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Teachers' knowledge that promote students' conceptual understanding

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Abstract

It has been argued that effective pedagogical content knowledge (PCK) could develop students' conceptual understanding. However, there is lack of empirical evidence supporting the relationship between PCK and students' understanding. This qualitative study was conducted to explore the components of teachers' PCK and other related factors that promote students' conceptual understanding in the topic of "Respiration" from the perspectives of teachers and students. The findings showed that components of teachers PCK; component of content knowledge, pedagogical knowledge, knowledge about students and knowledge of the context contributed to students' conceptual understanding of "Respiration". The study also found teachers' attitudes and teachers' emotions contributed to students' understanding. This study showed that with the appropriate teachers' attitudes and emotions coupled with effective PCK will ensure learning takes place. When learning process occurs, then only conceptual understanding of content can be achieved.

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1. Introduction

Teaching for understanding is an enormous challenge for science teachers. Among the challenges science teachers faced in teaching for understanding have to address students' misconceptions as well as motivate students' interest in learning science. The fact that learning for understanding, "explain ideas in science" as well as to "evaluate arguments based on scientific evidence" were given less emphasis at all levels also suggests that students may be learning science without actually understanding (Colley 2005). One possible reason for lacking of conceptual understanding among students is that science teachers are relying on teaching methods or strategies that are ineffective for promoting understanding of science.

Teaching and learning of science in classrooms is often characterized by the chalk-talk-laboratory method. In a study of science and mathematics education, Weiss, Banilower, McMahon and Smith (2001) found that the most common instructional activities in science classrooms were lecture and discussion. The researchers also noted that "despite the reported emphasis on science process and inquiry skills, classes at all levels are much less likely to

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stress having students learn to explain ideas in science (21–39 percent) or learn to evaluate arguments based on scientific evidence (8–29 percent), two skills integral to scientific inquiry” (p. 61).

In order to facilitate students’ understanding, teachers must have well-developed knowledge base for teaching, including knowledge of multiple instructional representations and the connections between them (Moseley & Brenner 1997; Rider 2004). Shulman (1987) argues that in producing an effective lesson a teacher must have at least three types of professional knowledge (professional knowledge): content knowledge, pedagogical knowledge and knowledge of students. The combination of these three types of knowledge are then formed PCK. Pedagogical content knowledge (PCK) is a form of teacher professional knowledge.

The initial definition of pedagogical content knowledge by Shulman (1986) was conceptualized further by others (e.g. Veal & MaKinster 1999; Segall 2004), expanded to include new components (e.g. Barnett & Hodson 2000; Magnusson, Krajcik & Borko 1999; Mishra & Koehler 2006; De Jong 2009), and investigated among teachers (e.g. van Driel, Verloop & de Vos 1998). Grossman (1990) expanded Shulman’s definition and proposed four component of PCK: (a) knowledge of the purposes for teaching specific topics at different level, (b) knowledge of students’ understanding and misconception, (c) knowledge of the curriculum material available for teaching specific topics and (d) knowledge of instructional strategies and representations for teaching specific topics. Magnusson, Krajcik & Borko (1999) defined five components of PCK: (a) orientations toward science teaching, (b) knowledge and beliefs about science curriculum, (c) knowledge and beliefs about students’ understanding of specific science topics, (d) knowledge and beliefs about assessment in science, and (e) knowledge and beliefs about instructional strategies for teaching science. Loughran et al. (2006) argue that PCK is a combination of knowledge and pedagogical knowledge of each form and interact with each other, so what is taught and how it was useful in ensuring that teaching a specific concept is understood by students because the teaching has been managed, planned, analyzed and presented well.

Despite the argument that PCK promotes conceptual understanding, there is however, lack of empirical studies investigating the relationship between teachers’ PCK and students’ conceptual understanding. Previous studies only measure the PCK of the teacher (Rowan et al. 2001), the practice of PCK (Loughran et al. 2004) and the development of teachers’ PCK (Darling-Hammond 2000; Goldhaber & Brewer 2000; Rowan et al. 2001, Loughran et al. 2006). Hence, this qualitative study aims to explore the components of teachers’ PCK and other related factors that promote students’ conceptual understanding in the topic of “Respiration” from the perspectives of teachers and students.

