Teachers' Pedagogical Content Knowledge and Subject Matter Content Knowledge: Is the Framework Still Relevant in Teaching of STEM

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ABSTRACT

This paper takes a sociocultural perspective on the relevancy of Pedagogical Content Knowledge and Subject Matter Content knowledge in teaching and learning of STEM subjects. To teach learners according to today's standards, teachers' need to understand Pedagogical content Knowledge and subject matter content knowledge deeply and flexibly so they can help students create useful cognitive maps, relate to see how ideas connect across disciplines and to everyday life. Effective teaching and teacher characteristics, endorse clearly the role played by adequacy of teachers' Pedagogical Content Knowledge and Subject Matter Content Knowledge as applied in the classroom teaching and learning encounters. Most of the features of effective teachers and effective teaching as a process indicate the necessity of application of the theory of social constructivism, to enhance teachers' knowledge about prior knowledge of students and their socioeconomic backgrounds. Qualitative research method using classroom observation were used to collect data. Population was made up of 10 teachers in the University of Technology in South Africa. The sample for this investigation was drawn using purposive sampling technique. Classroom observation was analysed using rubric. The overall findings indicates that Pedagogical Content Knowledge and Subject Matter Content Knowledge, enhanced educators' professionalism and improved quality of teaching and learning outcomes, including motivational levels of both teachers and learners in the classroom. Specifically, Pedagogical Content Knowledge and Subject Matter Content Knowledge facilitate teaching effectiveness and learning efficiency in the teaching of STEM subjects in the University of Technology. It is therefore critical for the University of Technology that are engaged in the teacher programmes to visit how Pedagogical Content Knowledge and Subject Matter Content Knowledge are purposely incorporated into the training programmes. It showed that component of teacher Pedagogical Content Knowledge and Subject Matter Content Knowledge generally is beginning to enhance teaching, learning and assessment positively in the classroom.

Keywords: Effectiveness, Pedagogical Content Knowledge, Subject Matter Content Knowledge, Teaching, Teacher

INTRODUCTION

To teach learners according to today's standards, teachers' need to understand subject matter content knowledge deeply and flexibly so they can help students create useful cognitive maps, relate to see how ideas connect across disciplines and to everyday life. This kind of understanding provides a foundation for Pedagogical Content Knowledge that will enableteachers to make ideas accessible to others [27], [28]. Furthermore,[27], [28] introduce the phraseof Pedagogical Content Knowledge, Subject Matter

Content Knowledge, and the importance of this knowledges for effective teaching. [5] and [30] alluded that the research on teachers' knowledge and how this knowledge is acquired constitute a substantial area of inquiry in exploration on the nature of teaching. They point out that,how teachers' make sense of their profession world, the knowledge, and beliefs they bring with them to the task, and how teachers understand of teaching, learning and students, and the subject matter informs their everyday practice are important questions that necessitate an investigation of the cognitive and affective aspects of teachers' profession lives. [27], [28] furthermore, allude that the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students.

In [27], [28] theoretical framework, teachers need to master two types of knowledge (a) Content knowledge also known as deep knowledge of the subject itself and (b) knowledge of the curriculum development. Content knowledge encompasses what Shulman called the structure of knowledge: the theories, principles, and concepts of a particular discipline. [12] support Shulman in defining Pedagogical Content Knowledge as an over changing conceptions of what it means to teach a particular subject, knowledge of curricular, material and curriculum in a particular field, knowledge of student understanding and potential misunderstanding of subject area, and knowledge of instructional strategies and representations for teaching particular topics. And, explanations, interpretation and illustrations used by teacher, in the process of Subject Matter Content Knowledge presentation in the classroom. [17] describe Pedagogical Content Knowledge as a set of attributes that helped someone transfer the knowledge of content to others it includes more useful forms of representation of these ideas, the most powerful analogies, illustrations, examples, explanations and demonstrations-in a word, the ways of representing and formulating the subject that make it comprehensible to others. Thus, the following elements and relationship are important in the framework we propose.

Content knowledge is the knowledge about the actual subject matter that is to be taught to learners [17]. The content to be covered in secondary school curriculum. Clearly, teachers must know and understand the subject matter that they teach, including knowledge of central facts, concepts, theories, and procedures within the given field [2],[22].

