

Levels of Connecting Pedagogical Content Knowledge with Pedagogical Knowledge of History of Science

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Abstract. This paper proposes an approach for science educators to help science teachers use history of science in science education. The difficulties discouraging science teachers in the literature is similar to obstacles experienced during a study to put history of science into eighth grade science curriculum. To overcome difficulties, science teachers need to connect their pedagogical content knowledge with pedagogical knowledge of history of science. This approach suggests four levels to connect them: Interest level, Socio-Cultural Level, Epistemological Level, and Conceptual Level. These levels will help science educators and textbook writers to put history of science into science teaching.

1. Introduction

Teachers believe that history of science (HOS) is potential resource for instructional materials (Becker 2001; Wang & Cox-Petersen 2002). However, science teachers don't use them unless personally interested. Studies with significant contributions to HOS in science teaching have not convinced science teachers to use historical material in their science lessons (Wandersee 1992). Teachers are persistent in using the traditional curriculum and do not want to change it (Rutherford 2001).

The use of HOS in science teaching is not only a matter of how knowledgeable science teachers are in HOS but also how well they can employ instructional strategies appropriate to subject matter. Teachers' knowledge of subject matter is different than a scientists' knowledge of the same subject. Shulman (1986) introduced the idea of pedagogical content knowledge (PCK) as subject matter knowledge for teaching. Most studies on use of HOS in science teaching suggest pedagogical approaches with a poor connection to PCK. On the other hand, teachers' knowledge of HOS is expected to be different than knowledge of a historian of science. From this perspective, a science teacher is expected to have pedagogical knowledge for HOS. Monk and Osborne (1998) and Galili (2001) also stressed the need for connection between HOS and pedagogical content knowledge. Knowledge of HOS without connection to PCK is potential reason for a teacher's hesitation in application of historical materials to their classes.

2. Levels of Connection

Historical information and its relationship with science education were categorized in literature. For example; Reichenbach's distinction between the context of discovery and the context of justification (Osborne, Ratcliffe & Bartholomew 2003); Stinner's three levels of historical and conceptual development, a foundation level, a research level, and a pedagogical level (Stinner 2003), and three domains in instructional practice related to the Contextual Domain, Conceptual Domain and Procedural Domain (Wang & Cox-Petersen 2002)

The categories proposed in this paper are based on the author's experience with a study previously conducted (Seker & Welsh 2006). In the study, four different curriculums were developed: (a) Traditional curriculum based on School District Science Education Standards, (b) Curriculum with the development of scientific knowledge throughout the history, (c) Curriculum with information related to scientific methods followed by scientists in the history, (d) Curriculum with personal life stories of scientists, who build scientific knowledge related to the content. Before the study, the science teacher and researcher worked on developing curriculum materials with the concern of classroom realities. Three curriculum with HOS were compared to traditional science classroom with regards to student learning, perspectives on aspects of NOS, and interest in science. The results of the study support that there were differences in class contexts with regards to the use of HOS (Seker & Welsh 2003). Factors influencing the distinctive characteristics of class contexts can be listed as:

- a) teacher's pedagogical knowledge for HOS,
- b) teacher's pedagogical content knowledge,
- c) connection of both a and b.

The difficulty the teacher had connecting PK for HOS and PCK was at different levels for each class context. Accordingly, four different levels are proposed here for science educators in training teachers/pre-service teachers.

- a) Interest Level
- b) Cultural Level
- c) Epistemological Level
- d) Conceptual Level

2.1 INTEREST LEVEL

At the interest level, teachers are expected to use short stories about scientists' personal lives without connection to the concepts of science or NOS. For example, telling students Sir Isaac Newton was raised in the home of his grandmother after his father died and his mother abandoned him to remarry. This type of historical information focuses student attention on scientist's experience as a person rather than as a scientist. The HOS can play a humanizing role in science teaching. The purpose of this level is to catch student interest in science lesson. Mitchell described 'catch' component of interest as short term interest for the period of lesson. Continual use of these stories may help students generate individual interest in science (Welsh & Seker 2003)

2.2 SOCIO-CULTURAL LEVEL

At the socio-cultural level, historical information is related to the interaction between science and society. For example, Jewish scientists escaped from Germany to the U.S., and their inventions played an important role in changing the direction of World War II (Wandersee & Roach 1998). This historical information should be used to "hold" student interest in science. Mitchell described "hold" component of interest as meaningfulness and value of the material. This historical information should be used when there is need for how much information student learning is meaningful and valuable. At this level, HOS may help students humanize science because they can see scientific endeavors are part of society and culture (Becker 2000; Matthews 1994; Wang & Marsh 2001)

2.3 EPISTEMOLOGICAL LEVEL

At the epistemological level, the teacher should develop discussion sessions on the ways scientists produce scientific knowledge. For example; Galileo is one of the first experimenters and he developed theories about motion which were opposite to the accepted ideas of Aristotle. Using this opposition, the teacher will purport to help students understand the empirical and tentative nature of scientific knowledge in the NOS Class.

HOS is always related to NOS. Both explicit and implicit ways of teaching NOS can be developed with the use of HOS (Seker & Welsh 2005). The concern of using HOS for student understanding NOS is teachers' lack of knowledge for aspects of NOS (Lederman & Lederman 2004).

2.4 CONCEPTUAL LEVEL

At this level, the similarities between students' alternative ideas and scientific concepts from the HOS should be used. The purpose of this historical information is to help students learn science content. Students' prior knowledge is important when developing learning activities due to the similarity between students' naive ideas and historical scientists' ideas (Roach & Wandersee 1995; Stinner & Williams 1993). For example; the concept of impetus is similar to students' pre-concepts of force (McCloskey 1983).

At this level, teacher will face that students do not want to discuss their own ideas (Irwin 2000). At the middle and high school level, teachers may have a motivation problem and should take advantage of historical information at interest and socio-cultural level to "catch" and "hold" student interest before creating discussion sessions.

3. Conclusion

History of science includes potential resources for science educators. The obstacles to bring them into science lesson should be addressed in teacher education programs. Courses in college of education should present historical information with pedagogical content knowledge. The levels proposed in this paper can facilitate pre-service teachers learning of history of science. Initially they should be familiar with scientists' life stories instead of confronting historical information embedded with philosophical and sociological arguments. Also, textbook writers can use *Levels of Connection* to provide history of science in teacher's handbook. This will help science teachers find information to use history of science in their lessons.

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