

A Review of Concepts, Theories & Empirical Evidence of Pedagogical Content Knowledge(PCK)

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Abstract

Pedagogical Content Knowledge (PCK) continues to be an important construct in understanding how effective teachers are and how well their students achieve. Based on the work of Shulman, PCK combines content knowledge (what is taught) and pedagogical knowledge (how it is taught) and contextual knowledge of learners and environments in which they learn. This review incorporates conceptual, theoretical, and empirical views of PCK, emphasizing the multidimensionality of PCK and its contribution to quality instruction. The paper initially discusses the difference and relation between content knowledge and pedagogical knowledge and their combination as PCK. It then examines key elements of PCK including knowledge of learner's misconceptions, instructional strategies, curriculum design and assessment practices. The constructivist theory serves as the guiding framework which emphasizes the learning as an active process, contextual and social where teachers act as facilitators of knowledge construction. Empirical studies reviewed show that teachers with higher levels of PCK have a positive impact on student's academic achievement in

disciplines and also highlight the need for specific teacher training and professional development. The local and international contexts also provide evidence that PCK is dynamic and develops as an experience, reflective practice, and a process of constant learning. The paper ends by saying that the need to enhance the PCK of teachers is essential in order to enhance learning outcomes and to overcome misconceptions and stimulate student motivation, especially in science and mathematics education. This review therefore offers valuable insights for teacher education programs, policymakers and researchers who are concerned with improving the quality of instruction by building the professional knowledge base of teachers.

Keywords: Pedagogical Content Knowledge, Teacher Effectiveness, Student Achievement, Constructivism, Teacher Education.

1.0. Conceptual Review

1.1. Meaning of Pedagogical Content knowledge

The pedagogical knowledge is connected with how the educator would impart a topic (Gess-Newsome, 2013). GessNewsome

clarified it could involve an understanding of student misconceptions or naive theories they enter into the subject with when they are initially acquiring knowledge of it. It could also be a determination of what can be taught at what grade level or who can be taught. The third one is contextual knowledge. The area of contextual knowledge contains larger knowledge including knowledge of the scientific method and its applicability to the lesson. The pedagogical knowledge is the how of what is being taught. The bigger structure (e.g., the scientific method) is contextual knowledge. These various domains comprise the super set of pedagogical content knowledge (Gess-Newsome, (2013). The pedagogical knowledge base of the teachers comprises of all the cognitive knowledge needed by the teachers to produce efficient teaching and learning situations. Pedagogical content knowledge is considered to be on a spectrum of which the educators are able to acquire more of it through proper training and experience. The major hope of an educational improvement point of view is that the improvement in teacher pedagogical knowledge content can result in learning improvements in student achievement. A more prepared teacher who understands the content to be taught and how to impart the subject into a certain group of students is anticipated to cause student gains compared to a less prepared or a less experienced teacher. With the mounting issues in the education sector around the quality of teachers, it is necessary to have a critical examination of what PCK is all about. Trying to connect the Pedagogical content knowledge to the academic success of the students, it would be reasonable to begin with the explanation of the concept: Pedagogical Content Knowledge (PCK) first.

When defining PCK, it would be more appropriate to view them as distinct entities,

i.e. Content Knowledge (CK), and Pedagogical Knowledge (PK), and subsequently adopt them as the same, i.e. Pedagogical Content Knowledge (PCK) (Jacob, 2020).

1.2. Content (Subject Matter) Knowledge.

Content Knowledge (CK) or subject matter knowledge refers to the knowledge of the subject area without regard on how to teach the subject area (e.g. Geography, Mathematics and English language). It is the knowledge and information that teachers impart and the students are supposed to acquire in a certain subject or content area.

This definition was consistent with that of ozden (2018) who defined content knowledge as the concepts, principles, relationships, processes and applications that a student is expected to know in a given subject in academics, fitting his/her organization of the knowledge. The content knowledge is usually the facts, concepts, theories, and principles, which are being taught and learned within particular academic subjects or courses in schools.