2. Methodology

The methodology employed in this study was qualitative approach based on case study design. A total of five secondary Biology teachers and 17 Form Four (16 years old) students were involved. An initial framework of teachers’ knowledge contributing to students’ conceptual understanding was conceptualized. The components of teacher knowledge identified from the literature review were: content knowledge, pedagogical knowledge, knowledge about student and knowledge of the context. Data was obtained from interviews with teachers and students as well as classroom observations and was analyzed qualitatively using constant comparative method. The comparative method involves constantly comparing the themes emerging from the data analysis to the initial framework. The common strategy such as method triangulation (the used of multiple methods of collecting data) member checks, peer review and audit trail also done to ensure the validity and reliability.

The topic of Respiration is the focus of this study and it is the basic knowledge in physiology. It has been shown that students’ understanding of respiration is weak and there exist a widespread of misconception at all levels of education (Köse 2008; Hong Kwen Boon 2007). According to Cliff (2006) in the teaching of “respiratory physiology” is a major challenge to teachers because students already have their own ideas about the human body that they bring to the classroom. So many ideas were brought against the scientific idea or misconception (Wandersee, Novak & Mintrezes 1994).

3. Findings

The findings showed that component of teachers’ PCK that contributed to the students’ conceptual understanding in topic of "Respiration" were content knowledge, pedagogical knowledge, knowledge about students, and knowledge of the context. These components contributed to students’ understanding either individually or collectively. The

teachers' content knowledge was found to match to the concepts and principles that appear in the Form Four Biology syllabus. This shows that teachers possess the content knowledge that enables them to teach "respiration" at Form Four. The concepts of "Respiration" possessed by teachers were: (i) process of "respiration" in the production of energy; (ii) structure of "respiration" and breathing mechanisms for animals and humans; (iii) concept of gas exchange across the surface of the "Respiration" and transport in human; (iv) regulatory mechanisms in the "Respiration"; (v) importance of health care systems "Respiration" and (vi) respiration in plants.

This study also found that teachers have other types of knowledge related to "Respiration" such as: the examples in the Malaysian context, history and the appreciation of God's creation. For example, how catfish and "Haruan" survive longer on land than other kinds of fish is a particular example in the Malaysian context. Teachers also knew about the historical origin of the word "aerobic" and discovery of knowledge about the "Respiration" by "Ibn Sina". Teachers also relate to the structure of respiration to the greatness of God's creation which is the emphasis of Malaysia science curriculum. Teachers' pedagogical knowledge in "Respiration" consists of general pedagogical knowledge and specific pedagogical knowledge and both types of knowledge were interconnected and influencing each other. Although, general pedagogical knowledge can be used for other subjects, particularly science subjects, but it plays a significant role in teaching a particular topic. On the other hand, specific pedagogical knowledge is specific and only be used in teaching the topic of "Respiratory". Categories found in the general pedagogical knowledge were: (i) Teaching preparation; (ii) Explanation skills, (iii) Assessment methods, and (iv) Classroom management. Meanwhile, the specific pedagogical knowledge consists of (i) Teaching methods, (ii) Teaching Techniques (iii) Resources and teaching aids. The teaching methods that were highlighted by the teachers when teaching Respiration were explanation, analogy, demonstration, experiment and group work. The components of knowledge about students in topic the "Respiration" revolve around the teachers' general knowledge about students, students' misconceptions in the topic "Respiration" and learning difficulties faced by students in the topic of "Respiration". Knowledge about the context consists of the learning environment in schools and the use of examples in the context of student life.

In addition to these four components, this study also found that there were other factors that affect students conceptual understanding i.e. teachers' attitudes and teachers' emotions. Attitudes and emotions of teachers were found to have a positive impact and negative effect on students' understanding. For example, the attitude of teachers who are eager and earnest motivates student to follow the lesson. Thus, learning happens and often promotes understanding. Conversely, when teachers are not motivated or emotionally unstable the learning and teaching process probably does not lead the student to participate. So learning will not happen and understanding can not be achieved. The components of PCK and its interrelation are shown in figure 1.

