

Examining the Correlation between Teachers Pedagogic Content Knowledge and Student Achievement in Mathematics

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Abstract— This paper tried to unveil the relationship between teachers' pedagogic content knowledge and students' achievement in Mathematics using Educational Psychology Interactive process. It reviewed the concept of pedagogy, highlighted its components and how these components are related using a framework called "A Transactional Framework of the Teaching/Learning Process developed by W. Huitt in 2003. It can be seen that the students' achievement therefore, is a process in which the teachers' and students' characteristics relate with teachers' and students' behaviours in the classroom processes in addition to the environment to produce students' performance.

Index Terms— teacher, pedagogy, knowledge, students, characteristics, achievement, mathematics.

I. INTRODUCTION

The concept "Pedagogic content knowledge" (PCK) was introduced by Lee Shulman (1986). Its aim was to have an answer to what he described as "missing paradigm" in research on teaching and teacher education (Depaepe et al., 2013; Kraut et al., 2016). Shulman (1986) suggested that Subject matter is central in research on teaching and teacher education. He identified Pedagogic content knowledge as one of the seven categories of teachers' knowledge base, that is content knowledge, general pedagogical knowledge, curriculum knowledge, knowledge of learners and their characteristics, knowledge of educational context, and knowledge of educational ends, purposes and values (Depaepe et al., 2013).

Though, he was criticised for a number of reasons by some scholars for lack of theoretical and empirical basis for the existence of pedagogic content knowledge as a distinct category in teachers' knowledge base (Depaepe et al., 2013). However a review of a systematic way in which the concept has pervaded mathematics educational research by Depaepe et al., (2013) shows that of the 60 research articles related to PCK reviewed 51(85%) articles refer to Shulman's concept of PCK. Therefore, one can confidently conclude that Shulman's idea of PCK is still the most valid and acceptable concept.

To understand the weakness and strength of any nation, their educational level has to be compared with the

international benchmark. In order to develop a sustainable policies to guarantee the performance of their educational systems, educationists and governments at all levels are trying to seek a better way of improving the sector by providing the opportunity to its citizens to learn. The Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) tests focus on the key areas of reading mathematics and sciences, not only to evaluate students' understanding but how well students can apply the knowledge learned in contemporary world (OECD, 2016; Provasnik et al., 2016).

Government can set the course and assessments to provide the benchmark, but it is teaching that must be improved to push the students along the path of success. There is overwhelming yearning for improvement in teaching as pointed out by Jerome Bruner (1996) as cited in the book by Stigler W.J. and Hiebert J. (2009) titled *The Teaching Gap*: "It is worrisome when debating on education without attention being given to the intimate nature of teaching and school learning. The debates have been devoted so much on performance and standards that they have mostly overlooked the means by which teachers and students alike go about their business in real-life classrooms-how teachers teach and how students learn".

Therefore, for students' learning to improve, quality of teaching has to be addressed. Teaching is one of the processes designed to facilitate students' learning in the educational system (Depaepe et al., 2013; Firmender et al., 2014; Olfos, Goldrine and Estrella, 2014). However, there are many other factors responsible for effective learning, such as school factors, environmental factors, societal factors and socioeconomic factors among others (Crisp, Nora and Taggart, 2009; Sirin, 2005). Some of the major Challenges facing the teaching of Mathematics today are in areas of classroom management, instructional models and classroom communication among others (Julie et al., 2017). Embedment of Mathematics is in individuals in different ways which can be seen in cultural, professional, practical and recreational behaviour, but the opportunity is not the same (Königet al., 2017; OECD, 2016).

Generally, success of students in Mathematics and in other areas of learning is mostly attributed to teaching methods (Ellington and Race, 1999). According to Villanueva (2015), "You cannot give your students what you do not give yourself" (p.1), it is clear therefore, teachers cannot teach what they don't know; hence, it is important to ensure that teachers are competent in the content of what they teach and

the methodology they use and how it is conducted to have impact on the student's ability (Zazkis and Zazkis, 2011).

