VIEWS OF STUDENT KNOWLEDGE AND COLLABORATION

Elementary Pre-Service Teachers' Initial and Changing Views about Students' Prior Knowledge and Collaborative Learning

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Abstract

Pre-service teachers face many challenges as they learn to teach in ways that are very different from their own education. They often come into their teacher education courses with pre-conceptions about teaching and learning that are not consistent with contemporary learning theory. To build on this knowledge in teacher education courses, we need to identify the actual beliefs and knowledge that pre-service teachers have when they enter our classrooms. In this exploratory study, we investigated pre-service teachers' pre-instructional conceptions of students' prior knowledge and collaborative learning. Twenty-two students were studied over a sixteen-week period. Results indicate that our pre-service teachers held a limited number of common conceptions about prior knowledge and about collaboration, some of which were resistant to change. Although significant learning gains were measured, many pre-service teachers continued to use a blank-slate model for student cognition and continued to use collaboration as a solution to classroom management.

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Students in teacher education programs today face many challenges as they strive to learn and adopt reform notions of teaching that are still in flux. Two central aspects of current educational reform stem from social constructivism and focus on the role of students' prior knowledge in learning and instruction, and how to effectively use collaborative classroom structures to enhance participation, motivation, and learning.

Eliciting and building on students' prior knowledge is a central tenant of contemporary learning theory (e.g., Greeno, Collins & Resnick, 1996; Shepard, 2000). By eliciting prior knowledge, teachers can confront problematic student ideas and utilize vague but useful preconceptions as seeds for what will become the intended learning outcomes (Van Zee & Minstrell, 1993; Hammer, 1995; Otero, Johnson and Goldberg, 1999). This has been particularly central to science education. Knowledge of what students understand has made it possible for curriculum developers and teachers to address this knowledge with direct experiences allowing students to apply and modify their ideas so that they are consistent with evidence and with scientifically accepted ideas (Brown and Clement, 1989; McDermott, Shaffer and Somers, 1994; Rochelle, 1998). For example, research in science education has identified several common experience-based conceptions students bring into the classroom and utilize in various contexts. Student ideas such as "force is proportional to velocity," "air pressure or rotation cause gravity," "plants get bigger because they eat soil," and "a shadow is an entity that travels through space" have been identified as common ideas held and used by children in the science classroom (AAAS, 1994; Driver, Guesne, & Tiberghien, 1985; Driver, Squires, Rushworth, & Wood-Robinson, 1994; Minstrell, 1991). Knowledge of these common student ideas has allowed practitioners and curriculum developers to design programs

that provide opportunities for students to articulate these ideas, utilize these ideas, gather evidence that pertain to these ideas, and modify these ideas so they are consistent with evidence. This generally occurs in an open classroom environment where norms of argumentation and the valuing of one's own ideas and the ideas of others have been established.

Collaboration and the social nature of knowledge have also emerged as a central tenant of contemporary learning theory in all content areas. Knowledge is often directly influenced by the social settings in which it is learned and applied (e.g., Vygotsky, 1978). Language is also an important mediator of knowledge. Thus, the nature of classroom discourse plays a critical role in promoting the kind of learning and thinking that is valued (Ball, 1991), and in forming "communities of scholarship" (Bruer, 1993; Scardamalia et al.,1989). Further, fundamental aspects of the nature of science include human articulation of conceptual models and theories, defending and supporting of claims using evidence from observations, considering alternative perspectives, and the notion that "facts" come about through the process of consensus within the scientific community. Within the science classroom it is important that students not only learn the big ideas and theories but also the origins of these ideas. In the reform-based classroom, these ideas can be generated through children's interaction with each other and with laboratory apparatus, through their articulation and defense of ideas, by the consideration of alternative perspectives and through collaboration and consensus (Brown, Collins, & Duguid, 1989). The teacher of a reform-based course must therefore be skilled in structuring a successful collaborative environment where a set of obligations and expectations about talking, listening, and expressing one's thoughts are developed.

The teaching of science is also largely dependent upon the teacher's understanding of the continuity and connections of concepts within the content area. Unfortunately, many undergraduate students leave their science courses with a conception of science as a set of disconnected facts and figures to be memorized. Students fail to learn (and courses fail to teach) the social origins and tenable nature of science knowledge in undergraduate science courses, yet reform-based teaching in the elementary school depends upon these concepts. Physics education researcher David Hammer (1994) identified a set of "epistemological beliefs" held by students before,

during and after participating in an undergraduate physics course. This research demonstrated that many students often leave their undergraduate physics courses with beliefs that physics knowledge is a collection of fragments and is thereby not expected to be a coherent whole. Students often believe that a piece of knowledge is either known or it is not known, and this knowledge comes from some authoritative source. These types of understandings of the nature of science knowledge are detrimental to reform based teaching where teachers are expected to guide students in their gradual conceptual development of science content and the tenable, collaborative nature of science knowledge (NSES, 1995).