Content (Subject matter) knowledge is a body of knowledge pertaining to knowledge in a specific subject. It comprises the conceptual and procedural information in the specified area. Niess, 2015, argues that the knowledge of subject matter is significant because it determines and creates the content taught by the teachers. CK is the knowledge that the teacher has on the subject taught. Kilic (as cited by Jacob, 2020) argues that it is not only necessary that the teacher knows that something is so, but he or she also needs to know why it is so.

Therefore, the attention is paid to in-depth knowledge of the subject matter studied in school. According to Shulman (in Akpo 2012), the content knowledge is the one that is concerned with the subject, e.g., Physics and its structure. Bertram and Christiansen

(in Jacob, 2020) point out that content knowledge accepts not only the propositional knowledge, a knowledge of what of a field, but also the procedural knowledge, a knowledge of why. With this in mind, this suggests that teachers must not only be conversant with the features beyond merely the facts of their subject, but they must also be able to define the essential principles and organization of the subject and the methods of producing knowledge that are employed in the subject. Moreover, an educator should have knowledge of the nature of knowledge that is, epistemological and ontological on the topic. Following suit, Muller, 2012 argues that knowing what entails knowing why something is held as knowledge in the field of interest and this is the content knowledge.

1.3. Pedagogical Knowledge

Scholars have defined Pedagogical Knowledge (PK) to imply various things based on how they are used. Pedagogical Knowledge according to Serhat Kurt, 2019, defines the knowledge of teachers in terms of the practices, processes, and methods of teaching and learning. Being a type of generic knowledge, PK includes the purposes, values, and goals of education, and can be used more closely related fields such as the knowledge of student learning styles, classroom management, lesson planning and assessment. Pedagogical knowledge is a strategy and style that enables the teacher to deliver his/her lesson in a stimulating manner (Korau, 2010). It is the professional experience of instructors in the development of effective teaching and learning conditions among all the learners (Jacob,2020). According to Shulman (2004), PK entails the principles of teaching and strategies that are used in classroom management and organization. Moreover, the knowledge of a teacher about the purposes of learning, assessment, and

education of students is also a part of PK (König, et al., 2016). Pedagogical knowledge refers to the knowledge of teaching. Ogunboyede (2011) calls the science of teaching pedagogy. Ozden (in Jacob,2020) reinforces this definition saying that pedagogy is science of teaching, instruction, and training. PK refers to the general knowledge regarding pedagogy, instructional strategies, student learning, assessment techniques, and knowledge of various theories regarding learning. According to McCaughtry (2015); Sidhu, Fook, and Kaur(2011), pedagogical content knowledge concerns the subject of teaching and learning. According to Shulman (as cited in Kilic, 2009), pedagogical knowledge refers to any theory or belief concerning teaching and learning process that a teacher has that affects the teaching of that teacher. Based on these definitions, it might be interpreted that pedagogical knowledge is a subject-specific knowledge about teachers of developing and facilitating an effective teaching and learning experience to all learners regardless of their subject. Stephen, Pompea & walker(2017) propose that pedagogical knowledge has to do with how the instructor would teach a subject. It may have to do with a knowledge of the misconceptions of the learners or the naive theories that they bring to the subject when they are new to the subject. It may also be an evaluation of what can be taught at what grades or to students. Rodgers and RaiderRoth (2016) claim that not all teachers are familiar with his or her subject matter, and can easily de-escalate it to help it reach his or her students (p. 8). Compression of the subject matter knowledge is through the possession of pedagogical knowledge. The process contains the capability to plan and prepare materials, time and classroom management skills, implementation, problem-solving, and teaching strategies, questioning techniques,

and assessment (Hudson, 2017). An empirical evidence review by Guerriero 2017 about the general pedagogical knowledge of teachers came to the conclusion that three primary overlapping components were present:

instructional process (teaching techniques, didactic, organizing of the lesson and classroom management).

Student learning (cognitive, motivational, emotional dispositions of individual students; their learning processes and learning development; student heterogeneity and adaptability in teaching).

Evaluation (assessment, diagnosis, principles and evaluation procedures).

