, 2001) [15]. This knowledge would encompass both rudimentary technological proficiency and awareness of the distinctive qualities of specific sorts of technologies that would be conducive to various components of the instructional processes. An educator who uses technology well would be capable to combine technological knowledge with vast content understanding and pedagogical knowledge. Effective technology integration would be defined as the junction of the three knowledge domains, or technological-pedagogical-content knowledge. The element of technological knowledge is made up of both the fundamental technological skills that teachers need to possess and a comprehension of the features of specific kinds of technologies utilised in teaching and learning processes (Pierson, 2001) [15] (p. 427).

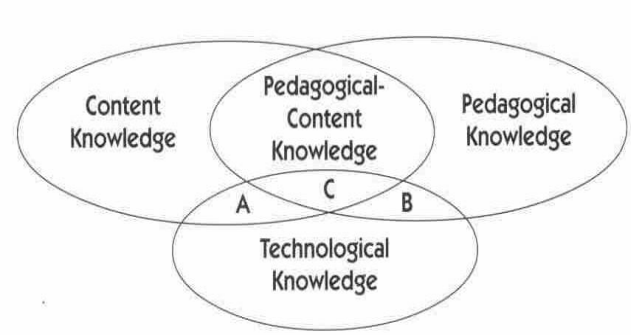

Fig 5: Technological Pedagogical Content Knowledge (adapted from Pierson, 2001, p. 427) [15]

Margerum-Leys and Marx (2002) [12]

Based on Shulman's PCK framework Margerum-Leys and Marx (2002) [12] proposed that the application of computers may benefit learners perform better or which teachers are need to be equipped with knowledge that is extensive and versatile. However, they suggested a "Knowledge set" "Pedagogical Content Knowledge of Technology" (p. 446). That was in addition to the use of educational technology. According to them there is a multifaceted interplay between pedagogical knowledge and technological knowledge. One of the authors' findings was that mentor teachers frequently learned about technology from student teachers. Later, they (mentor teachers) would combine this knowledge with pedagogical understanding to transact lessons in their classroom. The study also showed that knowledge of availability and usage of technology, was a crucial aspect in understanding how technology could be beneficial in educational settings.

Niess (2005) [14]

Niess (2005) [14] studied development the connections among pedagogy, technology, and subject-matter expertise of pre-service science and mathematics teachers made a contribution with his technological pedagogical knowledge sub-constructs (TPK). This particular teachers' knowledge base was referred to by Niess as "a technology PCK (TPCK)" (p. 510) and was defined as occurring when technology turns to be essential of instruction.

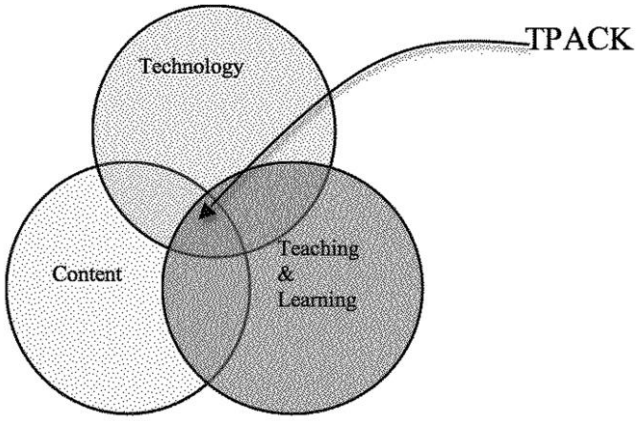

Fig 6: TPACK model Niess (2006)

Angeli and Valanides (2005) [1]

In the same year When evaluating preservice teachers' technology integration knowledge, Angeli and Valanides (2005) [1] proposed the phrase "ICT-related PCK" (p. 294) adding contextual knowledge to CK, PK, TK, and TPCK, that is required for successful technology integration.

Koehler and Mishra

The TPCK framework concept has drawn a lot of interest from the scholarly community during the past 18 years. Similar to Pierson (2001) [15], Koehler and Mishra (2005) [9] constructed the TPACK using the same line expanded Shulman's notion of PCK by including the third domain i.e., technology. In their introduction of their TPCK framework, Koehler and Mishra suggested that the three knowledge domains of content (C), pedagogy (P), and technology (T), as well as the intersections; Pedagogical Content Knowledge, Technological Content Knowledge, and Technological Pedagogical Knowledge, can all be used to understand TPCK. (Koehler & Mishra, 2005) [9]. In the beginning the term was documented as TPCK but later it was altered to TPACK to make it easy to pronounce (Thompson & Mishra, 2008) [20] to illustrate how the three knowledge domains are represented as a "Total PACKage" rather than as three separate domains (Thompson & Mishra, 2008, p. 38) [20]. In 20008 b Koehler and Mishra (2008) [20] developed the idea of TPACK into a contextual form of knowledge, recognizing that effective technology integration necessitates educators to understand the complex interplay among technology, pedagogy and content and understanding of the educational environment which includes knowledge about learners, the educational institution, the environment and the accessible infrastructure. When teaching a particular subject, the TPACK framework places a strong emphasis on preparing teachers to use technology judiciously.