Pedagogical knowledge is deep theoretical knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values, and aims [2], [22]. This is a generic form of knowledge that is involved in all issues of student learning, classroom management, and lesson plan development and implementation and student evaluation. It includes knowledge about techniques methods to be used in the classroom; the nature of the target audience; and strategies for evaluating student understanding [2], [5]. A teacher with deep theoretical pedagogical content knowledge understands how students construct knowledge, acquire skills, such pedagogical content knowledge requires an understanding of cognitive, social, and development theories of learning and how they apply to students in their classroom. Hence, Pedagogical Content Knowledge constitutes and represents the functional teaching experiences of teachers over the years of teaching career.

According to [27] represents advanced thinking about teacher knowledge by introducing the idea of Pedagogical Content knowledge. He claimed that the emphasis on teachers' subject knowledge and pedagogy were being treated as mutually exclusive domains in research concerned with effective teaching domain [27]. The practical consequence of such exclusion was production of teacher education programmes in which a focus on either subject matter or pedagogy dominated. To address this contrast, he proposed to consider the necessary supportive relationship between the two by introducing the notion of Pedagogical Content knowledge [10], [22]. This knowledge includes knowing what teaching approaches fit the content, and likewise, knowing how elements of the content can be arranged for better teaching. This knowledge is different from the knowledge of a discipline expert and from the general pedagogical Knowledge shared by teachers across disciplines [8]. Pedagogical Content Knowledge as articulated by Shulman is concerned with the representation and formulation of concepts pedagogical techniques, knowledge of what makes concepts difficult or easy to learn, knowledge of students' prior

knowledge and theories of epistemology. The epistemologically concerns the thought, the intelligence, the knowledge, the consciousness, the imagination, the perceptions, the sensations. It raises questions about the scientific discourse from a historic and linguistic point [8]. It also involves didactics knowledge of teaching strategies or methods that incorporates appropriate conceptual representations, to address learner's difficulties and misconceptions and foster meaningful understanding. It also includes knowledge of what the students bring to the learning situation, knowledge that might be either facilitative or dysfunctional for the learning task at hand. Pedagogical Content Knowledge exists at the intersection of content and pedagogy. Thus, it does not refer to a simple consideration of content and pedagogy, together but in isolation, but rather to an amalgam of content and pedagogy [2] thus enabling transformation of content into pedagogically powerful forms.

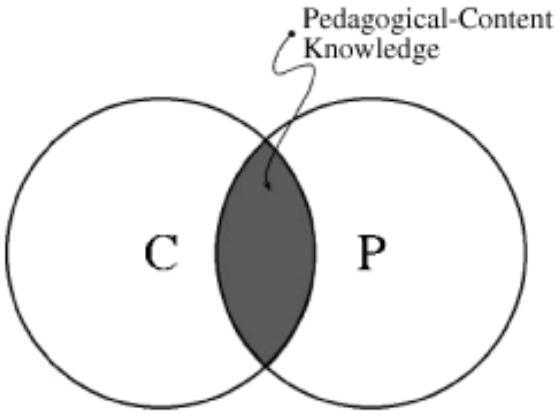

Figure1: The Two Circles of Pedagogical Knowledge and Content Knowledge joined by Pedagogical Content Knowledge.

Pedagogical Content Knowledge represents the blending of content and pedagogy into an understanding of how particular aspects of subject matter are organised, adapted, and represented for instruction. [27, [28] argue that having knowledge of subject matter and general pedagogical strategies, though necessary, were not complex ways in which teachers' think about how particular content should be taught, he advocated for Pedagogical Content knowledge the content knowledge that deals with teaching process, including the ways of representing and formulating the subject that make it comprehensible to others [12], [27]-[28]. The purpose of the study is determining the extent Pedagogical Content Knowledge and Subject Matter Content Knowledge relevant both teaching effectiveness and learning outcomes, in day-to-day teachers' classroom teaching.

The Theory of Subject Matter Content Knowledge

Helping students learn subject matter involves more than the delivery of facts and information. The goal of teaching is to assist students in developing intellectual resources to enable them to participate in, not merely to know about, the major domain of human thought and inquiry[4]. [3] define Subject Matter Content knowledge that is still quoted by more recent researchers in this domain [4] they define it as including concepts, algorithmic operation, the connections among different algorithmic procedure, the subset of the number system being drawn upon, the understanding of classes of student errors, and curriculum presentation. [27], [28] and [12] expand this definition to include the syntactic and substantive structures as the different ways in which the fundamental principles and concepts of a discipline are organised. The syntactic structure relates to the set of rules that assist one in determining what is true or false, valid, or invalid within a discipline. Syntactic structures also consist of the tools of inquiry within a discipline.