In the recent past, students are being encouraged to study Sciences and Mathematics by the society to enable them choose careers in the areas of medicine, engineering and technology (Diekman et al., 2010; Mata et al., 2012). With teachers as agents of change, pedagogic and content knowledge are the key ingredients in teaching strategies, skills and content. Therefore, competency of teachers in content of the subject and teaching strategies and skills are very vital. As professionals, teachers should be able to influence the environment making it conducive for learning; in other words, teachers should have knowledge of students' characteristics and the environmental context of learning in addition to their professional knowledge.

This paper therefore, aimed at examining the correlation between teachers' pedagogic content knowledge and students' achievement in Mathematics using Educational Psychology Interactive: The Teaching/Learning Process model developed by Huitt, (2003) a framework called "A Transactional Framework of the Teaching/Learning Process."

II. THEORETICAL PERSPECTIVE

The theory to be applied is the Constructivism theory which view learning as a process of interacting between the teacher and students (Amineh and Davatgari, 2015; Mvududu and Thiel – Burgess, 2012). Advocates of constructivism are of the view that students study adequately through communications with the environment (Ertmer and Newby 2013). Steffe and Killion as cited in Chambers and Timlin, (2013) expressed that, from a constructivist point of view, "learning Mathematics is mainly about Mathematical collaborations between an instructor and learner". Learning is a perpetual, deep rooted process in which its outcomes are as the result of relations with the environment (Brown, Collins, and Duguid as cited in Chambers and Timlin, 2013). The constructivist approach does not concentrate exclusively on the activity of the instructor or the students; it is about the connections between the two. The instructor should try to see individual activities and also the students from the learning perspective (Cobb and Steffe as cited in Chambers and Timlin, 2013).

Scholars argued that there is no generally acceptable definition of constructivism. Piaget is believed to be one of the first scholars to advocate a constructivist teaching method, despite the fact that he didn't recognize him-self as an authority. He had confidence in the significance of human collaboration and physical control in the acquisition of knowledge (Ertmer and Newby 2013). The accentuation of the constructivist classroom starts with the learner. The classroom ought to be a place that cultivates and sustains learning and improvement of knowledge (Booyse and Chetty, 2016). The constructivist classroom makes a situation that energizes learning. The instructor ought to make surroundings where learners can understand Mathematics as it identifies with this present reality. Learners are to be approached with deference and obligation. The fear of failure syndrome should be eradicated; keeping in mind the end goal so that learners can gain from their errors. Constructivism

concentrates on Student-centred teaching, which isn't new in training (Khalid and Azeem, 2012). The students assume a remarkable part in the basic leadership process with reference to what, when, and how learning should affect them.

The approach and teaching strategies used during the instructional practice have the tendency of influencing the students' achievement either positively or negatively (Duze, 2011; Firmender et al., 2014). Pedagogy which is the term used to describe the process a teacher uses to impart knowledge to the students has been a given range of definitions by scholars. And all of these justifications are centred on what teachers are ordinarily to do in the classroom and how they do it (Firmender et al., 2014). Learning therefore, refers to a potential change in behaviour and achievement refers to the transformation of this potentiality into behaviour (Olson and Hergenbahn, 2013 p.4). A teacher should be able to see himself as the key tool in this process of teaching and learning. Teachers' knowledge of content and theories of a subject are important factors in students' academic achievement (Julie et al., 2017). According to Shulman (1986) as cited in Fien et al., 2013, content knowledge is categorized into three; these include "Subject Matter Knowledge, Pedagogical Content Knowledge and Curriculum Knowledge".

Julie et al., (2017) defines Content Knowledge as "knowledge and understanding of teachers about the planning and organization of the learning and teaching strategy". It is an accumulation of different perspective of teachers' knowledge domain such as General Pedagogical Knowledge, Subject Matter knowledge, Knowledge of the student characteristics and Knowledge about the environmental context of learning. Guerriero (2013) recognizes Pedagogical Content Knowledge as an imperative instructive approach for making successful teaching and learning environments for every student.