Based on the above, it is also evident that pedagogical knowledge is the art and science of teaching. Thus, the education courses taught by students in different Colleges of Education and different Departments of Education in Universities are all aimed at assisting in the creation of teacher knowledge about teaching in the same way that content courses create content knowledge. Quality teaching is the premeditated and considered organization of teaching that leads to a logical learning process on the part of students. A good teacher must also account the significance of the content he or she is teaching, the choice of pedagogical strategies, and the combination of those two to efficiently address the teaching context in the clarity of how the needs of the students (achievement in school) are met (GessNewsome, Carlson, Gardner and Taylor, 2010). When a teacher can deliver his/her lesson in a manner that appeals to the learners and resonates well with them, then it implies that the pedagogical knowledge of the teacher is good. Through pedagogical knowledge, Timothy (in Tsafe, 2013) noted that teachers that offer good students relationships, and implement better classroom conditions would enhance the academic performance of

learners making them eager to score high marks. The pedagogical knowledge can be applied to look at how the teacher can effectively convey the instructions in the classroom.

1.4. Pedagogical Content Knowledge Conceptualization.

The Pedagogical Content Knowledge (PCK) is significant in the classroom instructions. A PCK would entail the teacher competence in teaching or learning process, competence in terms of delivering conceptual approach, relational understanding and adaptive reasoning of the subject matter. Scholars appear to have no agreement on what PCK should be in the case of a teacher. This is due to the fact that a number of authors have differing perceptions of PCK. To begin with Shulman (in Akpo, 2012), the defender of PCK, the theories of teacher knowledge were divided into seven categories, one of which featured the content knowledge of a given subject, coupled with the pedagogical knowledge of the given subject (pedagogical content knowledge). The theorist emphasized that a teacher ought to be aware of the content, pedagogy and the curriculum, as well as interplay of the teacher-centered and curriculum aspects. Hassard (in Jacob, 2020) defined PCK as the knowledge of teachers that enables them to teach effectively in a discipline as compared to the knowledge of the discipline. Pedagogical content knowledge was simply defined as the teacher knowledge that enables teachers to help students to reach certain content knowledge in a meaningful manner (Miller, 2007 (in Jacob, 2020). In facilitating student learning, Shulma defined PCK as the methods through which teachers represent and construct the subject-matter knowledge. Other researchers have held, however, that PCK and subject matter knowledge are not always sharply distinguished, as subject matter knowledge is a source that can be

converted to teaching (Tobin, Tippins, and Gallard, in Ozden, 2017). Among the most significant things about being a teacher is the ability to arrange the learning environment in a way that helped the students to grasp a certain concept and help them advance their intellectual growth. According to Akpo, (in Jacob,2020), Pedagogical content knowledge is what this type of knowledge is called. Pedagogical content knowledge was the term used by the author to denote the methods of representing and developing the subject in a manner that allows it to be understood by others. PCK, according to the scholar, comprises the patterns of expressing and constructing the subject that render it intelligible to others, the sense of what involves effortlessness or difficulty in learning particular topics and lessons and the notions and preconceptions learners of varying ages and backgrounds hold about learning those most commonly taught topics and lessons. Nonetheless, Kilic (2009) also claims that pedagogical content knowledge comprises of four parts namely knowledge of the subject matter, knowledge of pedagogy, knowledge of learners, and knowledge of the curriculum. In order to elaborate more on this, knowledge of subject matter can be defined as the familiarity with ideas, facts, and processes and the correlation of concepts. Pedagogical knowledge includes lesson planning knowledge and teaching strategies. The awareness of learners presupposes the awareness of the typical challenges, mistakes, and misunderstandings of students. Lastly, curriculum knowledge entails curriculum learning objectives of varying grades, and instructional resources like technology, manipulative and textbooks. In a similar progression, Sidhu, 2011 merely emphasized the fact that PCK describes teaching and learning of the subject. The ways in which teacher connect their subject matter (Content Knowledge-what they

know about what they teach) their PK (what they know about teaching) and the way subject matter knowledge is involved in the process of pedagogical reasoning are considered embodiments of PCK. It must be noted though, that PCK incorporates the integration of the subject matter expertise with pedagogical approach and the learning aspect knowledge to create a high quality classroom practice. It is a special information possession of teachers that enables them to think about the organization and significance of an instructional topic, identify the attributes that will render it more or less advantageous to the students, and defend the application of the teaching means basing on the learning requirements of the students.

