Science Teachers perceptions of their Pedagogical Content Knowledge (PCK)

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Abstract. Pedagogical content knowledge (PCK) is a way of representing and formulating knowledge making it comprehensible to others. PCK in science is used as a framework to guide the analysis of evidence about how science teachers' knowledge develops over time. From the literature review, it is shown that the teacher's role lacks specific identity in his exercise. Disregard on the management and use of certain components such as Pedagogical Content knowledge and teaching methods demonstrates that science education is a complex process. The objective of this paper is to study the perceptions of science teachers towards about PCK. The methodology used is qualitative with a phenomenologic approach where the sample consisted by three Natural Science teachers from a Public School of Colombia. This study enabled to recognize an adaptation of the PCK Framework that shows the importance of the science topics contents into the fundamental components of PCK.

Keywords: Pedagogical Content Knowledge (PCK), Science teaching, Education.

1 Introduction

Pedagogical content knowledge (PCK) is a framework used to represent and formulate the knowledge to others [1], so that the teacher continues learning while studies and executes their own practice [2]. In addition, PCK is characterized by the quality and relevance of knowledge and how it is put into practice [3]. Shulman [4] describes four important characteristics of PCK: i) PCK includes discrete categories of knowledge that are applied synergistically to practical problems; ii) PCK is dynamic; iii) content (science in this case) is central to PCK; and iv) PCK involves the transformation of other types of knowledge [3],[4]. PCK is structured by five broad fields: *Orientations to teaching science, Student thinking about science, science-specific strategies*, *Science curriculum*, and *Assessment of students' science learning* [5]. PCK in science is used to analysis processes about how pedagogical and disciplinary science

teachers' knowledge develops over time. For this reason, teachers use PCK components in an integrated way while planning and carrying out an instruction [3].

Research on PCK, particularly in the teaching of science field has been developed [6],[7],[8],[9], for instance, Crawford [10] examined the knowledge, beliefs and efforts of five prospective teachers to present teaching science from an inquiry point of view using field-work experience in a high school. Hume & Berry [11] exploratory study focused on the identification of foundations on which novice teachers can begin developing their PCK using of Content Representations (CoRes). Abell et al [12], used the PCK to propose a model which uses experiences of doctoral students and faculty mentors for the development of pedagogical knowledge on science teachers. Another research examined the impact of a transformative model of integrating technology and peer coaching for developing technological and pedagogical content knowledge (TPACK) of pre-service teachers teaching science [13]. Dijk and Kattmann [14], developed a model "Educational Reconstruction for Teacher Education" (ERTE) to improve science teachers' pedagogical content knowledge (PCK). Friedrichsen and Berry [15] proposed the use of learning progressions in the PCK framework there is a gap in the PCK researches towards the way this knowledge develops across science topics.

From the literature review, it is identified and existing gap [15] is observed in each one of the researches previously mentioned and also it is confirmed by [16]. Also, in the Secondary school where was applied this study, it is found that the teachers disregard the use of certain components of the PCK, confirming the theoretical assumptions of [12], which states that often the teacher has no mastery of such components and therefore he could generate very few new teaching strategies [12].

The objective of this paper is to study the perceptions of a science teachers about PCK in a Colombian Secondary institution, making emphasis in how the PCK is developed across science topics content. In this sense, a PCK adaptation for this study was designed. This document is structured as follows: The second chapter defines the Pedagogical Content Knowledge (PCK); in the third chapter, we explain the methodology. The next chapter shows results and discussions. Finally, the conclusions of study are presented.

2 Pedagogical Content Knowledge

PCK is a heuristic framework for teacher knowledge [2], it, involves the interpretations and transformations of content linked to teachability, teachers' knowledge about its own teaching process and how this knowledge changes over broad spans of time [2],[14],[17]. Shulman [4] posited PCK like a specialized knowledge that distinguishes teachers from others subject matter specialists. This difference is specially observed in the teachers' pedagogical actions, which are evidenced through the understanding of the concepts to be taught, obtained through the reflections made by themselves [18]. Thus, PCK is the knowledge of what in specific domain is taught. It is what teachers know about their subject matter and how to make it accessible to students. PCK includes conceptions about the meaning of teaching a particular subject, knowledge of curricular materials and curriculum in a particular field [19]. PCK is used in science as a model to describe and interpret the way in which teachers in initial training and beginners,

learn to interpret and transform the content of a topic into understandable meanings for a group of students in the classroom [17],[2]. Shulman represents the blending of content and pedagogy into an understanding of how particular subjects, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction [1]. In addition, he states that PCK is included in a knowledge base for teaching that consists of seven categories: *i) content knowledge, ii) general pedagogical knowledge, iii) curriculum knowledge, iv) PCK, v) knowledge of learners and their characteristics, vi) knowledge of educational contexts, vii) knowledge of ed- ucational ends, purposes and values, and their philosophical and historical grounds* [14].

