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PEDAGOGICAL CONTENT KNOWLEDGE: SHOULD WE KEEP IT ALIVE?

ABSTRACT

The purpose of this article is to question what constitutes a good science teacher. A good science teacher, often argued, among anything else, is the one who has to know his/her subject-matter area very well. Then, to become an outstanding science teacher should also be fairly simple with this line of reasoning. The person, who has sufficient subject knowledge, will be teacher. This paper will provide a review of the literature on the profession of science teaching and report characterizations of effective science teachers.

INTRODUCTION

The rapid development of mass electronic devices coupled with constant price drops is the locomotive force of these changes. Moreover, Science for All Americans goes on: "the terms and circumstances of human existence can be expected to change radically during the next human life span. Science, mathematics and technology will be at the center of that change - causing it, shaping it responding to it. Therefore, they will be essential to the education to today's children for tomorrow's world." And finally they raise a crucial question: "What should be the substance and character of such education?" (Benchmarks: 1).

Well, this paper is not going to undertake such an enormous task, rather it will focus on a sub-dimension of education and its associated problems. The purpose of this article is to dwell around the question what constitutes a good science teacher? A straightforward question, perhaps to a certain degree even a naive question, seems to be easily answered -or spontaneously! A good science teacher, often argued, of course, is the one who knows his/her subject-matter area very well. Then, to become an outstanding science teacher should also be fairly simple with this linear reasoning in terms for the person who intends to choose the profession of teaching. Namely, a bunch of solid hard core science courses should suffice for this holy aim!

These commonsensical attributes mentioned above that portray a good

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science teacher might have some truth to it. At least it assumes that there is something to or about a teacher that makes this profession to a certain degree unique. However, is that all a science teacher has to do provide or know? Or more specifically what is the knowledge base for teaching?

Shulman (1987) acknowledges that many characterizations of effective teachers already exist and are addressed in the body of scientific literature. However, unfortunately, most of these studies reported dwell on teacher's management of classroom.

The studies of Holmes Group (1986) and the Carnegie Task Force assume that there exists a unique teacher knowledge base, in fact their studies are building around this assumption. They also believe and report that this knowledge base is developmental in nature. Moreover, they argue that this should constitute teacher education and directly structure teaching practice.

However, Shulman (1987) points out that the rhetoric regarding the knowledge base rarely specifies the character of such knowledge. According to him, it does not indicate what teachers should know, do, understand, or purport that will cause teaching to become more than an act of individual labor or personal style.

By studying expert and novice teachers over a three year period and then comparing these cases with each other Shulman was able to construct 7 distinct knowledge dimensions that he believes to constitute a teacher's knowledge base. These are as follows;

1. Content knowledge;
2. General pedagogical knowledge, with special reference to those broad principles and strategies of classroom management and organization that appear to transcend subject matter;
3. Curriculum knowledge, with particular grasp of the materials and programs that serve as "tools of the trade" for teachers;
4. Pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding;
5. Knowledge of learners and their characteristics;
6. 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
7. Knowledge of educational ends, purposes, and values, and their philosophical and historical grounds.

This knowledge base is the minimal essential to educate teachers to think soundly about their teaching practice as well as to perform skillfully. Therefore, teachers must learn to use their knowledge base as the main source for their choices and actions. Among the categories listed above, pedagogical content knowledge (PCK) is of peculiar interest due to the reason that it represents the distinctive frames of knowledge for teaching. The comprehension of subject matter or content, however, does not particularly distinguish teacher from a person confident in the same major area. But the key to label someone as a teacher lies at the intersection of content and pedagogy. That is the teacher's capability of transforming his or her content knowledge into forms that are pedagogically effective in an intact classroom.

The idea of PCK, allows the natural extension of the concepts subject matter and pedagogy to emerge to the surface as on whole entity. In particular, it represents an understanding of how certain topics, issues are organized, represented, dealt with, and as a result presented for teaching or in general for instruction. Shulman (1987) furthermore adds that "pedagogical content knowledge is the category most likely to distinguish the understanding of content specialist from that of the pedagogue" (p. 8).

