EXPLORING THE USE OF PEDAGOGICAL CONTENT KNOWLEDGE (PCK) BY PHYSICS TEACHERS IN CENTRAL BHUTAN

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ABSTRACT

This research explored the use of Pedagogical Content Knowledge (PCK) by Physics teachers in teaching grade 10. The study employed a qualitative research design. The tools used were semi-structured interviews, class observation and document (lesson plan) analysis with teachers. The qualitative data were analyzed based on predetermined themes.

The main findings of this study revealed that the teacher displayed adequate use of PCK, in the form of content knowledge and knowledge of teaching strategies to teach two topics of force and motion (gravitational force and gravitational field). However, they displayed limited knowledge of learners' misconceptions on the topic and the use of alternative teaching strategies for learners with difficulty. Further, it was found that the teachers used social networks, lesson observations, and lesson review to enhance their PCK in Physics.

Keywords: Pedagogical content knowledge, Knowledge of subject matter, Knowledge of teaching strategies, Knowledge of learners' conception

INTRODUCTION

The use of PCK was defined as merge of content knowledge and pedagogical knowledge to enhance communication of concepts (Shulman, 1986; Halim & Meerah, 2002). Thus, following elements of PCK were explored:

Knowledge of Subject Matter in Teaching Physics

Knowledge of the subject matter (content) of the topic in which the teacher is engaged, that is, conceptual knowledge and procedural knowledge: able to arrange concepts by connecting one concept to another, maintaining the sequential and hierarchical flow of facts (Ryan and McCrae, 2005).

Knowledge of Subject Matter in Teaching Physics

Knowledge of teaching strategies classified as use of strategies and use of examples Sibuyi (2012).

Knowledge of Subject Matter in Teaching Physics

Knowledge of learners' conceptions included whether the lesson goal was achieved through assessment, whether the prior knowledge of learners were considered, whether the misconceptions were identified and addressed and whether the learners' difficulties are regarded Sibuyi (2012).

LITERATURE

In PCK, content and pedagogy are merged appropriately to enhance the knowledge of teaching. PCK includes knowledge of strategies, ways of representing the subject, and knowledge of common pupil difficulties. However, the lack of PCK is a barrier to better science teaching (Halim & Meerah, 2002).

The importance of in-cooperating PCK in teaching Physics is necessary. Johnston and Ahtee (2006) in their comparative study of PCK in Finland and England found that teachers from both countries were less positive about the teaching of Physics as the Physics phenomena are abstract in nature. Halim and Meerah (2002) in their study on Physics teachers' PCK in

Malaysia found that teachers' PCK for promoting conceptual understanding is limited and lacked the ability to transform their understanding of basic concepts in Physics. This lack of knowledge restricted them to employ the appropriate teaching strategies required to explain scientific ideas.

The importance of PCK is also realized in Bhutan. The 21st-century transformative pedagogy offered to Bhutanese teachers emphasized understanding learners in terms of academic equity and achievement gap to build every student, and on assessing students' daily work (Wangdi, 2016). Teachers need to be academically and professionally proficient with a broad knowledge of the subject matter, knowledge of the discipline and require a willingness to cast a critical eye on their practice and pedagogy (Dorji, 2009). A teacher should possess a good knowledge of the subject matter with the ability to deliver it in a way that it captures and holds the interest of the students using creative means to answer to their needs (Sherab, 2009). Bhutan Education blueprint's first wave of change wass also focused on up-skilling the teachers' content and pedagogical competencies (MoE, 2014). Education blueprint a time bound roadmap (2014-2024) of Bhutan's education system that includes policy initiatives and recommendations to achieve the overall education goals of the country (MoE, 2014).

The recent curriculum change in grade ten Physics highlights to explore the use of PCK in teaching and learning. The change aligns with the study Kumari (2015) who posited that the teachers' pedagogical content knowledge can bridge pedagogical transitional gap created due to change on curriculum. Halim and Meerah (2002) also found that PCK comes with experience and practice. Thus, it was imperative to explore Physics teachers' purposeful use of PCK to assure that they are aware and in continual exercise.

METHODOLOGY

Site and population are selected as per the convenience of the researcher considering factors like accessibility, location, and time. Therefore, data was collected from Physics teachers in schools in central Bhutan. The sample schools are located in varying environments classified as an urban and rural areas.

The researcher used the tools developed by Chick et al. (cited in Sibuyi, 2012) to explore the use of PCK in teaching. Thus, the qualitative tools to explore teachers' PCK to teach force and

motion chapter in grade ten were lesson observation, document (lesson plan) analysis, and pre-lesson semi-structured interviews. All these three tools were used for a single lesson of the sample teachers to gather abundant information. Another round of semi-structured interview was used to understand the use of PCK.