Shulman and others authors [2],[5],[12],[18],[19], have proposed differences in this model from the domains of teacher´s knowledge. These authors affirm that knowing science is a necessary but not sufficient condition for teaching. Science teachers must also have knowledge about orientations to teaching science, student thinking about science, instructional strategies in science and the assessment of students' science learning.

The Figure 1 shows the PCK model used in this study. This model is an adaptation of the theoretical assumptions proposed by (Schneider & Plasman [2], Magnusson [5], Abell et al [12], Grossman [19], Loughran [20], Herrera et al [18] and Park & Oliver [21]). In this model, components related to how teachers' knowledge is developed across science topics content. Thus, Science Teachers PCK is structured by the following components: orientations to teaching science, instructional strategies in science, student thinking about science and assessment of students' science learning. These components in turn are structured by categories, which are described below.

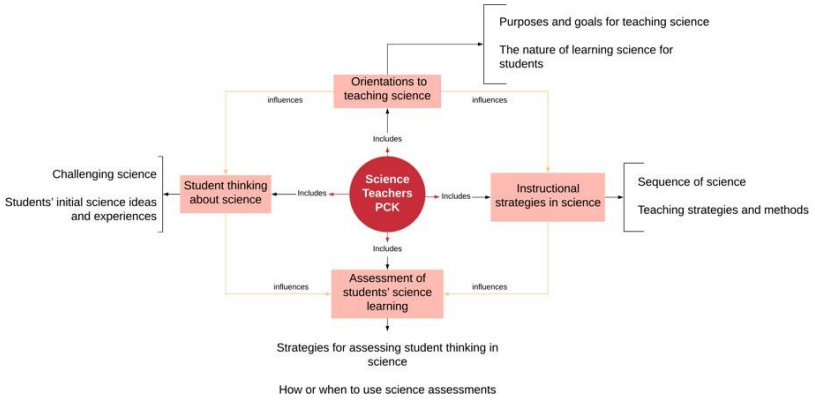

Fig. 1. Model of PCK for teaching science designed using theoretical assumptions by Schneider & Plasman [2], Magnusson [5], Abell et al [12], Grossman [19], Loughran [20], Herrera et al [18] and Park & Oliver [21].

Orientations to teaching science (OTS)

This category includes teachers' ideas about the purposes and goals for teaching science and the nature of teaching and learning science [2],[17]. Magnusson et al, [5] states that it is the first and most influential part of a teacher´s pedagogical content knowledge.

This category influences and shapes the other aspects of the teacher´s PCK. OTS is considered like a teacher's interrelated set of knowledge or beliefs about the purposes and goals for teaching science and the nature of learning science for students [22]. In addition, the expectations in the teaching learning process and the importance that science learning plays in the role of teacher in the OTS [20]. In this process, students learn science by exploring ideas, contexts or possibly problems with teachers´ guidance, who assume a specific role in this process as well as students [2],[22].

Student thinking about science

This category as well as instructional strategies in science constitutes a key component of PCK for the exploration of previous knowledge and the identification of difficulties or limitations in learning [4],[20]. The *student thinking about science* is centered on the following categories: teachers' ideas about challenging science ideas for students and students' initial science ideas [19],[23].

Instructional strategies in science

This category includes teachers' ideas about the sequence of science (organizing science content for learning) and science teaching methods and strategies [20],[24],[25].

Assessment of students' science learning

This category includes teachers' knowledge about how and when to use science assessments (reasons for which the contents are evaluated and assessment actions) and strategies for assessing student thinking in science (including contents evaluation, evaluation aspects and the student's role in the evaluative process)[20],[26].