Original conceptualisation of pedagogical content knowledge theory

[12] and [27], [28]credited by worldwide researchers and educators in the field of education as the originator of: 'Pedagogical Content Knowledge and Subject Matter Content Knowledge Theory.'

Essentially, the Pedagogical Content Knowledge and Subject Matter Content Knowledge viewed as two sides of the same or one coin [14]. Where the Pedagogical Content Knowledge, is the 'head side of the coin' and the Subject Matter Content Knowledge, is the tail or bottom side of the Pedagogical Content Knowledge and Subject Matter Content Knowledge coin [27], [28]. Furthermore, [27], [28] suggest that one framework for explaining the fundamental knowledge that impacts on teaching practice can be based on three different Content Knowledge. These include knowledge about subject matter, pedagogy, and curricula. Specifically, [27], [28] asserted that, Subject Matter Content Knowledge refers to the "…*amount and organization of knowledge per se in the mind of the teacher*". Consequently, it is generally agreed and accepted that a teacher's personal understanding about Subject Matter Content Knowledge is central to teaching and student learning. Thus, from a social constructivist teaching and learning theory perspective concept or subject matter are learned effectively, when teachers acquire adequate knowledge about their learners' basic learning needs, socio-economic family backgrounds, prior learned knowledge, meaningful lesson presentation and active, participative teaching style [32].

Furthermore, [32] concludes that according to Pedagogical Content Knowledge theory effective leaning takes place through: (a) exposure to new input from other which creates an awareness of what is unknown and leads to the expansion of cognitive structures, (b) explore to new ideas that may contradict one's own belief and cause a re-examination and restructuring of beliefs and (c) through the communication of one's own ideas to others which forces articulation and sharpens conceptualisation [32]. A second type of knowledge theory of Pedagogical Content Knowledge is pedagogy which refers to delivery of Subject Matter Content Knowledge through organized and systematic teaching or delivery of Subject Matter Content Knowledge to learners [6],[7]. This also represents the blending of content and pedagogy into a dynamic understanding of how particular topics, issues, problems, views are collated, blended, represented, and adapted to the diverse abilities and interests or needs of the learners, and presented systematically for classroom instruction/teaching [27], [28]. In addition, Pedagogical Content Knowledge is invariably linked to teachers' belief and personal philosophy about teaching practice. Thus, teachers may have a direct connection between their belief about their teaching practice, and the actions they take in the classroom, or teaching styles. So, teachers' beliefs, values and experience may have a direct connection between their beliefs about teaching practice and the way they deliver subject matter to learners in the classroom [6]. In some cases, teachers develop their own practical theories of action, and these theories may change as new experiences are acquired or included [32].

The third type of Content Knowledge according to [27], [28] theory refers to curricula. The third type of content is defined by [27], [28] as the teacher's: "…familiarity with various curricular programmes as well as knowledge of the curricular context, including the goals or valued ends of those context." The knowledge of the curricular is extended to include aspects of both official and operational dimensions [32]. Very often the official curriculum, which provides the basis for developing lesson plans, student evaluation/assessment and teacher accountability. While the operational curriculum refers to that which is taught to learners, how the importance of what is taught is communicated through content, and the learning outcomes for which students are actually held accountable. Essentially, the perceptions that teachers hold about the official curriculum influence what is operationalized in the classroom [32].

In addition, differences in teachers' educational orientations also have an impact both on how teachers organize their lesson plans and how they deliver or present subject matter to learners. In summarizing the main reasons for the origin of Pedagogical Content Knowledge theory by [27], [28], Shulman coined the concept, Pedagogical Content Knowledge to answer a question posed by the US-centred debate about the status of teaching as a profession. At issue or the heart of the argument was; whether schoolteachers could be regarded as professionals; aligned with doctors or lawyers or if they were simply, 'skilled workers.' Previously [27], [28] highlighted the transition from the 1970's when teacher education and knowledge of subject matter deemed important to children's education, to the mid-1980's examination of general understanding of educational issues. Specifically, he raised the question 'where did the subject matter go?' [27] emphatically pointing out that this was the 'missing paradigm' in teacher education and training. Without Subject Matter Content Knowledge, it would be difficult for a teacher to

instruct learners in a classroom encounter, and lesson content related to learners' knowledge and ideas was impossible. [27], [28] contended that the issues constituted the heart of 'teaching' yet were absent from analysis of teachers' education and competences. In contrast, medicine and law were defined by skills, cases and procedures that characterised practice and on which analysis of doctors' and lawyers' competences could be based. Consequently, to address the 'gap' [27], [28] first ushered his three categories of 'Content Knowledge' for teachers namely:

- Subject Matter Content Knowledge; and
- Subject Matter Pedagogical Knowledge.
- Curricular Knowledge[27].