III. CHARACTERIZATION OF TEACHER'S KNOWLEDGE

Some scholars are of the view that the mathematical understandings required for quality instruction are particular skills which can be attained in colleges (Marshall and Sorto, 2012; Totto et al., 2008). Hill and colleagues as cited in Olson, Goldrine and Estrella (2014), suggested three categories of knowledge required of mathematics teachers, these include: knowledge of the content and student knowledge of the content and teaching and knowledge of the curriculum.

Globally, the pre requisite of teaching profession has focused more on content knowledge as requirement for successful teaching (Marshall and Sorto, 2012; Schmidt et al., 2017). Apart from the knowledge of content, some scholars believe that to be successful mathematics teachers, sound basis in pedagogical knowledge is an added advantage because it is the required professional knowledge which is needed to teach the content of a particular subject (Marshall and Sorto, 2012; Schmidt et al., 2017).

There is an interconnection between pedagogical content knowledge and content knowledge, while the former is a combination of content and teaching knowledge (Schmidt et al., 2017), the latter is an accumulation of different perspective of teachers' knowledge domain such as General

Pedagogical Knowledge, Subject Matter knowledge, Knowledge of the student characteristics and Knowledge about the environmental context of learning (Schmidt et al., 2017).

In order to recognize expert teacher, studies have highlighted some of the characteristics to include: better strategies in problem solving, pedagogical content knowledge, respect for learners, better understanding of classroom management, understanding of the environment and societal factors as the key elements of a good teachers (Gess-Newsome et al., 2016; Guerriero, 2013; Krainer et al., 2015).

A systematic review on pedagogical content knowledge by Depaepe et al., (2013) showed major researches in the areas of pedagogical content knowledge and revealed that most scholars agreed that core components which constitute pedagogical content knowledge are knowledge of the students characteristics, knowledge of the instructional plans and knowledge about the environmental context of learning (Depaepe et al., 2013; Zazkis and Zazkis, 2011).

IV. GENERAL PEDAGOGICAL KNOWLEDGE

Careful planning and preparation are the key elements to successful teaching and learning. For it to be productive, a teacher must be acquainted with the curriculum materials which has being structured to suite the learning environment (Yusminah et al., 2012). Brophy (as cited in Krainer et al., 2015) suggested four general dimensions of teaching quality, namely; structure, motivation, classroom management and assessment.

In their contributions Krainer et al., (2015); Fien et al., (2013); Tatto et al., (2008) define general pedagogical knowledge (GPK) as a strategy of classroom administration, assessment, knowledge about students characteristics and learning process.

The term general pedagogical knowledge has many interpretations, but all the concepts point toward the same direction. According to Tatto et al., (2008), the essential parts of GPK are the common general methods of instruction and classroom management. On the other hand, Voss (2014) viewed GPK as classroom processes and students' heterogeneity. He went further and said that during the class session, teacher is the manager on direction of the classroom activities on what and how to present the topics to the students. Pedagogically, teachers have very important task to play in facilitating students' understanding, therefore, teacher is the driving force who creates and makes sure that the learning environment is productive.

V. CONTENT KNOWLEDGE

Teaching involves facilitating others' learning; hence, understanding what to teach is an important component in a teaching profession (Gess-Newsome et al., 2016; Guerriero, 2013; Krainer et al., 2015). The centrality of content knowledge is generally recognized as central constituent of what is expected of a teacher (Houston, 1990; Ingvarson and Rowley, 2017; Marshall and Sorto, 2012; Schmidt et al., 2017). In recent years, interest at international level on policies that promote quality teachers has remarkably

increased as can be seen in PISA and TIMSS among others (Ingvarson and Rowley, 2017; OECD, 2016). The role of Content knowledge in teaching profession cannot be over emphasised; hence, it goes beyond the delivery of facts and figures. The main aim of teaching is to develop the students' intellectual capability to enable them relate what they had learned to the real world for their benefit and the society. This therefore, can only be achieved if the teachers have conceptual mastery of content knowledge (Ingvarson and Rowley, 2017; Marshall and Sorto, 2017). From philosophical point of view one is convinced that teacher's content knowledge can influence the efforts in making the students to understand the subject more quickly.