PEDAGOGICAL CONTENT KNOWLEDGE

In general teachers are taught subject matter knowledge and then general pedagogical knowledge, though, not necessarily in this order. However, the scientific literature, at least for the time being, does not suggest that science teachers' subject matter knowledge are magically transferred to effective classroom teaching (Lederman, Gess-Newsome, 1992; Barnett, 1992).

Shulman (1986a) terms this "lost paradigm" or implicit body of knowledge as pedagogical content knowledge.

"A second kind of content knowledge is pedagogical knowledge, which goes beyond knowledge of the subject per se to the dimension of subject matter knowledge for teaching.... Within the category of pedagogical content knowledge I 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, 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 topics easy or difficult; the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons (p: 9-10).”

Pamela L. Grossman (1989, 1990) reexamines the Shulman’s understanding of PCK by investigating six English teachers where the half of them were graduates from teacher education programs. By contrasting these cases she aimed to understand the influence of subject-specific coursework in the growth of PCK. In describing the differences in the teachers’ knowledge regarding the purpose for teaching secondary English, curricular knowledge, and knowledge of student understanding she redefined PCK.

The first component includes knowledge and beliefs about the purpose of teaching a subject at different grade levels. She argues that these overarching beliefs of teaching a subject are reflected in teacher’s goals for teaching a particular subject matter. The second component includes knowledge of students’ understanding, conceptions, and misconceptions, and alternative conceptions of particular areas in a subject matter. Therefore, in order to come up with meaningful explanations and representations, teachers must have knowledge about what students already know about a topic and what they are likely to find confusing, irrational, and counter intuitive. The third component of PCK is teachers’ curricular knowledge. This includes knowledge of curriculum materials available for teaching particular subject matter, as well as knowledge about both horizontal and vertical curricula for a subject. Teachers reflecting on which books and topics are typically addressed at a certain grad and how the various strands of that grad curriculum might be organized could be an example of this specific component. Another example of this source would be teachers using their knowledge of what students have studied in the past and what they are likely to study in the future. The fourth and final component of pedagogical content knowledge includes knowledge of instructional strategies and representations for teaching particular topics. A rich repertoire that consists of models, metaphors, experiments, activities, or explanations that are particularly effective for teaching a particular topic would be an example of this component that is owned by experienced teachers.

Tamir (1988) is another important pioneer educator among the few that spend time, energy, and perhaps more importantly intellectual labor about

the construct PCK. His understanding differs in several ways with Shulman's definition. Firstly there is a shaper distinction between general pedagogical knowledge and PCK, which according to him is composed of four main parts, namely, student, curriculum, instruction, and evaluation. He hopes that this distinction will unfold itself in a more effective way in terms of teacher education programs. General pedagogical knowledge by definition should be handling by experts in general pedagogical and, hence, can be taught in mixed disciplinary classes. Subject matter specific pedagogical knowledge (PCK in 'Shulmanien' terms) he believes should be practiced by experts in a particular discipline working with pre-service teachers preparing to teach in that discipline. Secondly he forms subcategorize for each of the four domains mentioned above. Knowledge and skill are the two crucial subcategorize "missed" by Shulman and his colleges, according to his point of view. The rational is that knowledge can be transmitted via speech, print, pictures, and films, whereas "skill can only be acquired by direct experience" (Tamir, 1988: 100), thus needs to be a distinct sub-domain. Tamir prefers the term subject matter specific pedagogical knowledge over pedagogical content knowledge because the term subject matter encompasses both the content (substantive) and the process (syntactic) components of a discipline.