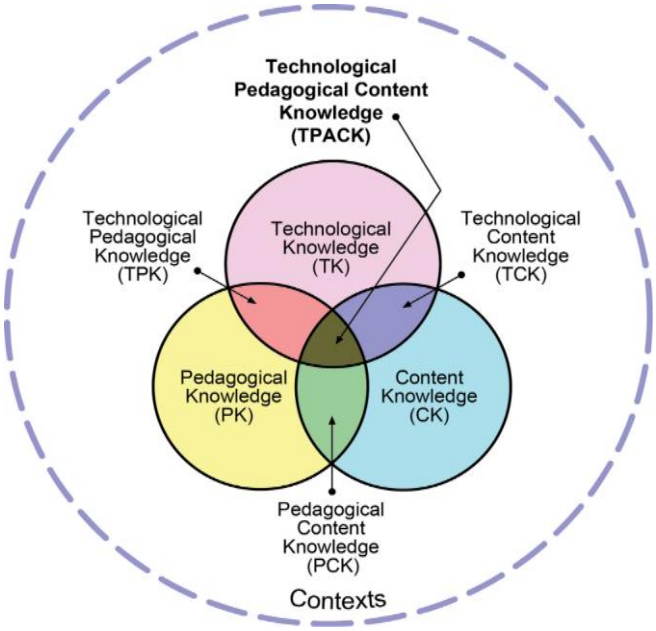

Fig 7: TPACK model (Koehler and Mishra, 2008) [20]

The TPACK framework consists of seven components. They are characterised as:

1. Technology knowledge (TK): Technology knowledge refers to the understanding of teachers of both established and emerging technologies that can be included into the curriculum.

2. Content knowledge (CK): Content knowledge refers to the "knowledge about actual subject matter that is to be learned or taught" (Mishra & Koehler, 2006, p. 1026) [11]. It refers to any understanding of the subject area that a teacher is going to teach.

3. Pedagogical knowledge (PK): Pedagogical knowledge refers to a teacher's understanding of different techniques, tactics, and strategies of teaching that help students learn.

4. Pedagogical content knowledge (PCK): Pedagogical content knowledge is a fine blending of pedagogy and content which aims to develop effective teaching practices in the subject matter. Shulman's (1986) [17] describes PCK as "an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (p. 8).

5. Technological content knowledge (TCK): Technological content knowledge refers to understanding of how technology and content interact with one another. It also relates to understanding how new representations of particular content can be developed through technology.

6. Technological pedagogical knowledge (TPK): The term refers to the understanding of how different technologies can be employed in teaching and the possibility that doing so could alter how teachers deliver their lessons.

7. Technological pedagogical content knowledge (TPACK): TPACK "refers to knowledge about the complex relations among technology, pedagogy, and content that enable teachers to develop appropriate and context-specific teaching strategies" (Koehler *et al*, 2014). TPACK also refers to understanding of the intricate relationships between content, technology and pedagogy that facilitate educators to create effective and context-specific teaching practices.

Different interpretations of TPCK

In the literature pertaining to TPACK, various clarifications of TPACK and specification of TPCK constructs emerged sooner or later from its initial identification as a framework for teacher knowledge. TPACK is primarily defined and interpreted from two opposing perspectives, explicitly the integrative view and the transformative view. The integrated view, which states that TPCK should be considered as an integrative body of knowledge, is reflected in the TPACK framework developed by Koehler and Mishra (2008) [20]. Each of its subcomponents is defined by the intersections of pedagogy and content (PCK), technology and content (TCK) and technology and pedagogy (TPK). On the other hand, the transformative view proposed by Angeli and Valanides' (2005) [1] conceptualizing TPCK as an exclusive and distinct body of knowledge. Significant influences on TPCK development include learners, content, pedagogy, technology, and context. The transformative approach holds that TPCK evolves beyond the elements that make up its core and cannot be adequately explained by adding all other TPACK elements.

While the integrative view predicts that high amounts of TPK, TCK, PCK, TK, and PK will result in high levels of TPCK, and the transformative view predicts that TPCK will be influenced by PCK, TCK, and TPK, but not by PK, CK TK, directly.

Conclusions

This study examines the historical development of TPACK framework published from 1986 to 2008. It is found that the studies regarding technology integration in teaching learning started in the 1990s, and the number of studies has greatly expanded since 2000. Besides, many research studies have been carried out based on the theoretical framework of TPACK. The integrative view and the transformative view

are two conflicting viewpoints that are largely used to describe and interpret PCK as well as TPACK. Also, throughout the first decade of the twenty-first century, an increasing number of empirical research on the TPACK of in-service teachers as well as domain-specific TPACK were carried out, with an indication of the direction for future TPACK research (Ying-Tien Wu, 2013) [21].

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