In order to assure quality of new teachers and sustain the benefits of school systems, investing in initial teachers' preparation is very important to policy-makers (Schmidt et al., 2017; Ingvarson and Rowley, 2017). Series of studies have shown that teachers trained in subject content, pedagogy and classroom management feel more prepared to teach than those who have not undergone the training (Marshall and Sorto, 2017; Schmidt et al., 2017).

VI. STUDENTS' CHARACTERISTICS

In child development which elements have greater role "nature" or "nurture", this has been the question for the past decades. Some people are of the view that physical, emotional, and social capacity of a child is determined by the set of genes (Piaget and Duckworth, 1970), while others attributed it to the environment in which the child lives in and grow up. To some large extent, the generally acceptable belief is that they both influence the child (Hoff, 2003).

Changes occur in infancy stage as the child passes through to adulthood, understanding these stages enable the teacher to know the students better and be able to attend to their needs. Therefore, performance of students can be influenced by the environment in which the students grow up (Hoff, 2003). However, the way teachers, family, and community respond to these students affect the opportunities of their performance either positively or negatively (Munley, 1975; Piaget and Duckworth, 1970).

Nurmi (2012) similarly, reviews lots of research findings. He writes "The obtainable research proposes that students' characteristics play significant role in classrooms in terms of teacher-student relationship" (p.177-197), which result in high level of academic performance.

It is an acknowledged fact that teacher influences the students' performance, students on the other hand have impact on the teacher's instructional model and their relationships with teachers and these characteristics suggest numerous responses from teachers and impact teacher-student interactions (Dobbs and Arnold as cited in Nurmi, 2012; Conejeros-Solar et al., 2015).

Teaching and learning is a complex process in which several models exist, some models look at the process only from the perspective of teachers, while others view the students' input to the process as important elements (Guerriero, 2014). The general belief shows that students' characteristics are part and parcel of teaching and learning process (Nurmi, 2012). Some of the students' inputs to the

process include general ability, attitudes, beliefs, motivations and learning related behaviours.

VII. KNOWLEDGE ABOUT THE ENVIRONMENTAL CONTEXT OF LEARNING

Learning environment can be described as a place and space; that is a school, a classroom, a library and indeed it occurs in a physical location. In today's world where technology is the driving force, learning environment can be suggested as the support systems that organize the condition under which students study best. It is a system that accommodates the learning needs of every student and supports positive relationship required for effective teaching and learning.

Although, hitherto, environmental influence had not been considered as one of the major factors that affect academic achievement in school, hence, it has little research attention; however over the last decades number of studies have suggested that there is correlation between the environment and students' achievement in academic (Iwuagwu et al., 2016; Durujiet al., 2014; Shamaki, 2015). Therefore, to enhance students' achievement the school environment remains an integral area for studies and should be well managed.

While effectiveness of teachers and the achievement outcomes of students are assumed to be directly influenced by the school leadership in which principals or head teachers are the managers, the conditions of teachers and students alike are mostly influenced by the school administrators. Having information of the environment where teaching and learning occurs will go a long way in enhancing effective teaching and learning (ibid.).

VIII. CLASSROOM MANAGEMENT

It is difficult to find claims of the argument about whether or not reducing class sizes account for enhancement in the performance of students. Many argued that small class size brings about individualised instruction, student-centred teaching, high quality instructions, less disruptions and better engagement of students academically (Hattie, 2009 p.85-86). Classroom management is all about how the teacher applies his professional knowledge in organizing the students, time and materials for effective teaching and learning (Konig et al., 2017; Guerriero, 2014); it incorporates a broader range of procedures in which teachers encourage classroom environments that maximize the pre occupation of students and minimize disruption and conflict in the class. Therefore, low disruption, improved on-task behaviour and improved achievement have been linked to a sound and effective classroom management (Skiba et al., 2016).

Classroom management is a collection of methods of teaching that promote self-control by students which permit them full benefit of learning time (Skiba et al., 2016). In classroom management there are no haphazard or inconsequential comments and above all, good manners and self-discipline are required of a teacher.