3 Methodology

This qualitative research aims to describe and interpret the educational reality from within. It is based especially on phenomenology [33],[34],[35], which points to the subject (teacher for this case) as a producer of knowledge built through what is perceived subjectively [36]. In this way, this study intends to inquire about the Pedagogical Content Knowledge presented by science teachers of a secondary school based on the meanings that they attribute to their knowledge from a pedagogical and disciplinary view point. The study sample were three Science teachers from a Public School in Colombia, which constituted a twelve percent of total population of the teachers of that school.

The research was carried out during six weeks, where three in-depth interviews were conducted following the theoretical assumptions of [2],[8],[18]. The analysis of data gathered was both manual and software-based.

The analysis categories used in this study are described below according to PCK model previously described in (see Table No. 1):

Components of science teacher PCK	Categories for each component of PCK
Orientations to teaching science	Purposes and goals for teaching science The nature of learning science for students
Student thinking about science	Challenging science ideas

	Students' initial science ideas and experiences
Instructional strategies in science	Sequence of science
	Teaching strategies and methods
Assessment of students' science learning	Strategies for assessing student thinking in science
	How or when to use science assessments

4 Discussion and results

This study is based on the qualitative analysis of content revealing accurate information about perceptions of science teachers on its PCK. The following were questions used in each category applied:

Orientations to teaching science

a. Purposes and goals for teaching science

What do you expect students to learn when you teach the contents of Natural Sciences?

The first teacher interviewed (T1) affirmed that *"The knowledge that students get here put them into practice in their daily lives and serve to live and live in society"*

The second teacher interviewed (T2) stated that "*Students must be educated from their own knowledge of science and also as a researcher, where emphasis is placed on field work involving the social and formative part that is very important in education*"

The third teacher (T3) affirmed that *"We aspire that our students obtain an appropriate knowledge to defend themselves in their daily lives, that everything we see in natural sciences is applicable to their context"*

It is evident that teachers have different points of view about learning expectations in students, where two main trends stand out, regarding teaching for daily life. [27] affirms that an compara- tive analysis of daily life with the field of the science reveals significant differences in their goals and in the cognitive means used to achieve those goals. The lack of awareness that students have of these differences can lead to a general learning difficulty in their study of science. Therefore, many students a) have misconceptions of scientific objectives, b) import goals and ways of think- ing that are effective in everyday life but are not suitable for science, and c) devise inappropriate ways of thinking for science.

Why is it important for students to learn these contents?

"It is important for them to learn to value the environment, take care of their health and take care of their body"(T1).

"Undoubtedly every discipline of knowledge, the student has to structure the knowledge part ... you have to teach the young person to build their own concepts and that is where education is failing" (T2)

"Knowledge is applicable to everyday life. Everything we study in science is applicable to everyday life" (T3).

According to [28] the construction of knowledge is possible through successive approaches from a descriptive point of view, thus taking it to a process of understanding. Which indicates that students build knowledge through a process of approach to the object of study where it occurs

through a progressive bidirectional transit of the processes of description, analysis and understanding. In this way is necessary to be reflective about the complexity of the processes associated with teaching and learning for to challenge and cope with the different facts that the daily live.

b. The nature of learning science for students

What is your role during the teaching, learning and evaluation process of Natural Science content?

"The role is basically to guide all processes" (T1)

"I consider myself a facilitator of student learning, also of research skills. I hope they are good researchers and that without permeating the creative part of them they will build their own experience, their own learning process" (T2)

"First, we make a diagnosis to the students, based on that, strengthen a little more those who are a little more advanced and reinforce a little those who are less advanced in knowledge"

According to [29] the teacher's role in the process of knowledge building is to be a mediator between the student's cognitive side and the content he will learn, which are in accordance with the sociocultural knowledge that gives him a great meaning to this process. In addition, the function of the teacher is to be a guide and guide of the mental processes that are generated in the individual. In this question, the first two interviewees T1 and T2, agree that the teacher should have a role of guide, mediator or facilitator, in the teaching-learning process, while E3 refers more than anything to the didactic sequence used for the design and development of its classes.

What is the student's role during the process that guides you in learning the contents of Natural Sciences?

"The role must be participatory, it is not an entity that is there, static, but participates in the activities in a group or individual" (T1).

"The student is the most important because they are the object of learning of the teaching-learning process, for them it is that we are the teachers" (T2).