DISCUSSIONS

Knowledge of subject matter

Knowledge of the subject matter is more than just being able to present the facts correctly. It encompasses aspects such as being able to arrange concepts by connecting one concept to another, maintaining the sequential and hierarchical flow of concepts as this study focuses (Ryan & McCrae, 2005). The study had revealed that the teachers have the knowledge of subject matter (conceptual and procedural knowledge) as they maintained the sequential flow of concepts and were able to relate the concept of gravitational force to the meaning of force and related examples. To this, Etkina (2010) suggested that if a Physics teacher does not comprehend the idea, it is difficult to convert concepts into student comprehension. Similarly, Nargund-Joshi et al. (2011) stated that PCK could promote the transformation of subject-matter information to help students learn.

Moreover, on the use of concept maps by participants, Karakuyu (2010) supports that the use of the Physics instruction map has proven to be more successful in enhancing student achievement. The instruction concept map was evident in the concept maps they drew during the interview. Thus the teacher participants could link concepts of Physics to teach two topics of force and motion.

In addition, Teacher A taught the lesson inductively to make sense of the key concepts by relating them to examples and explanations. To this Hubber et al. (2010) in their study on "Force with a Representational Focus" concluded that teachers need to conceptualize science learning in terms of students' science induction practices. Uwizeyimana et al. (2018) too concluded that the teacher should shift from this traditional (deductive and teacher-centered) method of teaching to active (inductive or learner-centered) methods of teaching. Teacher C

taught to locate the center of gravity requiring both conceptual and procedural knowledge. The finding is collaborative with Sibuyi (2012) who pointed out that if learners are taught procedures without knowing the concepts, then learners would not be sure when or how to use what they know. Aydin et al, (2016) too found that in Physics, teaching procedural knowledge requires practice that involve showing the relationships between the concepts. Thus the experience they have as teachers (17 for teacher A and seven years each for B and C) and academic qualifications (B. Ed. in Physics and Math for all three teachers) may have contributed to their knowledge of teaching Physics as suggested by (Sibuyi, 2012).

Knowledge of teaching strategies

The use of different teaching strategies and examples serve as a means of communicating the subject matter. Teaching strategies can also be subject-specific. Hence, the discussion on knowledge of teaching strategies was classified on the use of teaching strategies and examples.

Use of Strategies: The importance of pedagogy was also reflected by Jatsho and Rinchen (2016) in their study on "Teaching Physics Strategies", carried out for grade nine students at one of the schools in Thimphu. They posits that the use of different teaching strategies has strong relevance to student learning. In line with this, De Miranda (2008) concluded that the teacher should know how to use various teaching methods to make learning appropriate. Similarly, the findings of this study revealed that all teachers used demonstration and student activity to make the lesson student-centered. Teachers consistently expressed that using the demonstration method was to show the phenomenon and the activity to involve them in teaching the two topics (gravitational force and field) under force and motion which indicates the use of content-specific strategies. Correspondingly, Tamang (cited in Jatsho and Rinchen, 2016) and Wang (cited in Jatsho and Rinchen, 2016) listed subjected specific strategies in teaching Physics indicating the use and availability of subject specific PCK in Physics. Besides, Jatsho and Rinchen (2016) also confirmed that the demonstration method gave students enough opportunity to acquire knowledge. Therefore, the use of similar strategies to teach the same concept indicates that the participant teachers demonstrated subject or content-specific strategies. The use of subject-specific strategies indicated that knowledge of teaching strategies was related to content knowledge.

Additionally, Teacher A highlighted the use of Kegan's cooperative learning structures to make the lesson student centered as evident in the class observation and lesson plan. To this Rabgay (2018) recommended to use and promote cooperative learning strategies as the teaching and learning approach of choice for the benefit of science teachers and students through his research conducted for the tenth-grade students of Samtse Higher Secondary School. Similarly, the study conducted by Ho & Boo (2007) on "Cooperative learning strategy: exploring effectiveness in the Physics classroom" confirms that the use of cooperative learning helps achieve a better understanding of Physics concepts. Thus, the use of cooperative learning strategies could make Physics learning interactive and student-centered.

Use of Examples: Another aspect of knowledge of teaching strategies include providing suitable examples to improve students' understanding of the Physics concepts. All three teachers provided various coherent functional examples including contextual examples, for which students exchanged suitable examples accordingly. Apart from textbook examples, teacher participants included examples from the local environment and the internet. In support of this, the study on "Strategies for Teaching Physics," by Tamang (2004) found that the use of appropriate and live examples enables both teachers and students to be more comfortable and interactive during lessons. Similarly, De Jong (2009) and Parker, et al. (2018) affirmed that knowledge of representation involves the presentation of ideas in the form of analogies and descriptions that are consistent with the degree and skill level of the student. Similarly, the study conducted for 830 science students and 52 Physics teachers in Nigeria to identify the areas of Physics considered posing difficulty found that students have difficulties in specific topics that lack concrete examples, mathematical manipulations, and visualization (Erinosho, 2013).