IX. CLASSROOM COMMUNICATION

Communication is an inevitable tool in teaching and learning process (Booyse and Chetty, 2016). Teacher in a

classroom is obliged to communicate effectively to the learners in order to achieve the desired objectives (Fashiku, 2017). Effective communication encourages participation and it is central not only in the classroom set-up but in every human societies. When there is breakdown in communication, crisis is inevitable (Booyse and Chetty, 2016). Classroom situation where teaching and learning take place requires more skilful communication, it enhances interaction between teacher and students making teaching and learning successful. Consequently, communication barriers should be avoided by teachers (Fashiku, 2017).

X. INSTRUCTIONAL MODEL

For learning to be stimulated, its outcome requires different set of instructions, Gagne (as cited in Ilie, 2014), proposed nine events of instructions in the process of teaching and learning called Gagne's theory of instruction which are: getting hold of attention, informing the students of the objective, motivating, recall of prior lesson, presenting the stimulus, providing learning guidance, eliciting performance, providing feedback, assessing performance and enhancing retention and transfer (Ilie, 2014; Ngussa, 2014). All these are referred to as external factors which have to be combined with internal conditions like the state of mind of the students to bring to the learning activities, previously learned skills, and personal objectives of the individual students (Ngussa, 2014). Hence, teachers as organizers of knowledge need to proffer proper environments for successful learning. They need to use effective approaches in teaching so as to exploit knowledge and produce best performance of the students (Ngussa, 2014; Skiba et al., 2016).

XI. GENERAL ABILITY

Bandura, (1969) introduced the concept of self-efficacy within the context of social learning theory. He extended the notion of self-reinforcement to include self-regulatory processes and self-efficacy beliefs. Bandura believed that there must be procedures for perceiving and interpreting behaviour for commencing action and for regulating behaviour in the light of its perceived consequences. Furthermore, he held that students nurture prospects about themselves and the environment, about what is likely and unlikely to happen, about what they can and cannot do (ibid).

Therefore, interest in the subject is the driving force, when students have an interest in a subject like mathematics they are likely to be motivated and develop the skills of becoming effective in learning of the subject (Dunlosky et al., 2013; Conejeros-Solar et al., 2015; Watanabe and Mcgaw, 2003).

On the other hand, nervousness about the subject can be a barrier to the understanding of the subject (Dunlosky et al., 2013). In addition, for effective learning environment like school where more than fifty percent of the students' times are spent is important in the sense that if a student is separated from the learning environment, the mastery of fundamental skills and concepts is likely to be reduced (Dunlosky et al., 2013; Watanabe and Mcgaw, 2003).

XII. BELIEFS AND ATTITUDES

Attitude refers to “a relatively enduring union of beliefs, feelings, and behavioural inclinations towards socially important events, groups, or objects” (Hogg and Vaughan as cited in Marcela and Dana, 2016; Pitsia et al., 2017). The three components of attitude are the affective component (feeling/emotions about objects), the behavioural components (ways of acting or behaving towards objects), and cognitive component (beliefs/knowledge of objects) and also known as ABC model of attitudes (Marcela and Dana, 2016).

There is a link between attitude and learning, students with poor attitudes toward school and learning tend to have poor academic performance, their beliefs and feelings are that learning in the school will not help them to succeed in future. Therefore, their behaviour toward school and learning will be negative and this implies that the performance of students can be affected by the students themselves.

According to Fisher, Schult & Hell (2013) “sex differences in secondary school success” shows that during adolescence, girls are better motivated to learn in comparison with their peer boys, which is also reflected in their learning outcome, this means that girls seem to have positive attitudes toward learning than boys.