As teacher educators we stand behind these important ideas and treat them as central themes in our teacher education courses. As educators we stand behind the tenets of contemporary learning theory and strive for a constructivist approach in our own teaching of pre-service teachers. However, teaching within this tradition requires that we understand pre-service teachers' (PSTs) pre-instructional conceptions about various aspects of science teaching and learning. We are not sure that we do. Knowing more about PST's initial and developing conceptions of teaching and learning would greatly enhance the teacher education program and its effectiveness (Borko & Putnam, 1996). For this investigation, we investigated PSTs (*our* students') prior knowledge about two components of learning and teaching: the role of students' prior knowledge and the structure and purpose of collaborative tasks. Thus, we set out to explore PSTs' awareness and beliefs as exhibited in a semester-long, multi-stage assignment where teacher education students were asked to plan and implement elementary grade science lessons in their practicum placements. Specifically, we wanted to know:

1- What are our PSTs' initial conceptions of prior knowledge and collaboration and how do they inform PSTs' models of student learning, assessment, and reform-based teaching?
2- What changes can we observe in these conceptions as our PSTs refine unit-level plans over a semester?
3- What areas appear to be particularly resistant to change for our PSTs?

This investigation emerged from our attempts to tie PSTs' teacher education courses to their practicum experiences teaching elementary grade science. We sought to provide PSTs with the opportunity to become aware of, articulate, apply, reflect on, and, as a result, modify their knowledge about learning and teaching in the context of their practicum experiences.

We compare our teaching approach to a reform-based, hands-on, minds-on approach to science but in this case, instead of science content, PSTs were studying their own students' initial and developing conceptions of science in a collaborative learning context. Our intention in coupling coursework with practica is two-fold: (1) to provide authentic learning experiences for our own students consistent with reform philosophy and (2) to help in the development of PSTs' pedagogical content knowledge (PCK). Prior research suggests that PCK appears to develop out of classroom teaching experiences that also draw on content knowledge (van Driel, Verloop, & de Voss, 1998).

Method and Data Sources

Context of the Study and Participants

The licensure program is a four-semester program leading to a Master of Arts degree in instruction and curriculum and elementary teaching licensure. At the end of two semesters of coursework PSTs engage in a student teaching experience in diverse settings. PSTs (n=23) participated in the coursework under investigation during their second semester. The cohort consisted of three males and twenty females, 13% of which were Hispanic. The age of this population ranged from 23-40. These students were above average in academic performance and demonstrated a strong commitment to teaching elementary school in diverse settings.

Data

The data for this study were collected over a 16-week period throughout the second semester of the program. The primary data source used was generated through a cumulative semester-long assignment designed to meet the requirements and learning goals for two required courses in the program: Theories of Learning and Development

(i.e. educational psychology) and Elementary Science Theory and Methods (i.e. science methods). The assignment was developed through a collaboration of the instructors of the two courses. The purpose of the cumulative assignment was to help students integrate, apply, and reflect on what they were learning in educational psychology and science methods. The cumulative, feedback-based assignment was also designed to serve as a teaching and learning tool that would help students develop connections between what they were learning in class and their practicum experiences. The assignment was organized into six parts each of which was designed to build upon the part that precedes it: (1) topic, grade level, rationale, standards addressed, (2) learning objectives with post-assessment, anticipated student prior knowledge with pre-assessment and rubric for evaluating assessments, (3) unit plan with modified pre and post assessments based on instructor feedback, one detailed lesson plan that would be implemented, (4) full analysis of pre-assessment data with implications, inferences, and lesson modifications, (5) description and reflection of implemented lesson with analysis of learning gains, implications and inferences made from learning gain data, proposed revisions to lesson or assessments, (6) final revised unit, assessments, and reflection on the practicum-based assignment. Each stage of the assignment was turned in at various points throughout the semester and was returned with substantive instructor feedback. Through the process of negotiating with the cooperating teacher and considering instructor feedback on their plans, PSTs were expected to modify their initial and developing ideas about teaching and learning.

Coding Scheme

PSTs' levels of awareness and attention to their students' prior knowledge and the need to structure student collaboration were measured by reviewing PSTs initial (before implementation and before instructor feedback) and final (revised after instructor feedback and after implementation) unit and assessment plans. This method established certain initial and final "states" of how PSTs described their teaching and assessment activities. It serves as an early exploration into PSTs' early, changing, and persistent notions, and provides insights that can guide future studies and designs for teacher

education programs. Codes were generated as a part of the qualitative analysis directly from the data. For further examples of this, see appendix A.

