A New Paradigm for Implementing Culturally Responsive Pedagogy to Pre-service Science Teachers

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Abstract

Teaching teachers the nature of science and the process of inquiry is challenging, even if the teachers hold bachelor degrees in the sciences [1]. Compounding this challenge is the need to develop teachers' social, cultural, economic, and political competencies for educating the next generation of youth in the increasingly competitive global economy [2].Traditional methods of teaching future science teachers from a positivist's perspective that science is largely a construction of knowledge no longer suits the needs of today's global learner. Science teachers must understand the new habits of mind in today's youth and design appropriate, supportive instructional learning environments, whether it is to empower students to act (in the case of capitalistic societies) or design for a more multicultural and socially integrated scientific literacy. In either case, there is a need for a more learner cantered approach to instruction rather than a scholarly academic perpetuation (scientist begets scientist) of the content specific disciplines. In this paper, I propose a new paradigm: we must raise the critical consciousness of our teachers to think and live in a diverse global society by promoting equally ontology with epistemology in order to foster inquiry as a form of praxis.

Keywords: *Inquiry, cultural competency*

1. Introduction

Ever sense John Dewey [3] questioned the use of pre-determined, contrived material for lessons, science educators have been searching for the ideal space between behaviourist-based heuristic methods [4], student-cantered concept development methods (concept formation and the meaningful assimilation of new ideas/concepts [4] [5], and varying teacher directed [6], guided [7], and facilitated [8] constructivist models. Kirschner presents a convincing argument that more directed inquiry instruction produces the best results in the teaching of science [9].

> After a half-century of advocacy associated with instruction using minimal guidance, it appears that there is no body of research supporting the technique. In so far as there is any evidence from controlled studies, it almost uniformly supports direct, strong instructional guidance rather than constructivist-based minimal guidance during the instruction of novice to intermediate learners. Even for students with considerable prior knowledge, strong guidance while learning is most often found to be equally effective as unguided approaches. Not only is unguided instruction normally less effective; there is also evidence that it may have negative results when students acquire misconceptions or incomplete or disorganized knowledge [9, p. 83-84]

While Kirschner's argument is valid and based on the meta-analysis of studies on different methods of instruction, Kirschner fails to take into full account the ontological, social, linguistic, and cultural biography each learner brings to the classroom [10].

2. Discussion

The brain develops a complex neurological network (e.g., mind map) each time a learner commits learning to long-term memory. Scientists develop this network over time, each time refining the network as new knowledge and understanding refines the underlying cognitive structure. We call this well-developed network "conceptual structures for scientific reasoning" (Fig. 1). As science teachers, our goal is to develop this network with our learners, with some success among those pre-determined to become scientists and with limited success for those learners who are taking science courses for general education purposes. In either case, if our instructional approach is to develop this structure by requiring the learner to quickly (i.e., short-term memory) the ability to reason scientifically through pre-determined lab experiences, then our short term success will be minimal [9].

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For our pre-service teachers, we have deconstructed the manner in which scientists approach problems by designing lesson design models, such as the 5Es [11] and the Learning for Use [7]. Each of these models build off development and learning theories ([12, [13], [14], [15]) and offer a good structure for science teachers to design lessons. However, these designs are limited in that all assume the learner is an "empty vessel," and fails to account for the students' collective ontology. Teachers become increasingly frustrated when students fail to see the scientific merit in the lesson.

If we consider the academic preparation of the learners' epistemological framework (Fig. 1), then learners are pre-disposed to at least discern evidence from unsupported opinion. Learners in our science classes with a well-developed epistemological framework often seek dualistic [16] right or wrong answers and often fail to contextualize the evidence as reasonable in the larger framework. These learners can demonstrate some scientific reasoning, but the demonstration is often limited to the task at hand and fail to consider the larger application of the learnt material. Certainly as learners in science continue their course of study, they are able to move from dualist thinking to more relativistic thinking [16] and, therefore, develop a stronger scientific, cognitive framework for understanding scientific processes. When these learners become our next generation of teachers, then they have established a complex neurological framework for scientific reasoning. And when these teachers begin teaching, they are pre-disposed to think that their students should think like a scientist and have quickly forgotten the need to develop this framework with carefully crafted scaffolding of scientific reasoning.