Furthermore, Teacher C used Powerpoint presentations to teach. This tool, as transcribed in the interview, was used to stimulate interest in students by showing real phenomena. Xingeng and Jianxiang (2012) affirmed that PowerPoint presentation produces better visual effects, efficient information transfer, and systematic knowledge structures. Even more, embedding technology can enrich the teaching and learning experience. Powerpoint presentation depicted the teacher's ability to use Information and Communication Technology in teaching (ICT).

Knowledge of learners' conception

The teachers should know themselves through the lens of students so that the teachers understand the level of learners to make the teaching and learning process interactive. So this discussion was carried to see the following.

Lesson Goal and Assessment: Lesson goal should be aligned to the assessment with a clear focus on what an individual student ought to understand. The objective used by participating teachers showed that every child was included (every child, each child) and were timely (at the end of the lesson, by the end of the lesson) which were measurable (define, explain, describe and solve). Correspondingly, Nilsson and Vikström (2015) concluded that a clear focus and awareness of what the students should understand makes it possible to teach the different concepts. All teachers fulfilled their lesson objectives in the lesson delivery. However, Teacher A's objectives were not fulfilled fully at the end of the lesson as it was given as homework. Correspondingly, a survey by Jang (2009) showed that the homework and tests as an assessment (of PCK) were perceived to be difficult tools that took time notwithstanding fast teaching pace. Largely, the assessment was carried out during the class to fulfill the lesson objectives in the form of teamwork and questioning.

Prior Knowledge: Teacher participants began instruction by building on students' prior knowledge and connecting it to new concepts (gravitational force and field). The prior knowledge focused on what students have already learned about force, gravity, and related examples. Correspondingly, Uwizeyimana et al. (2018) placed importance to consider prior knowledge of students as it aligns with most of the learning theories in education and building onto prior knowledge of students enhances learning. So the teachers laid importance in consideration of prior knowledge.

Misconception: Misconception ignored over time would lead to the accumulation of information on top of the wrong knowledge, resulting in incorrect knowledge interconnection and hence expanding misconception (Aydin, 2012). The deeper the misconceptions are, the more difficult it is to make corrections (Djanette & Fouad, 2014). However, teachers under study did not have a specific intervention or strategy to identify and address the

misconceptions. They point out misconceptions related to the topic during the interview. Only Teacher A had a teaching on the misconception identified as the gravitational force being related to earth. So the teachers did not plan and address students' misconception though they could identify the probable misconception.

Learners' Difficulties: The teacher with the knowledge of how students understand would help to develop and apply specific pedagogy appropriate to the student, domain, or concept (Veal et al., 1999). In line with this, all three teachers were very friendly to students while teaching. It was evident from the opportunities given to students, acknowledgment for participation, calling students by names, and correcting students' answers with a positive tone. For the students with learning difficulties, teachers attended to the individual student during activities. Such students were also made to work in groups by mixing with high achievers. However, teachers did not plan separate strategies for learners with learning difficulties. Correspondingly, Halim et al. (2014) revealed that the PCK of science teachers should be different for high and low-achieving students and knowledge of students' understanding. Hence, the teachers did not have and execute strategies for learners with difficulty though attended individually during activities.

Concisely, the knowledge of learners included most of the best practices in teaching Physics indicated by Uwizeyimana et al. (2018). Their best practices included making use of instructional objectives, consideration of prior knowledge, construction of knowledge (teacher or student-centered), the inclusion of daily-life examples, working in groups discussion, use of many resources in learning physics, and use of the inductive approach. Thus the use of subject-specific strategies was displayed by teachers.

CONCLUSION

The teacher participants could build up the knowledge through relating one concept to others (which was mainly through the use of prior knowledge and examples to teach gravitational force and gravitational field). Similarly, inductive lessons in Physics lesson gave an opportunity for students to link Physics concepts with other concepts and use examples to understand.

The teacher participants used teaching strategies, including subject-specific and content-specific strategies to teach gravitational force and field. Similarly, the use of practical and familiar examples in Physics (to teach gravitational force and gravitational field under the force and motion chapter) implied the display of Physics teachers' knowledge of teaching strategies under PCK. Use of cooperative learning strategies helped to involve students in learning Physics concept. The use of PowerPoint presentation depicted the teacher's ability to integrate ICT.

Lesson objectives were fulfilled through assessment during the lesson while the practice of assigning homework was seen as procrastinating of objective fulfillment. Prior knowledge of students was considered through the use of the basic concept of force and students' understanding of gravity to teach gravitational force and gravitational field. However, Physics teachers, in the study did not plan and teach on student misconception of the concept though they were able to identify during the interview. Similarly, teacher participants did not use alternative teaching strategies for learners with difficulty though teachers attended to students with difficulty by moving around during student activities. Nevertheless, teachers were very friendly to students as they acknowledged student participation, accepted mistakes, and corrected students' answers with a positive tone.

In general, understanding and use of subject PCK in teaching Physics was shown by the Physics teachers except for dealing with learners' misconception and using alternative strategies for learners with difficulty.

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