"After I gave students their prior knowledge…" Pre-service teachers' conceptions of student prior knowledge

Valerie K. Otero and Mitchell Nathan
University of Colorado, Boulder, CO 80309-0249, Valerie.Otero@colorado.edu

Abstract: Pre-service teachers often enter the teaching profession with pre-conceptions about teaching and learning science that are not consistent with contemporary learning theory. To build on this knowledge, we need to identify the beliefs and knowledge that pre-service teachers have about science teaching. In this exploratory study, we investigated pre-service teachers' pre-instructional conceptions of students' prior knowledge. Results indicate that our pre-service teachers held a limited number of conceptions about prior knowledge including a blank slate model of learning.

Introduction

Eliciting and building on students' prior knowledge is a central tenant of contemporary learning theory [1]. Research in science education has identified several common ideas or idea fragments that are articulated by students in various classroom contexts [2] [3] [4]. Knowledge of common ideas such as "force is proportional to velocity" has made it possible for curriculum developers and teachers to address student prior knowledge through direct classroom experiences that allow students to apply and modify their existing and developing ideas [5] [6].

Teaching science also depends on teachers' understanding of the continuity and connections within the content area. Unfortunately, many undergraduate students leave science courses with the idea that science is a set of disconnected facts and definitions [7]. This misunderstanding of science is detrimental to reform-based teaching and interacts with teachers' views on how to teach science effectively.

Knowing more about prospective teacher's (PST's) initial and developing conceptions of teaching and learning science would greatly enhance the teaching of science methods. In this paper, we report on an investigation of PSTs perspectives on the role of elementary students' prior knowledge in teaching and learning science.

This investigation emerged from our evaluation of our own teaching. At the end of the semester preceding this study, we found that we had failed to teach our pre-service teachers some of the central tenets of our philosophies. Comments such as "After I gave students their prior knowledge, I continued with the lesson," appeared in pre-service teachers' final projects. We realized that while we know how to teach *science* by building on our students' prior knowledge of science, we were not sure how to teach *science methods* by building on our students' prior knowledge about teaching and learning science. We realized that we did not even know what types of common ideas our pre-service teachers might have regarding student prior knowledge, collaboration, and assessment.

Thus, we set out to explore PSTs' awareness and beliefs as exhibited in a semester-long, multi-stage assignment where PSTs were asked to plan and implement elementary grade science lessons and assessments in their practicum placements. Specifically, we wanted to know: What are our PSTs' initial conceptions of prior knowledge and how do these conceptions inform PSTs' models of student learning, assessment, and reform-based teaching?

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Methods and Data Sources

PSTs (n=23) participated in the coursework under investigation during their second semester of a four semester licensure program. These students were above average in academic performance and demonstrated a strong commitment to teaching elementary school in diverse settings.

The data for this study were collected over 16 weeks. The primary data source used was generated through a cumulative semester-long assignment we designed to meet the learning objectives for our two courses: educational psychology (Nathan) and elementary science theory and methods (Otero).

The cumulative assignment was designed to serve as a means of formative assessment to help students develop connections between what they were learning in class and their practicum experiences and to provide us with information that could help us modify our methods instruction. The six stages of the assignment were turned in at various points throughout the semester and were returned to students with substantive instructor feedback. The six-stage sequence is as follows:
Part A: Topic, Justification and Standards, Part B: Objectives and Anticipated Student Prior Knowledge, Part C: Unit Plan and Assessment Plan, Part D: Analysis of Pre-Assessment Data, Part E: Analysis of Post-Assessment Data and Learning Gains, Part F: Modified Unit and Assessment Plan and Reflection on Implementation.

Parts A through F of the cumulative assignment provided several opportunities for prospective teachers to reveal their understandings of the purpose of eliciting student prior knowledge and the impact they think it has, or should have, on instruction.

Codes representing PSTs conceptions of students' prior knowledge were identified through the evaluation of all six parts of the assignment. The codes shown in table 1 are organized into two categories on the basis of our inferences about whether they represented naïve conceptions of student prior knowledge or reform-based conceptions of student prior knowledge. We realize the potential danger of labeling student knowledge in terms of "naïve conceptions." However in this early stage of the development of an understanding of PST's thinking, we use this term as a starting point that will lead to the development of a more sophisticated model of PSTs knowledge as resources for teaching and learning about science instruction.

Table 1: Empirically generated codes

Naïve Conceptions of Prior Knowledge	Reform-Based Conceptions of Prior Knowledge
Blank slate model of cognition	Appreciation of experience-based ideas
Pre-assessment data has little connection to lesson plan	Prior knowledge is used as a resource for learning
Fragmented, vocabulary-based view of science/ you either know it or you don't	Coherent, conceptual view of science, appreciates "partial" understandings
Instruction leads to learning/prior knowledge is a correct interpretation of prior instruction	Knowledge develops over time, prior knowledge is derived from prior experience and prior instruction