Marks (1990) following an analysis of interviews with eight fifth grade mathematics teachers proposed yet another slightly different version of pedagogical content knowledge. According to him PCK is also composed of four main components, moreover all of these components have several subcomponets the four main parts of Marks' PCK are as follows:

1. students' understanding of the subject matter
2. media for instruction in the subject matter (i.e. texts and materials)
3. subject matter for instructional purposes
4. instructional processes for the subject matter (1990: 5)

Hashweh (1987) used the concept of pedagogical content knowledge to explore secondary teachers' knowledge of science and their planning and simulated teaching of a lesson based on information given. He found that the teachers with better knowledge of science, [that is better "content knowledge"]; "were more likely to detect students preconceptions; to exploit opportunities for fruitful "digressions"; to deal effectively with general class difficulties, and to interpret correctly student's insightful comments." (1987: 118)

While most of the studies naturally used either experienced or novice

or a combination of teachers as their research participants, Fernández-Balboa and Stiehl (1995) chose university professors (n=10) to understand the nature of PCK. All the professors had between 15 to 31 years of teaching experience at the college level. Although they began their initial analyze on the four components outlined by Grossman (1990), as a result of their study a few important differences with regard to these components emerged. Thus, the researcher ended up with yet another alternative structure of PCK. Their components included knowledge about: (a) *the subject matter*, (b) the students, (c) numerous instructional strategies, (d) the teaching context, and (e) one's teaching purpose. Here raises an interesting point; did not Shulman drive the whole construct of PCK because it is the unique knowledge a teacher has. The knowledge of "transform their understanding of it [the subject matter] into instruction that their students can comprehend" (Shulman, 1986: 8) Alas, the authors provide a poor rational why they saw the urge to include subject matter as an integral part of PCK. Especially, knowing that they are the first to do so.

Finally, pedagogical content knowledge according to Wilson et al. (1987) is not merely a repertoire of various representations of subject matter knowledge. Pedagogical reasoning, a term to portray the distinct way of thinking a teacher generates during an intact classroom teaching, promotes the generation of subject-matter transformations into teachable forms. This on the other hand plays a crucial role in developing PCK growth.

PROBLEMS ASSOCIATED WITH PCK

Whatever definition one might use, one thing is for sure, pedagogical content knowledge is a construct that is made up several components. The three main parts are general pedagogical knowledge, subject matter knowledge and the "wisdom" of experience.

However, the very nature of PCK is where the ambiguity also cultivates. This became especially clear in the previous section where researchers tried to get a firmer grasp on the nature of PCK. Especially, the attempt of an empirical distinction of pedagogical content knowledge between that of subject matter knowledge is problematic. Expressions like "the division between PCK and subject matter knowledge may become blurred" (Lederman et al., 1994: 143) is an example where the tension of the nature of PCK comes to surface. This problem is explicitly acknowledged by other authors that etude PCK as well (e.g. Marks, 1990).

IMPLICATIONS FOR SCIENCE EDUCATION

Despite the studies conducted on PCK, I feel there is still little documentation regarding the exact nature of pedagogical content knowledge that can arise among science teachers as a result of teaching. In addition, the fact that research aim to define and portray indisputable the concepts at hand does not apply very well to PCK. However, the ambiguity of PCK i.e., the many different understandings of PCK among advocates should not be regarded or treated as a weak point of PCK. Also it is not an acceptable reason to abandon the whole construct as some people might argue for.

Experts agree that the construct PCK is the ultimate knowledge that distinguishes science teacher form content specialists. In addition, PCK is also the paradigm used to transform the knowledge required to teach specific school subjects, therefore, I believe, it will help to facilitate the understanding of science teacher education in several important ways that might not be accessible otherwise.

The construct PCK enables the science education community to open a valuable door for initiating the vantage point for studying teacher education as a unique source of teacher knowledge. Where these teacher knowledge is regarded as how those teachers make sense of teaching and learning. The keyword here is making sense rather than being trained to execute almost "perfect" algorithmic behaviors that were emphasized in the past. By introducing the construct PCK the science education community will allow and legitimate the shift from a behavioristic focus which in turn will reshape our understanding of the theoretical framework of teaching practice (Richerdson, 1994).