By Subject Matter Content Knowledge, Shulman meant the 'amount and organisation of knowledge per se in the mind of a teacher [27]. In support of his argument, Shulman cited a biology teacher as example, He contended that this teacher's knowledge of the subject may reasonably be expected to be equal to that of a non-teacher or 'lay' biologist. In addition, Shulman explained Subject Matter Pedagogical Knowledge as: 'the way of representing and formulating the subject that make it comprehensible or understandable to others' [27], that is the analogies, illustrations, examples, explanations and ideas that a teacher uses during lessons delivery in the classroom. While the third category, 'Curricular Knowledge' equates to a doctor's knowledge of current techniques and/or treatments to relieve an illness: in teaching terms, current materials include textbooks, software, laboratory demonstrations and other learning media available to use in the classroom. [9] and [23] endorsed their arguments on subject matter Pedagogical Knowledge as follows: "…an understanding of both content and process are needed by teaching professionals…within the content we must include knowledge of the structures of one's subject, Pedagogical Knowledge of the general and specific topics of the domain and specialised Curricular Knowledge [27]". Subsequently, in his 1987 paper, Shulman refined the three categories of knowledge:

- Content Knowledge.
- General Pedagogical Knowledge, with special reference to those broad principles and strategies of classroom management and organisation that appear to transcend subject matter.
- Curriculum Knowledge, with grasp of the materials and programmes that serves as 'tools of the trade' for teachers.
- Pedagogical Content Knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding.
- Knowledge of learners and their characteristics.
- Knowledge of Educational contexts, ranging from the workings of the group or classroom, the governance and financing of school districts, to the character of communities and cultures; and
- Knowledge of Educational ends, purposes, and their philosophical and historical grounds.

According to Shulman [27], [28] Pedagogical Content Knowledge constitutes a unique feature of teachers' vocabulary in teaching and practice, worthy of special attention as a distinctive/unique feature of the work/profession. While other professions, such as law and medicine, have their own nomenclature and curricular knowledge, for example in law, this comprises in medicine, knowledge of anatomy, physiology, biochemistry as well as pharmacology, medical and surgical procedures. Furthermore, law and medicine also have their equivalent of 'learners' that is, clients needing advice or patients requiring curative attention. Shulman argues that although the other knowledge types have their equivalents in different field, pedagogical content knowledge, remains unique to teaching profession and teachers [3]. Thus, Pedagogical Content Knowledge content and pedagogy are blended, that is, the teacher combines his or her understanding about a topic with instructional strategies and additional knowledge to promote learner learning effectively. [27] describes and explains Pedagogical Content Knowledge fundamentally as:

"…the capacity of a teacher to transform the Content Knowledge he or she possesses into form that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the

learners, [27]."

In support of the latter arguments and proposals by [7] contend that, recently there has been a renewed recognition of the importance of teachers' Subject Matter Content Knowledge, both as a function of research evidence[6], [7] and, as a function of recent literature from reform initiatives such the Holmes Group (1986) and the Renaissance Group[7]. [14] assert strongly that teachers' Subject Matter Content Knowledge are essential and significant to good teaching and student learning understanding. Furthermore, [27], [28] contends that in addition to teachers Subject Matter Content Knowledge and their knowledge of general instructional methods of teaching expertise should be described and evaluated [27] terms of Pedagogical Content Knowledge.