Results and Conclusions

The instructional units proposed and implemented by PSTs spanned a range of grades and primary education science topics. The qualitative analysis of PSTs initial conceptions of student prior knowledge yielded four common themes: (1) a blank slate model of student cognition, (2) attempts to elicit student prior knowledge with few attempts to utilize this knowledge in the proposed unit plan, (3) the proposed unit plan focused on definitions of terms and vocabulary rather than on connected concepts and (4) the belief that instruction necessarily leads to learning and prior knowledge comes from prior instruction. Although PSTs never explicitly stated, "students are blank slates" the data revealed many examples of this type

of thinking. Blank slate models where inferred on the basis of students' comments as well as on their instructional designs and implementation strategies. Many students assumed from their pre-assessment data that the children had *no* prior knowledge about the topic and therefore there was no need to modify their lessons: "Most of (the students) had no prior knowledge about (nutrition labels) at all," "Due to the fact that students demonstrated zero prior knowledge..." Many also assumed that since children had no prior knowledge about the topic, they needed to provide it to them: "Seeing this lack of prior knowledge, I began with an introductory informative text in order to provide some basic information." While all PSTs actively elicited students' prior knowledge as part of their plan, few PSTs connected this information to their learning objectives or instructional plans.

PST's pre-assessments often elicited from students definitions of particular vocabulary terms rather than students' experience-based knowledge associated with the concepts to which the terms refer. In the pre-assessment phase PSTs often asked students questions such as "What is matter?" PSTs often concluded that if the pre-assessment showed that students were unable to answer such questions with the expected formal definition, then the students had little or no prior knowledge of the concepts. These PSTs went on to teach definitions of these terms and to assess students' ability to correctly define the terms. From data such as this we inferred a *knowledge as fragmented terms/you either know it or you don't* perspective of science content, where little attention to gradual conceptual development was evident.

Two extended examples are provided below. In the first example, pre-assessment data from fifth grade students led to changes in Donna's thinking about the purpose and practice of eliciting student prior knowledge. The excerpt below was taken from Part D of Donna's cumulative assignment.

> "This (pre-assessment) activity will help me assess the student's understanding of matter, how much they know, and whether everyone is on the same level or not. The students wrote down and shared *even if they did not know anything about matter.*" (emphasis added).

After evaluating instructor feedback and after implementing the lesson, Donna's perspective about student prior knowledge seemed to change. In part F she reported:

> "Initially I was surprised by the students' responses and the prior knowledge they used to solve the vacuum tube question, but that is because my pre-assessment did not get to what the students knew."

When she implemented her lesson, Donna learned that the students knew very much about solids, liquids, and gases. Donna was surprised that students knew so much about matter and in her reflection in Part F, she concluded that she had initially failed to pre-assess what students *did* know about the concept of matter. As a result of this experience, she revised her pre-assessment so that it could provide greater opportunities for students to tell her what they *did* know about matter rather than whether they could directly recall the academic definition of matter.

The second example is drawn from Vicky's part F final report, a revised sixth grade unit on matter. In part F, Vicky stated,

> "It is clear that students did not know anything about matter. I asked the students: *What is matter?* and *How do you know that?* I was not really surprised at the results of the pre-assessment. Because I know that they did not previously study matter or its states so their lack of knowledge on the subject was not a shock. According to the graphs and data collected, it is evident that the majority of the students do not know what matter is. As I was expecting the students to be unfamiliar with matter when I created my lesson, I am not going to change or modify my lesson."

The excerpt above is an example of a student who maintained a naïve conception of students' prior knowledge and a vocabulary-based understanding of science even at the end of the semester when she turned in part F. The comments in the example, in addition to broader context of the implementation reported in part F, reflect a *knowledge as*

fragmented terms/you either know it or you don't perspective of science knowledge. According to Vicky, the students did not answer the pre-assessment question, "what is matter" with the expected definition, "matter is anything that has weight and takes up space" therefore, they did not know anything about matter. An alternative perspective is that the pre-assessment question simply did not provide students with the opportunity to tell the teacher what they *did* know. Vicky's assessment measured students' knowledge of the definition of the term "matter" but it provided little information about students' reasoning about solids, liquids, and gases.

Discussion

Physics education research faculty are increasingly finding themselves in positions of teaching science methods. It is therefore important to establish a sense of the types of understandings that prospective teachers have about the content we are expected to teach.

This paper reports part of a larger investigation of PSTs prior knowledge about teaching and learning. Our investigation suggests that prospective elementary teachers possess some naïve conceptions about the teaching and learning of science. These naïve conceptions are typically not consistent with reform perspectives and are not very useful for guiding instructional practices aimed at deep learning. Our analysis of changes in perspectives from the initial and final stages of the assignment (reported elsewhere) suggests that with appropriate instruction that builds on PSTs experiences and perspectives, PSTs can make changes toward a more reform-based view of teaching and learning science.

Curricula that target students' prior knowledge in relevant instructional sequences has been shown to greatly impact learning gains in undergraduate physics. A similar methodology can be applied to teaching science methods courses as we become more aware of the types of knowledge with which PSTs enter our methods courses.

Drawing on the findings of this study we have created lessons that build on the prior knowledge of PSTs for our science methods courses. We have utilized quotations and pre-assessment analyses from our PST data to construct lessons that build on the conceptions that PSTs exhibited in our study. This work shows promise for helping physics education researchers help prospective teachers embrace and understand reform-based practices.

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