Second, studies based on the theoretical underpinnings of PCK will provide portrayals of excellence in science teaching. Researchers can fine tune or calibrate their main questions on the hypothesized parts that constitute PCK. Grossman's aforementioned components, for example, might advice the research on how experienced science teachers (or if they do) integrate them all and apply them to appropriate classroom situations at the right surroundings and at the right instants in order to achieve preferred teaching and/or learning. Intact classroom observations hence are important data sources for this kind of focus. Rich cases portraying effective science teachers performing their art can help, in fact will help (Tamir, 1990) to inform novice science teachers (e.g., Fernández-Balboa, Stiehl, 1995).

This brings me to the third dimension of PCK. I argue that pedagogical content knowledge will directly inform science education programs in a positive way. What is the role of higher education in the education of a science teacher? How are theory and practice integrated when one actually teaches? What do student/teachers bring to their teacher education programs? What models, metaphors, examples, lab activities, etc. are most effective in teaching for desired understanding? How good are we in education novice teacher? Is teaching merle an art or talent that is inborn to a certain degree? What students' alternative conceptions most likely will be a barrier for meaningful learning? Questions such these or those that are not listed here, fall directly into the domain of PCK. Thus, a theoretical understanding of various sources of teacher knowledge can help us to exploit the potential of the different contexts within teacher education programs for supporting different kinds of meaningful student learning.

Fourth, PCK studies showed empirically that science teachers with insufficient pedagogical content knowledge may prepare improper concept demonstrations that could intensify student's misconceptions (Hashweh, 1987; Clermont et al., 1994). Results such these will help science educator build especially courses geared toward pedagogical content knowledge deficiencies so that content is not taught independent of pedagogy.

Last but not least, studies on PCK will promote developing the body of research on the knowledge base of teaching particular to conceptualization, delineation and refinement of the construct PCK.

POLITICAL ASPECTS OF PCK

Introducing the idea that teacher's have a unique knowledge has of course a political dimension to it. First of all, it allows legitimating that teaching is a distinct profession. Consequently not an alternative job opportunity such as for engineers that could not find a job or a safe job for housewives (especially in the kindergarten and elementary levels) which is approved by their husbands in particular and approved by the society in general.

Thus, PCK raises questions about who should be a teacher. Especially when confronted with national and/or regional science teacher shortages! What should we do? How should we behave? It is common that governments or some other type of authority in many countries, including the US (Clermont et al., 1994), immediately will tend to hire people that have the necessary subject

matter knowledge in order to cope with the shortage problem. In instances such as these, PCK might provide more damped transitions. For example, special science teacher programs informed by PCK research could help to improve largely the new comers understanding and practice of teaching by helping them to acquire the knowledge and skill needed to promote learning among science students of various abilities.

Much more could be hypothesized of the political dimension of PCK – and should be done. However, I only intended to hint the reader that there exists a political dimension of PCK, and thus leave it for them for further inquire.

CONCLUSION

Researchers agree that the unique knowledge science teachers' possess can be empirically expressed in terms of the construct pedagogical content knowledge. Despite the fairly new definition and introduction of PCK with Shulman educators before him had declared similar understanding and beliefs about a unique entity that can be attributed only to the teaching profession. For example the great philosopher and educator Dewey had a similar conception. Namely, "... a process of interpretation [by which] the content is examined for structure and significance, then transformed as necessary to make it comprehensible and compelling to a particular group of learners [in a particular group of circumstances]" (Marks, 1990: 7-8). Bruner (1966) also elucidated to this body of knowledge by referring to it as "psychology of a subject matter."

However, the exact nature of the construct is not well established yet. Therefore, there are many debates about its nature. Moreover, research on PCK has primarily focused on a sound understanding and establishment of pedagogical content knowledge. This idea clearly displays the need for continuous research on PCK, which in turn is crucial for science education.

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