The concept pedagogical content knowledge has been a major research outcome of the Stanford knowledge growth in a Teaching Project conducted by Shulman and his colleagues and students [6],[5], which represents a new, broader perspective in the dynamics of understanding of teaching and classroom learning. Emphatically, [7], states that Pedagogical Content Knowledge is a special type of knowledge that is unique to teachers, and in fact is what teaching is about. It relates to the way in which teachers transmit their Pedagogical Knowledge (i.e. what they know about what they teach), in the classroom and school context, for the teaching of specific learners. It is essentially, the integration or the synthesis of teachers' Pedagogical Knowledge and their Subject Matter Content Knowledge that comprises Pedagogical Content Knowledge. To elucidate the concept, recourse to [27] original Pedagogical Content Knowledge-theory is cited as follows "…embodies the aspects of content most germane to it teach-ability. Within the category of Pedagogical Content Knowledge include, for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations in a word, the ways of representing and formulating the subject that make it comprehensible to others…pedagogical content knowledge also includes an understanding of what makes the learning of specific concepts easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring then to the learning situation [28]". Pedagogical Content Knowledge theory as originally conceptualised by [28] maintains that, is that form of knowledge which makes teachers' rather than subject area expects. [4] comments emphatically as follows: "…there is a vast difference between knowing about a topic (Content Knowledge) and knowledge about the teaching and learning of that topic (Pedagogical Content Knowledge)." It is difficult to practically use Pedagogical Content Knowledge in the actual classroom teaching situation.

Pedagogical Content Knowledge and Subject Matter Content Knowledge theory and its application to teaching

The research review indicates that researchers devoted great effort to demonstrate relationship between Pedagogical Content Knowledge and Subject Matter Content Knowledge. In support of the assertion [22] and [18] contends that, Pedagogical Content Knowledge represents the knowledge the teacher uses in the process of teaching. [22] and [18] believes firmly that if teachers can identify the relationship between pedagogical Content Knowledge and Subject Matter Content Knowledge it will enhance his/her science teachers. Furthermore, [22] and [18] emphatically state that, there is a vast difference between knowing about a topic, knowledge, and teaching and learning of that topic. Consequently, to date, a reasonable well-agreed assertion arising from research is that Pedagogical Content Knowledge provides a sound theoretical framework for examining and understanding teachers' skills [1],[22]. Despite this, inconsistencies and disagreements that persist about Pedagogical Content Knowledge and Subject Matter Content Knowledge, meaning there is no overriding consensus about how this can best describe successful science teaching. Some researchers [1], [11],[22]-[23] pick on Pedagogical Content Knowledge as a means of enhancing both teachers' professional status and the process of educating them. But [22] remarks that although there is a wide agreement that Pedagogical Content Knowledge is a useful concept, finding out exactly what it compromises and using this knowledge to devise good practice in teacher education is not easy, Since the nature of Pedagogical Content Knowledge is tacit elusive or hidden knowledge: when preparing lessons, for example, teachers think pragmatically. [22]

and [18] contends that, gaining better overall understanding of science teachers' Pedagogical Content Knowledge and Subject Matter Content Knowledge and its development and the relationship between Pedagogical Content Knowledge and Subject Matter Content Knowledge will help establish science teaching practice of consistently higher quality. Furthermore, by Subject Matter Content Knowledge, Shulman meant the "amount and organisation of knowledge per se in the mind of the teacher." [28] defined Subject Matter Content knowledge as "the ways of representing and formulating the subject that make it understandable to others, that is, the analogies, illustrations, examples, explanations and ideas that a teacher uses in presenting lessons in the classroom encounter". To recap briefly on the components of Pedagogical Content Knowledge theory, [27], [28] refined and extended his three categories into a more comprehensive list of seven elements. He considers and identifies Pedagogical Content Knowledge as distinctive of teachers' practice, worthy of particular focus as a unique feature of their professional work. Research effort has attempted to establish these categories of teacher knowledge as an all-embracing paradigm for teacher education. But some aspects of Shulman's general views are widely accepted and criticised.

[1] and [18] have subsequently proposed many Pedagogical Content Knowledge models, with modifications to Shulman's prototype Pedagogical Content Knowledge theory. These researchers have added or omitted some aspects of Pedagogical Content Knowledge and interpreted and illustrated them differently. Thus, Pedagogical Content Knowledge gained momentum in investigations of knowledge of teachers and has been widely applied in schools in subjects such as Mathematics, Biology, Physical Science, Technology and Consumer Science. Pedagogical Content Knowledge is now a model for investigations of knowledge of teachers[22]-[23],[18]. Research findings on Pedagogical Content Knowledge suggest that this unique knowledge is related to the planning and instruction in the classroom. In addition, [11], [18] and [22], [23] argues that Pedagogical Content Knowledge is a broader category that is part of professional knowledge and is more formal than the category of practical knowledge which is more personal and situational.