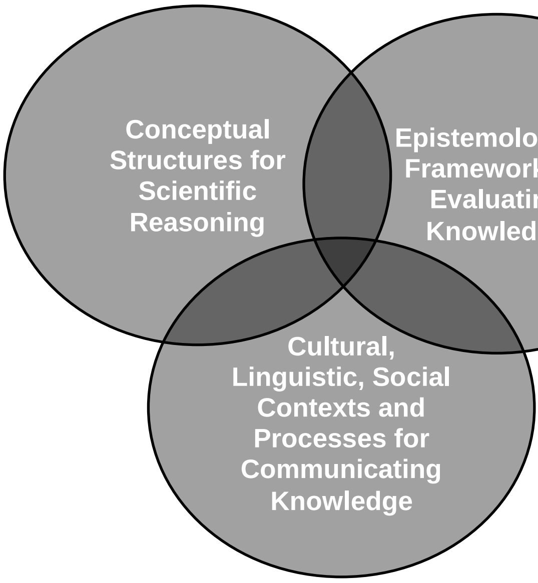

Fig. 1. The intersection of how scientists approach problems (Conceptual Structures for Scientific Reasoning), how learners use existing logic to determine what is important to know and understand (Epistemological Framework for Evaluating Knowledge), with the learner's biography (Cultural, Linguistic, Social Contexts and Process for Communicating Knowledge). The intersection, denoted by the dark intersection of the Venn diagram, is where science teachers need to plan their instruction in order to be successful in meeting the learning goals.

Each learner brings a rich background of culture, language, and experiences from which they have mapped their epistemological and cognitive frameworks. In classes with increasing diversity, particularly in the United States, science educators must now take into account that cultural, linguistic, and diverse (CLD) background of each student in order to plan for effective instruction [10]. If we include this important element (Fig. 1), then we now have the opportunity to better develop the learner's "scientific thinking" through carefully, highly structured, vicarious experiences.

Herrera offers a simple instructional design from which science teachers, particularly pre-service teachers, can begin designing the learning environment for effective science instruction [10]. Herrera begins with *activation*. In this early stage, we must activate learning by drawing upon long term memory of each learner. For example, when teaching about *the cause for moon phases*, we draw upon the learner's prior knowledge of phases. Learners contribute their own vocabulary (e.g., "Wolf Moon;" the first full moon in January).

In typical constructivist methods, then step is to begin building new knowledge structures through vicarious experiences ([6], [7]). What is important is to maintain the CLD framework, focusing on *connecting* the new short-term memory knowledge structures with the existing long-term cognitive structures. Piaget argued the importance of language development in the pre-operational stage [14]. In many regards, learners are in the pre-operational stage when learning new science content. We must train our pre-service teachers to understand that learning science is like learning a new language, and requires learners to refine long-term memory, rather than simply replace "old" language.
The final stage in Herrera's model is the *affirmation* phase [10]. Here, learner's refine existing epistemological and cognitive structures by mapping emotion and evaluation upon the existing structures. In science, we call these "ah ha" moments of discovery. In science teaching, following our traditional Learning for Use [7] or 5E models [11], we ask our learners to apply the new knowledge. Kirschner warns us that simply applying knowledge does not lead to long-term memory building, unless we follow Herrera's suggestion of *affirming* the new knowledge to existing CLD cognitive structures.

3. Summary

We all too often teach science as if the learners in the classroom are pre-destined to develop the same cognitive structures as ourselves. We train teachers to use inquiry-based models to help students construct learning to imitate how scientists do science. Both paradigms need to change to include the student's biography: the cultural and linguistic epistemologies that define the ontological approach a learner takes to understanding new material. The new paradigm requires a new model for preparing the next generation of science teachers. I proposed here that the new model blends traditional, structured constructivist methods with CLD methods, and thus, allowing for learners to develop their own critical consciousness on how scientists think about and solve problems.

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