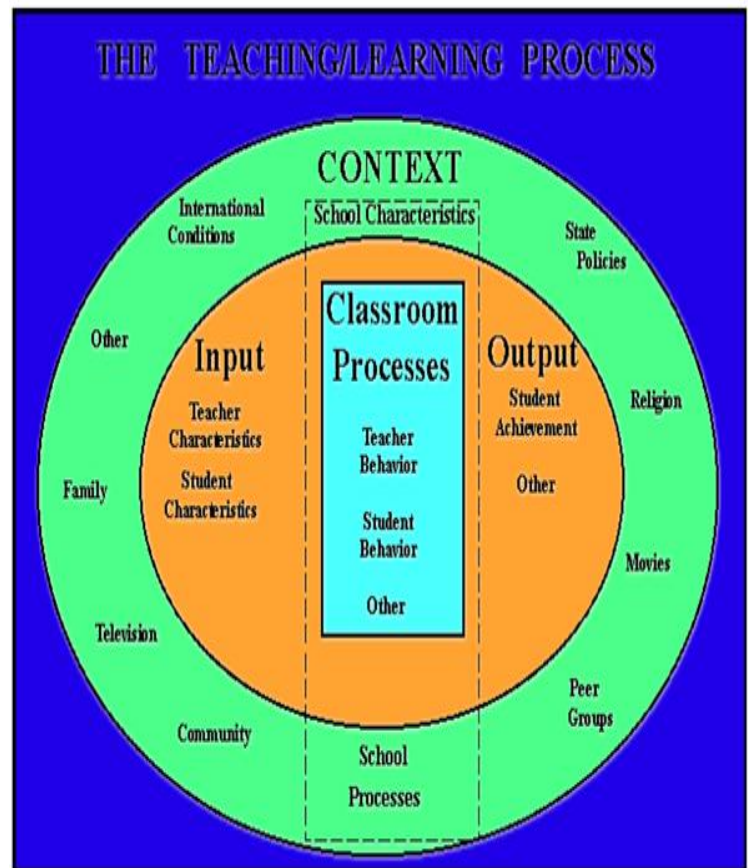
XIII. MOTIVATION

Motivation is viewed by both experience and inexperience teachers as a pre-requisite for effective learning, and impacting knowledge is the greatest challenge faced by most of the teachers. When students are not motivated, their learning efficiency will be very low and the students end up learning nothing, but when motivated, their learning ability will increase tremendously.

Maslow, (1943) as cited in Kaur, (2013) summarized human life in one simple model called “Hierarchy of Needs”. He submitted that there are general, instinct-like needs, which every human being attempts to fulfil (Maslow as cited in Kaur, 2013; Petty, 2004 p.43 -63). Therefore to motivate the students, teachers had to ensure that students’ belongingness, esteem and self-actualization needs are nourished through the learning activities plans (Kaur, 2013).

XIV. THE RELATIONSHIPS

In his quest to answer the questions related to teaching and learning process, Huitt, (2003) developed a framework called “A Transactional Framework of the Teaching/Learning Process”, he identified some of the indicators responsible for students success and categorised them as shown in the diagram



Source: W. Huitt, (2003)

In his view Output is the most essential of the categories of the indicators variables being the dependent variable that is used to predict or relate to the other variables. It is a measure of student learning taking part from the normal instructional process. The second most essential is the classroom process which has direct link to students’ achievement; these are teachers and students behaviours in the classroom as well as some other variables such as classroom climate and teacher/students relationships (Rosenshine & Stevens, 1986 as cited in Huitt, 2003). The third group of the indicators variable which described the Teacher and Students characteristics is called the Input which also plays direct role in students’ performance. These are qualities or characteristics of teachers and students that they bring with them to the classroom experience. The last indicator variable is the Context which refers to those variables outside of the classroom that have direct bearing with the teacher and student characteristics, classroom processes and output. These variables include school characteristics and school processes as demonstrated in the diagram (Duruji et al., 2014; Shamaki, 2015).

XV. CONCLUSION

This paper examined the correlation between teacher’s pedagogic content knowledge and the students’ achievement in mathematics. It reviewed the concepts of pedagogy, highlighted its components and how these components are related using a framework called “A Transactional Framework of the Teaching/Learning Process developed by W. Huitt in 2003. It can be seen that the students’

achievement therefore, is a process in which teachers and students' characteristics relate with teachers and students' behaviours in the classroom processes in addition to the environment to produce student's performance.

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