Wilson, Floden & Ferrini-Mundy (2001) are correct in its assertion that pedagogical content knowledge, is a form of professional knowledge, which is applied to impart the content of a specific branch of knowledge. Moreover, the PCK presupposes the subject matter knowledge rearrangement so that it can be applicable and adaptable in the dialogue between teachers and learners in the classroom (Shulman, as cited in Kleickmann et al., 2013). According to Kleickmann et al. (2013) perspective, pedagogical content knowledge refers to a kind of applied knowledge that teachers apply in order to achieve their actions in relatively contextualized classroom environs. Such applied knowledge implies among others:

- (a) Familiarization with the way to organize and format academic material to be taught directly to students;
- (b) Awareness of the general beliefs, misunderstandings and challenges that students may have when learning specific material; and
- (c) awareness on the particular instructional strategies that can be applied to meet the

learning requirements of students in certain classroom situations.

The knowledge required to make the subject matter accessible to students is the pedagogical content knowledge. Regardless of the fact that content knowledge and pedagogical knowledge are extremely significant to the teaching profession, PCK has been explained as the concept of how subjects and strategies in certain subject areas are learned and mis-learned (Jacob, 2020).

1.5. Components of Pedagogical Content Knowledge and Learning among students.

Pedagogical content knowledge (PCK) will not be a complete history without referring to the name of Lee Shulman, who is the first to coin such an acronym. Tsafe, 2013 (in Jacob, 2020) also suggested some crucial aspects of the pedagogical content knowledge.

- i. Knowledge on subject matter (content knowledge).
- ii. Conceptions of students on the subject and learning and teaching.
- iii. implications that were linked with the particular subject matter.
- iv. Overall pedagogical information about teaching techniques.
- v. Curriculum knowledge
- vi. Experience of learning situations.
- vii. Understanding of the aim of education.

According to Amm and Wu (in Jacob, 2020), among content, curriculum, and teaching, there is the fundamental element of pedagogical content knowledge, and it is teaching knowledge. According to Park and Oliver (2008), scholars have not been pleased with the description of the association between the different subdomains of teacher knowledge, yet four points have been mentioned regularly and consistently, which include PC, CK, PCK, and context knowledge. Voss, Kunter &

Baumert (2011); Konig et al. (2011) divided the element of pedagogical content knowledge to encompass:

Classroom management knowledge.

Experience in teaching practices.

Classroom assessment knowledge.

Structure

Adaptivity.

Awareness of the process of learning.

The familiarity with the student features.

The authors suggest that knowledge of classroom management would involve the maximisation of the amount of instruction time, managing classroom incidents, delivering instruction on a consistent basis, keeping lessons on a focused path, the clear direction; knowledge of teaching methods is having control over several types of teaching methods, understanding when and how each one can or should be used; knowledge of classroom assessment would involve knowledge of different types and purposes of formative and summative assessment, the influence of different frames of reference (e.g., social, individual, criterion-based) on attitudinal motivation in students. Also, structure involves structuring of learning objectives and the lesson process, lesson planning and assessment; Adaptivity involves learning groups in the classroom with heterogeneous learners; knowledge of learning processes involves knowledge of supporting and encouraging individual learning progress through knowing different cognitive and motivational and emotional learning processes (e.g. learning strategies, influence of prior knowledge, influences and quality characteristics of praise.); knowledge of individual student characteristics involves knowledge of the sources of cognitive, motivational, and emotional heterogeneity in learners.

As stated by Abell, et al (in Jacob,2020) the following areas were identified to be linked to PCK:

- i. (1) teaching or instructional strategies, assessment strategies, and collaboration strategies;
- ii. (2) knowledge regarding student interest, motivation, acquisition of conceptual and procedural knowledge and skills; knowledge of science learners, such as student thinking, misconceptions, and cognitive and affective requirements of tasks and activities;
- iii. (3) the knowledge of resources that can aid in teaching and learning; the knowledge of curriculum and learning objectives of the students.