"There are some students who have a much faster learning pace than others, so we can identify those who have that slower learning pace than others and try to reinforce a bit more in those with the slower learning pace"(T3)

According to [30] when the teacher refers to the teaching-learning process, he expresses a special concern regarding the contents and the appropriate didactics so that the knowledge is assimilated by the students and this allows to be the main actor in the construction of their own knowledge.

Student thinking about science

a. Challenging science ideas

What difficulties or limitations do students have in the process of learning the contents of Science?

"Probably, the most common mistake is that sometimes they don't handle scientific terminology" (T1)

"The problem that students have is that they try to memorize not to understand" (T2)

"Technology is being misused, students are taking the content that is available on the Internet very easily, for this reason there is no deep analysis of the issues" (T3)

It is considered that there are many difficulties or limitations that arise in the school context and that, in some cases they are ignored by some teachers, an example of this is the cognitive-affective relationship.

b. Students' initial science ideas and experiences

What are the main mistakes that students make while learning the contents of Science?

"Try to memorize everything, that is basically always the first mistake they make" (T1).

"The main mistakes for me not only the natural sciences, but the lack of responsibility and commitment, because many require the help of their parents and parents we have become permissive" (T2).

"*One of the main mistakes is distraction; another is to try to view the contents as something memoristic and repetitive*" (T3).

[31] states that the student's ability to understand is linked to the way in which the teacher guides the instructional process, which directly affects the student's performance. In this study, it was possible to verify that what the three respondents said is the educational reality that the teacher must assume daily: distraction, lack of training from the cognitive side, the school context, among others.

What do you know about students' previous ideas about the contents of Science?

"Each class seeks to identify what students know about a certain topic, to see how it can be deepened, or what strategies must be implemented so that these contents are assimilated or improved" (T1).

"It is necessary for the student to strive to build their own knowledge and to do it in the best way" (T2)

"Of course, we must take into account previous knowledge because that is the fundamental basis for us to guide the process" (T3)

The findings of this question are related to [32] approach, which states that the teacher's role is to be a mediator between what the student knows and the new knowledge. This requires the exploration of previous knowledge, the preparation of the classes and the transformation of the concepts by the students

Instructional strategies in science

a. Sequence of science

How are the contents of Natural Sciences taught in the school context? Doing what?

"As I told you, teamwork, master classes and laboratories when they can be done" (T1)

"From the school context I tell you there is more of the part of workshops, of practices in the class" (T2)

"The theoretical part must always be correlated with the practical part" (T3)

It is common for the concept of academic performance to be associated with cognitive ability, in many cases students who enjoy that great potential do not show such results in their academic performance

b. Teaching strategies and methods

What strategies could be used to teach the contents of Natural Sciences? Why?

"It would be essential to end that individualism and work as a team and cooperative work" (T1).

"The methodology by projects and the research methodology" (T2).

One of the strategies could be, application of Natural Sciences, but through "educational games" through workshops (T3)

Assessment of students' science learning

a. How or when to use science assessments

What aspects do you have in mind to evaluate the learning of the contents of Natural Sciences?

"Well, the theme that is given, basically that, but also the contribution of the students themselves" (T1)

"I am convinced that education lost When education became quantitative it appears to me from my point of view and I do that the qualitative part" (T2)

*"Within that there are several aspects, the knowledge itself, the behavioral aspect and the attitudinal aspec*t"

The aspects that are taken into account to evaluate the learning of the Science Content in the students, according to the contribution of the three professors interviewed, the aspect evaluated mainly is the knowledge in a quantitative and qualitative way for all cases, that is, it is had Consider knowledge, know-how and know-how

5 Conclusion

This study enabled to recognize an adaptation of the PCK Framework that shows the importance of the science topics contents into the fundamental components of PCK. In this way, the teachers is focused in an education directed to a for everyday events and research; while, the teacher's role for some is to be a revitalizer, another teacher believes that his role is to provide the information to the student. For this, they use strategies such as group work, knowledge exploration and active participation; while, the teacher sequences its content according to the objective of the subject he is developing.

This research allowed to conclude that the PCK is a fundamental piece for education and, it is a fact that, today the individual is not trained for life, but only in the learning of contents, research must be the central axis of school education, due to the attributes and benefits offered to education; therefore. It is necessary that the teacher be aware of the different ways of doing research and that during this process the knowledge acquired will help the student to develop in their daily lives.

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