The relevance of Pedagogical Content Knowledge and Subject Matter Content Knowledge Theory to teaching STEM

A significant number of eminent researchers in the discipline of pedagogics concur that Pedagogical Content Knowledge theory constitute the central or heart of teaching as a profession [2], [17],[21],[23] since, Pedagogical Content Knowledge provides the knowledge of teaching foundation or primary teaching knowledge base. Furthermore, studies about teacher effectiveness focus mainly on the issues of Subject Matter Content Knowledge and Pedagogical Content Knowledge as applied in the classroom teaching situation [22]. More recently there has been an increased focus on the distinction between abstract Content Knowledge and Pedagogical Content Knowledge as well as an increasing recognition of the significance of formative interactions in the classroom to improve student learning.

[21] Pedagogical Content Knowledge is viewed as a complex blending of pedagogy, Subject Matter Content Knowledge and comprises aspects related to an understanding of what is to be taught, learnt, and assessed, also an understanding of ways to facilitate effective learning, and an understanding of how to mix content and pedagogy to organize subjects for learners [1]. It is perhaps interesting to note that, most of the research work on Pedagogical Content Knowledge has been executed at Secondary Schools level in particular subject's areas such as Mathematics, Biology, Physical Science and Technology [10].

Classroom management regarding teaching of STEM

Many empirical studies have explored or investigated the characteristics of effective teachers [1],[20]. The common characteristics are understanding of curriculum aims and objectives; having a wide range of pedagogical strategies, having high expectations of all students; knowing students well; providing effective feedback; recognizing student success; having sound content knowledge of the subject and understanding what it means to make progress. According to [1] students learn best when teachers spend most of their time focusing on content, with learning activities focused on the learners' levels of

understanding. In addition, the learner learns more effectively when the teacher structures new information in relation to prior knowledge of the learner. [1], and [15] further argues that students learn poorly, when teachers' Subject Matter Content Knowledge is weak; confidence levels to teach that subject are low; leading to restricted classroom practices. [21] and [18] all these studies findings emphasize the importance of teacher subject-matter knowledge as well as Pedagogical Content Knowledge. Furthermore, adequate levels of teacher knowledge of Subject Matter Content Knowledge, was found to have a positive effect on decision-making related to changing Pedagogical Content Knowledge strategies for creating better learning opportunities [21],[18]. Additionally, sound Subject Matter Content Knowledge seems to have an elevated positive effort on planning, assessment, implementations. Effectiveness in teaching depend heavily or to a large extent on the combination of teachers' mastery of Subject Matter Content Knowledge and possession of adequate Pedagogical Content Knowledge levels for classroom effective teaching [21],[18]. The latter supports, the hypothesisthat states that: adequate or high levels of Pedagogical Content Knowledge and Subject Matter Content Knowledge of STEM, Schools teachers will lead to high levels of classroom teaching effectiveness. More and more researchers in the field of teachers' effectiveness, have posed numerous questions about effective teaching and characteristics of an effective teacher. In-variably most answers to the questions relate to adequate Pedagogical Content Knowledge and Subject Matter Content Knowledge possessed by teachers and applied consistently and effectively by teachers in classroom teaching encounters [24], [22]-[23]. For example, [22], [23] poses specific questions related to the characteristics of effective teaching as follows:

What makes a teacher effective?

- Is it adequate lesson preparation?
- Is it effective communication skills?
- Is it experience related to long service in teaching profession?
- Is it knowledge of student learning styles?
- Is it the teacher's ability to enforce discipline during classroom teaching?
  [22], [23] also corroborates by providing answers to the above stated questions as follows:
- Adequate knowledge of basic principles and procedures.
- Detailed planning and preparation of lesson plan.
- Adequate teaching experience (Pedagogical Content Knowledge and Subject Matter Content Knowledge).
- Self-reflection and modification of teaching techniques and teaching style.
- Ensure high level of flexibility.
- Possession of adequate classroom management skills.