2. Theoretical Framework

The research is founded on the constructivist theory. The constructivist theory is founded on the premise that the learner is an active learner in his or her learning process; knowledge is built out of experience. With events happening, every individual has a reflection on what has happened and brings in the new concepts with the existing knowledge. The learner forms the schemas to systematize the knowledge obtained. This model was embedded in the theories of learning by Dewey, Piaget, Vygotsky, Gagne and Bruner. The constructivist theory of learning is crucial in the learning process of the students. Constructivism is based on the concept that students actively create knowledge. The students build (or add) their new experiences to their existing background of knowledge. According to Woolfolk (1993) as cited in Serhat, (2021) learning not teaching is a dynamic mental process. There are numerous aspects of the theory of constructivism. These principles describe the theory in its entirety and their impacts on learning of the students. The key arguments include the following:

I. Knowledge is constructed. Each of the students starts the learning process already

having some existing knowledge and then proceeds to add his or her knowledge to it. Their choice of what to incorporate into the experience will make the knowledge of everyone distinct.

II. Learning is an inter-social activity. Socializing with other people plays an imperative role in knowledge building. It is important that group work, discussions, conversations and interactions are all important in creating understanding. Looking back to our past experiences, we are able to see that our connection to other people is directly related to the information that we have learned.

III. The process of learning is active. The students have to actively participate in discussions and activities to be able to build knowledge. The students cannot assume a passive role and memorize information. To construct ideas that are meaningful we will need a sensory response.

IV. Learning is contextual. Isolation is not the most appropriate method of retaining information. We learn by establishing a relationship between what we believe and information we already have. This is because learning is also going on in the case of our lives, or in conjunction to the rest of our knowledge. We are introspective about our lives and we sort out the new information according to the perspective that we have.

V. People learn to know how to learn, as they know how to learn. The student selection and arrangement of information improve as each student passes through the learning process. They can better categorize ideas and make more significant systems of thought. They also start to appreciate the fact that they are learning several concepts at the same time such as when they are

writing an essay about historical events they are as well learning the aspects of written grammar. They are learning when to remember things; they are also learning how to arrange important information in a chronological order.

VI. Learning exists in the mind. Practical tasks and experience cannot be sufficient to memorize information. To the learning process, it is essential to be active and reflective. Students have to be involved in activities at the mental level to form a comprehensive understanding.

VII. Knowledge is personal. Because every person's perspective is unique, so will be the knowledge gained. Every individual comes into the learning activity with their own experiences and will take away different things as well. The theory of constructivist learning is based entirely on each individual's own perspective and experiences.

VIII. Motivation is key to learning. Similar to active participation, motivation is key to making connections and creating understanding. Students cannot learn if they are unwilling to reflect on preexisting knowledge and activate their thought process. It is crucial that educators work to motivate their students to engage in the learning journey.

As Serhat (2021) says, one cannot just know the theory of constructivist learning. The teachers should also be aware of how to use it in the classroom. They want to establish a friendly atmosphere that will encourage active learning processes. In the constructivist learning theory, teachers become facilitators. They should encourage teamwork and they should modify their lessons in accordance to the previous level of the understanding of the class. After recognizing what students already know, the

instructors require to strive to expand the knowledge in those fields.

i. A constructivist classroom is highly dependent on four areas that are important to its success:

ii. The teacher assumes the position of a facilitator rather than a director.

iii. The students and the instructor have equal authority and responsibility.

iv. The process of learning takes place in groups.

There is sharing of knowledge amongst the students as well as the instructor.

The learning theory of constructivism can be applied to audio-visual aids in teaching in a number of ways. The major implications mentioned by Isaac, 2019, include the following:

i. Active Learning:

Constructivism underlines that learners have the active process of building up their knowledge through meaningful experiences. Active learning could be implemented with the use of audio-visual tools to deliver the visual representation, video, or interactive multimedia, which will stimulate students to discover, explore, and create associations between the new material and existing knowledge.

ii. True Situations:

Constructivism advocates learning in the real world situations. Audio-visual tools may be used to establish the real-life learning conditions by showing the videos, simulations or case studies, which reflect the use of knowledge in practical situations. This will enable the students to detect the applicability and veracity of the concepts taught.

iii. Multiple Perspectives: Constructivism acknowledges that learners have their different perspectives and experiences in the learning process. The use of audio-visual aids can include various voices, opinions and various representations of culture, which inform the students about various ways of thinking and knowing.