4. Conclusion

These findings support the definition of PCK presented by various researchers as a special teachers' knowledge to teach a particular topic (Van Driel, Beijaard & Verloop 2001). This study also showed that with the appropriate teachers' attitudes and emotions coupled with effective PCK will ensure learning takes place. When learning process occurs, then only conceptual understanding of content can be achieved. An implication of this study is the importance of attending to the emotive needs of the students, in which Shulman's theory of teachers' knowledge fail to take into account in promoting students' understanding in the concept of effective science teaching. The framework can serve as a guide in pre and in-service teacher training, particularly in teaching and learning "Respiration" Form Four Biology.

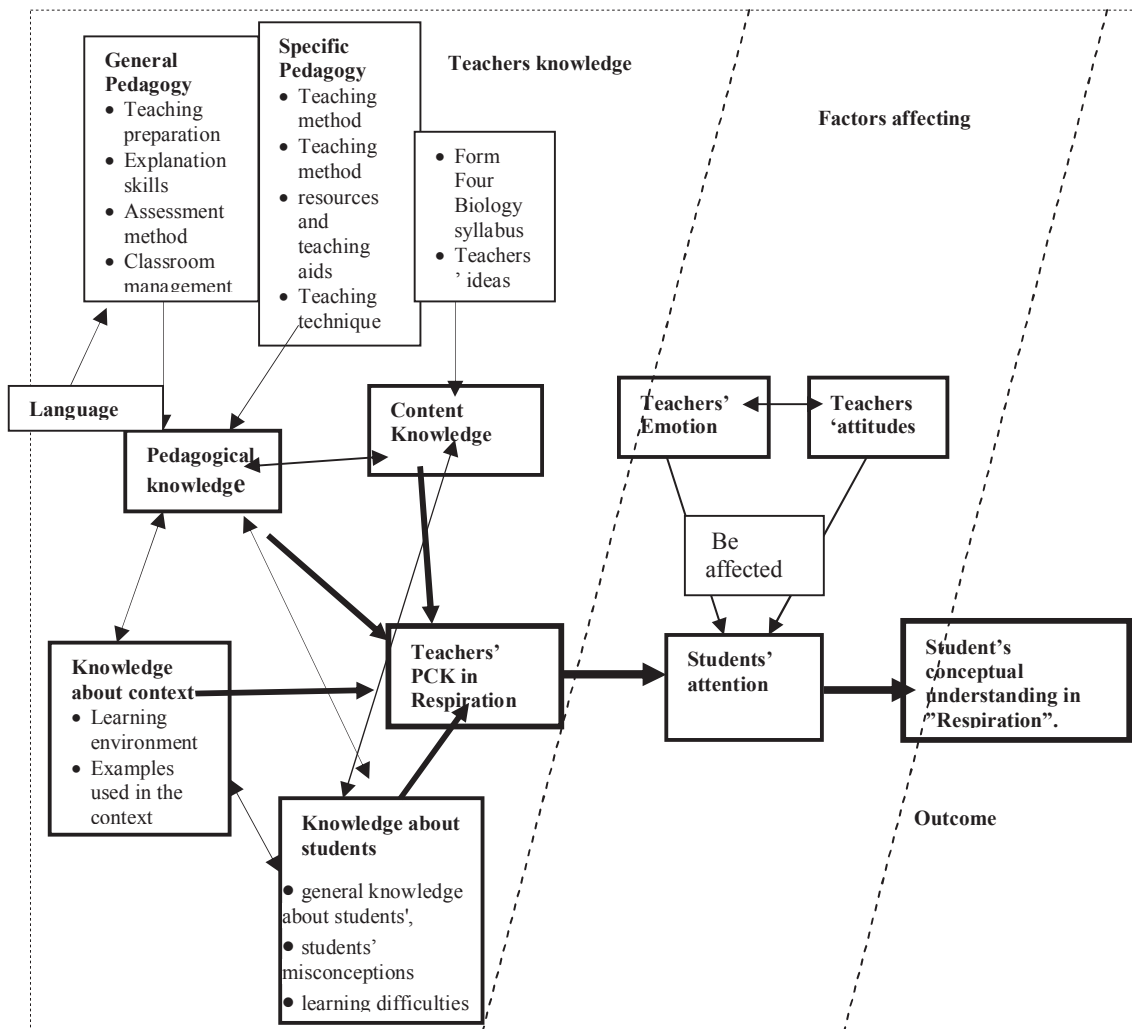


Figure 1. Framework of students' conceptual understanding and teachers PCK in the topic of "Respiration"

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