The above listed effective teaching skills provide a basic knowledge needed to execute effective teaching. Furthermore, STEM teachers that have many years of experience does not guarantee expert teaching; experience is useful only when the teacher continually engages in self-reflection and modifies classroom presentation techniques to better serve the needs of the learners. In addition, teachers must prepare to teach a wide range of students in terms of interest, motivation, and ability. Some of them may need additional coaching, research in didactics and preparedness on a class-by-class basics and respond to these needs accordingly. [3] display the following abilities and competences as follows namely:

- Adjust their lessons based upon the needs and abilities of their students.
- Keep abreast of developments in their field or discipline and incorporate these ideas into their lessons.
- Organize the materials in such a way as to best facilitate learning.
- Use effect communication skills.
- Formulate specific goals and objectives and then select the best methods for meeting those objectives.

- Share the course objectives with the students to clarify expectations for the students and open communication.
- Work to build rapport with their students.
- Establish a productive learning atmosphere anduse effective communication skills.
- Continuous engagement of students through questioning to challenge their thinking and cognitive functioning.
- Creating questions require students to put ideas together in a new way, often involving inductive and deductive reasoning.

Viewed collectively, all the above stated effective teaching teacher characteristics, endorse clearly the role played by adequacy of teachers' Pedagogical Content Knowledge and Subject Matter Content Knowledge as applied in the classroom teaching and learning encounters. Most of the features of effective teachers and effective teaching as a process indicate the necessity of application of the theory of social constructivism, to enhance teachers' knowledge about prior knowledge of students and their socioeconomic backgrounds [1], [2], [18].

METHODOLOGY

Qualitative component involving classroom observation was used as the instrument to collect data. The instrument was pilot tested to determine the appropriateness of the items. Pedagogical Content Knowledge and subject matter content knowledge presented by pre-service teachers to acquire one on one information about PCK and SMCK understanding the meaning that they attribute to their knowledge from a pedagogical and disciplinary point of view, the study sample were 10 teachers in the University of Technology in South Africa. Classroom observation using 8 structured questions were conducted. The naturalistic approach was adopted to studying teachers' content knowledge, misconceptions and how they apply the theory of Shulman in day-to-day teaching in the classroom. The analysis categories used in this study are described below according to PCK model. The classroom observation was analysed looking at the following questions:

- Special challenges, limitations encountered in the process of teaching.
- Importance for the learners to know and master.
- Beliefs or perceptions that influences in teaching.
- Strategies in teaching of STEM subjects.

DISCUSSIONS

A recurring question asked in this paper data analysis were: To what extent does Pedagogical Content Knowledge and Subject Matter Content Knowledge relevant both teaching effectiveness and learning outcomes, in day-to-day teachers' classroom teaching. The results of both the in-depth qualitative data analysis of the respondents' that teachers have wide variety of prior learning knowledge and useful/relevant vocational experiences to teach effectively.This group of educators' vocational experience ensured a dynamic balance between theory and practical outcome amongst learners. Perhaps a unique and/or significant finding, is that an overwhelming majority of teachers' respondents have high levels of Pedagogical Content Knowledge and Subject Matter Content Knowledge which enable them to teach effectively.Furthermore, the sample of these teachers' teaching styles and learner's progress in the classroom testify to the usefulness of the Pedagogical Content Knowledge and Subject Matter Content Knowledge theory by [27], [28]. The findings are significant and educative.From research review findings, many researchers, for example: [22] and [12] suggests five overlapping categories of conceptual teaching knowledge namely: (1) Conceptual knowledge; (2) subject matter structure, and nature of discipline; (3) Content specific teaching orientations and (4) Contextual influence (5) Nature of discipline. While [22], [25], contends that Pedagogical Content Knowledge results from the transformation of another domain knowledge. Consequently, their model of Pedagogical Content Knowledge includes the teachers' orientation to teaching the subject

knowledge of subject curricula, knowledge of instruction, knowledge of assessment, knowledge of learners' area understanding and knowledge of teaching. [12] suggest five more dimensions central to PCK components namely: (1) Knowledge and Beliefs about Purpose, (2) Knowledge of Learners, (3) Conceptions, (4) Curricula Knowledge and (5) Knowledge of Teaching Strategies. The characteristics of Pedagogical Content Knowledge common to all these conceptualisations are knowledge of Subject Matter, Learners, Curriculum, and associated Pedagogy. For example, [28], [20], points out most of the work on Pedagogical Content Knowledge has been done at the school level in particular Subject Knowledge areas.Inconclusion, of this discussion suffice to state emphatically that Pedagogical Content Knowledge and Subject Matter Content Knowledge are distinctive bodies of knowledge, which are unique to the teaching profession [13], [12], [20],[24],[27], [28].

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