iv. Collaboration and Social Interaction: Constructivism places a lot of value on social interaction and collaboration during learning. The audio-visual tools can be used in collaborative learning through including group discussions, problem solving, or video based interactions that expose the students to meaningful dialogue, exchange of ideas, and negotiating meaning with their peers.

v. Reflection and

Metacognition: Constructivism emphasizes the role of reflection and metacognition, in accordance with which students mainly think about the ways they learn, as well as keep track of their thinking. As examples of audio-visual aids, one may use self-assessment tools, reflections, and video-based self-reflection exercises, which will prompt students to reflect on what they have learned, what they have misconceived, and how their knowledge can be changed.

vi. Learner-Centered

Approach: Constructivism makes the learner central to the process of learning. The audio-visual materials can be adapted to the personal requirements, interests, and learning styles of students, which means that they can have individualized learning experience. They are able to offer several kinds of information representation, and thus the students have a chance to select the kind of presentation that best fits their learning styles.

Science literacy is very widely regarded as a necessity in contemporary developed and

highly technological nations (DeBoer, 2011). It is even theorized that supporting students to achieve science literacy will help meet the demands on the part of the society in having open-minded well-educated citizens, and the labor market in having skilled workers in science and science-related jobs (Roberts, 2017). The student achievement is considered to measure the science literacy of the students. Nevertheless, in a world that is increasingly traumatized by the growing pace of scientific and technological advancements, the reason why the modern student, as well as the future worker, feels compelled to pursue science or even science-related field, is also a matter of concern.

In the context of future participation of students, interest is one of the major variables in schools. The studies that were conducted in the past decades demonstrated a drop in the interest of the students during middle school and this is more evident in the science subjects and more specifically in physics (Schiefele, 2009). These results made educational researchers pay attention to the interest of students in the sphere of physics, however, some researchers report that affective-motivational variables of students remain under-researched in the field of science education (Fortus, 2014).

3. Empirical Review

Gasteiger, Bruns, Benz, Brunner, and Sprenger (2019) examined measurement tools of mathematical pedagogical content knowledge (MPCK) in the field of early childhood teachers have to take into account specific features of the early childhood teaching. To solve this gap, the authors suggested in the first suggestion a paper-pencil test having multiple choice items to measure MPCK and respect implicit knowledge of early childhood teachers. The test is premised on the description of four common situations in kindergarten. Mixed

with the situations, the authors constructed a group of items assessing professional knowledge related to the mathematical skills of children and two multiple-choice items that assess professional knowledge related to adaptive mathematical learning activity. A pilot test using a sample size ($n=149$) of both pre- and in-service teachers working in the early childhood education field was done with the 39 items. The findings demonstrate the evidence of the validity of the test content, responding procedures, internal test structure, and convergent evidence. Thus, the test is an appropriate initial step to assess the MPCK of early childhood teachers, as well as considering implicit knowledge of the teachers.

The study conducted by Felicia, Lasiele & Henry (2018) was based on the knowledge indices of teachers as predictors of the academic performance of secondary school students in Kwara state, Nigeria. The researchers were studying the type of teacher (B.Ed. / B.Sc.Ed. / B.A.Ed.; PGDE; or B.A. /B.Sc) that possessed the greatest Depth of Subject Content Knowledge; the greatest Depth of Pedagogical Knowledge; the greatest Depth of Subject Content and Professional Knowledge; and predictive power of Depth of Subject Content and Professional Knowledge on the Academic Achievement of students. The sample consisted of seventy eight English Language and Mathematics teachers in thirty two randomly selected secondary schools in Kwara state; and the intact SS II classes taught by the teachers. The quantitative data were obtained by the use of tests, observations and vignettes; and interpreted with the help of descriptive and inferential statistics. The results revealed that teachers holding B.Sc. had the best Depth of Subject Content Knowledge, Depth of Pedagogical Knowledge and Depth of Subject Content and Professional Knowledge. It was also discovered that pedagogical and subject

content knowledge of the teachers had a significant predictive relationship with Students Academic Achievement. There were marked differences in the Depth of Subject Content Knowledge with the Depth of Pedagogical Knowledge of the English Language and Mathematics teachers whereby the Mathematics teachers won by a significant margin.

Odumosi and Areelu (2018) conducted a study on teacher content and pedagogical knowledge about the achievement of students in algebra. The researchers sampled purposely 421 students in II of the senior secondary schools and 12 mathematics teachers in eight (8) public and four (4) schools in the Lagos State Education District 5 of the test-retest form of quasi-experimental design with a $3 \times 3 \times 2 \times 2$ factorial - matrix. The three tools utilized are TCTA, OSTP and SATA. The Spearman rho reliability of OSTP is 0.77 with the TCTA and SATA giving a reliability of 0.79 and 0.81 respectively using the gutman split half reliability technique.

The three tools that were created were tested and utilized in data collection. The analysis of data was performed with the help of graphs and ANCOVA. The findings $F(2, 387) = 0.56$; $p = 0.67$ established that all the types of subject were equally influenced by TCK in algebraic performance following exposure to the content knowledge of teachers. The $F(2, 387) = 12.91$; $p = 0.00$ however, showed that TPK did not have an equal effect on students in the achievement test of algebra. Conversely, $F(1, 387) = 0.11$; $p = 0.90$ was a significant value showing that there is no significant difference in the achievement of students in algebra following exposure to teacher content and pedagogic knowledge based on gender. Besides, $F(1, 387) = 0.21$; $p = 0.81$ indicated that school type has no significant influence on the achievement of students in algebra once they are exposed to teacher content and

teacher pedagogic knowledge. Besides, $F(1, 387) = 0.90$; $p = 0.34$ showed no significant interaction effect of content and pedagogical knowledge, gender and school type on students achievement in algebra. Based on the findings, the study suggests that, teachers in Mathematics who have a deep grasp of the subject besides being properly groomed in teaching pedagogy should be left to teach algebra in schools.

Lee, Robert and Capraro (2018) examined subject matter knowledge (SMK), knowledge of content and teaching (KCT) and knowledge of content and students (KCS) in posing problems by teachers. The data were collected and analyzed in terms of qualitative study design and inductive analysis through interviewing four mathematics teachers. The study involved the interviewing of four teachers. The findings were that the participants were SMK of problem posing, though this was not reflected well in their actual problem-posing results. Teachers with respect to KCS and KCT, the teachers knew the role of problem posing in developing students mathematically, and believed that there are a number of constraints that are hindering effective integration of problem posing in the classroom.

These results provide an understanding of the significance of professional development in pedagogical knowledge of teachers in problem posing.

Yildirim and Topalcengiz (2018) created the STEM Pedagogical Content Knowledge Scale (STEMPCK Scale). The structural validity of the scale was tested by using the exploratory and confirmatory factor analysis. The scale was analyzed using exploratory factor analysis of 443 pre-service teachers who were pursuing studies to obtain a degree in science teachers, preschool teachers, elementary school teachers, and mathematics teachers. The confirmatory factor analysis of the scale was

carried out based on the information on 212 students enrolled in the same departments. Overall, 655 pre service teachers were used to administer the scale. To establish the reliability of the scale Cronbachs Alpha internal consistency coefficient, corrected total item correlation and significance of the differences between item averages of the top 27% and bottom 27% were checked with the help of t-test. Based on the findings made, the STEMPCK Scale has six factors, 21 st Century Skills, Pedagogical Knowledge, Mathematics, Science, Engineering, and Technology. The scale included 56 items. Cronbachs Alpha values of the factors were between 0.878 and 0.90 and corrected item-total correlations were between 0.306 and 0.895. The t-test outcomes indicated that all the differences between the mean score of the 27 percentile of the top and bottom of the items were significant. The findings of the analyses suggest that the instrument possesses decent internal consistency, and the empirical data were in agreement with the theoretical structure. These findings suggest that STEMPCK Scale can be used as a suitable instrument to test pre-service teachers as far as their STEM pedagogical content knowledge is concerned. Conclusions and recommendations to future research are provided.

Odumosu, Olisama and Areelu(2018) examined the content and pedagogical content knowledge of the teachers concerning the performance of the students in Algebra in Lagos State Nigeria.

The researchers purposely sampled 421 students in II secondary school of eight (8) public and four (4) private schools in Education District 5 of Larry State with a $3 \times 3 \times 2 \times 2$ factorial matrix with the help of a test re-test quasi-experimental design. Graphs and ANCOVA were used in data analysis. Findings showed that TCK equally impacted all types of the subject in the case of algebraic achievement following

exposure to the content knowledge of teachers. But TPK did not have the same effect on the achievement test of algebra among students. Conversely, gender does not play a great role on the success of students in algebra following the exposure to the contents of teachers and teacher pedagogic knowledge. In addition, it was revealed that achievement of students in algebra after exposure to teacher content and pedagogic knowledge does not depend on the type of school. In addition, content and pedagogical knowledge, gender, and school type did not also there interact significantly on the achievement of students in algebra. In light of the findings, the research will suggest that teachers of mathematics who have deep knowledge of the subject matter and who are well groomed as regards teaching and pedagogy should be given a chance to teach algebra in schools.

Olasehinde-Williams, Yahaya and Owolabi (2017) examined the predictive usefulness of depth of subject content knowledge and depth of pedagogical knowledge of teachers on the academic success of students in English Language and Mathematics in Kwara State, Nigeria. A descriptive survey was chosen as the research design of the study. The sample included 78 English Language and Mathematics teachers who were selected at random in 32 secondary schools in Kwara State and the intact SS II classes that were taught by the teachers. The quantitative data were gathered by using tests, observations, and vignette. The analysis of data was done through descriptive and inferential statistics. The results revealed that teachers who had B.Sc. displayed the most profound depth of subject content knowledge, depth of pedagogical knowledge and depth of subject content and professional knowledge.

In addition, teachers who were pedagogical and subject content knowledge were identified to be important predictors of

student academic success. There was a marked difference between subject content knowledge depth and pedagogical knowledge depth of English Language and Mathematics teacher in favour of Mathematics teachers. Equally, the performance of the students in the English Language was worse than Mathematics, albeit, non-significant. The research suggested that changes were necessary in teacher preparation programmes. Wahid, Bahrum, Ibrahim and Hashim (2017) examined the mastery of the art teachers in mastering PCK in the area of visual art appreciation in Kuala Lumpur, Malaysia. The variables pertaining to art appreciation teaching were established. The paper used a qualitative research technique. Six art teachers were used as respondents. A purposive sample that was based on several secondary schools in Kuala Lumpur was used to select them. Interviews and observations are the data collection instruments. Art appreciation in schools cannot be overlooked in case students would be able to appreciate the art orally or in written form. Thus, the visual art education curriculum goal that involves generation of students able to describe, analyze, interpret and evaluate artwork will be attained.

4. Conclusion

The review has proved that Pedagogical Content Knowledge (PCK) is the key to successful teaching and learning. PCK provides teachers with the opportunity to present subject matter in access, engaging and meaning ways to students by combining knowledge of the content, pedagogical concepts, and contextual knowledge. The reviewed literature confirms that highly-qualified teachers in terms of PCK have a considerable impact on the academic success and motivation of students. It also indicates that PCK is dynamic and still develops with the process of training,

reflection, and teaching experience. Based on the constructivist theory, PCK stresses that teachers are facilitators who help learners to build knowledge in a participatory and social manner.

Finally, the improvement of PCK of teachers is important to attain the quality of education and enhance the results with students in all academic disciplines.

5. Recommendations

1. Teacher Education and

Training: Colleges of education and universities must incorporate specific PCK development in their curriculum, and pre-service teachers both learn rich content but learn to be effective pedagogues as well.

2. Professional Development: In-service Teachers should be offered the opportunity to engage in continuous professional learning to empower their PCK especially as far as dealing with the misconceptions of the students, teaching in new teaching methods, and making good use of assessments.

3. Policy Support: Education policy-makers ought to focus on teacher quality by promoting policies that boost PCK (e.g. by mentoring, collaborative teaching, classroom-based research).

4. Curriculum and Instructional

Design: The curriculum planners must incorporate the methods that promote active learning and contextualized instruction, which should also be consistent with constructivist principles to promote meaningful student engagement.

5. Future Investigations: There is a need to conduct additional empirical research, particularly in the local setting to determine the development and progression of PCK and its relationship with student achievement in various disciplines.

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