Pre-Service teachers' initial and revised levels of attention to prior knowledge and collaboration were coded for the presence or absence of references to various aspects of these important concepts in learning and instruction. The coding scheme is shown in the table1 and table 2.

Table 1: Initial and final Prior Knowledge Codes

Conceptions of Prior Knowledge Initial Codes	Reform-Based Ideas Final Codes
(P1) Blank slate model of cognition	(P-a) Attempts to elicit what students do know instead of what students do not know
(P2) Little connection to lesson objectives or planned activities	(P-b) Use of prior knowledge as resources for learning in lesson plan
(P3) Fragmented, isolated terms-view of science/you either know it or you don't	(P-c) Lesson design that allows for the gradual construction of concepts
(P4) Instruction leads to learning/prior knowledge comes from prior instruction	*This was final-coded as (P-c) but as a conception it differs slightly from Fragmented, isolated terms.*

Table 2: Initial and final Collaboration Codes

Conceptions of Collaboration Initial Code	Reform-Based Ideas Final Code
(C1) Is itself a tool for engaging students and ensuring participation	(C-a) Specific attention to how to encourage and monitor participation in groups
	(C-b) Attention to the form that collaboration takes (e.g. jigsaw)
(C2) Is accomplished by putting students in groups	(C-c) Importance of introducing and reinstating classroom norms
	(C-d) Plans to scaffold or guide students in collaborative activity
(C3) Facilitates meaningful learning on its own	(C-e) Assignment and discussion of the roles addressed by members of the group
	(C-f) Discussion, practice, and evaluation of collaborative skills (e.g. active listening)

Results and Conclusions

The units proposed and implemented by participants spanned a range of grades (from 1st through 6th) and primary education science topics. Most PSTs (40%) were placed in grades 1, 2, or 3. Thirty-five percent were placed in grades 4 or 5. The remaining 25% were placed in 6th grade, following their request. Specific lessons were in life, Earth, and physical science, and ranged from performing experiments and answering questions in partners and small groups, group model-building activities, and whole class discussions and demonstrations.

Prior Knowledge

As part of our investigation of then nature of PSTs' initial and changing views of learning and instruction, we conducted both qualitative and quantitative analyses of our teacher education students' evolving lesson plans and responses to our multi-step assingment.

Qualitative results. The qualitative analysis of PSTs initial conceptions of student prior knowledge yielded three common themes: (1) a blank slate model of student cognition, (2) attempts to elicit student prior knowledge with little or no attempt to utilize this knowledge in the proposed unit plan, (3) the proposed unit plan focused on definitions of isolated 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 comments such as "Most of (the students) had no prior knowledge about (nutrition labels) at all," "Due to the fact that students demonstrated zero prior knowledge" and "Seeing this lack of prior knowledge, I began with an introductory informative text in order to provide some basic information." The blank slate model was identified as pre-instructional (and in some cases post-instructional) knowledge held by many of the PSTs who participated in the study. While all PSTs actively elicited students' prior knowledge as part of their plan, few PSTs connected this information to their learning objectives, instructional plans, or post assessments. PSTs

often stated that the purpose of the pre-assessment was to find out what the students already knew and whether all the students were at the same place.

In the pre-assessment and post-assessment phase PSTs often asked students questions such as "What is matter?" and "What is a biome?" PSTs often concluded that if the pre-assessment showed that students were unable to answer these questions or answered "I don't know" then their lesson was appropriate and they went on to teach the definitions of these terms and to assess students' ability to correctly define the terms. The use of questions such as these led us, as teacher educators, to conjecture that PSTs tended toward 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 in their sequence of lessons. For pre-assessments, these types of questions elicited from students definitions of particular vocabulary terms rather than students' experience-based knowledge associated with the concepts that the terms refer to. Two examples of this are provided. In the first example, pre-assessment data from fifth grade students led PST Diane to reflect on the meaning of students' responses.

> Diane: For the pre-assessment on matter and the states of matter the class will contribute to a KWL chart. First, I will make sure that all of the students in the class are familiar with a KWL chart. This 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 responses are given below.

What I know

"I know that everything is matter. There are three main types of matter: solid, gas, and liquid."	"I don't know what that means."
3	19

What I want to know

"I would like to know if there are more types of matter."	"I want to learn everything."
1	21

> The students wrote down and shared even if they did not know anything about matter.

After evaluating instructor feedback and the actual implementation of the lesson, she said, "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

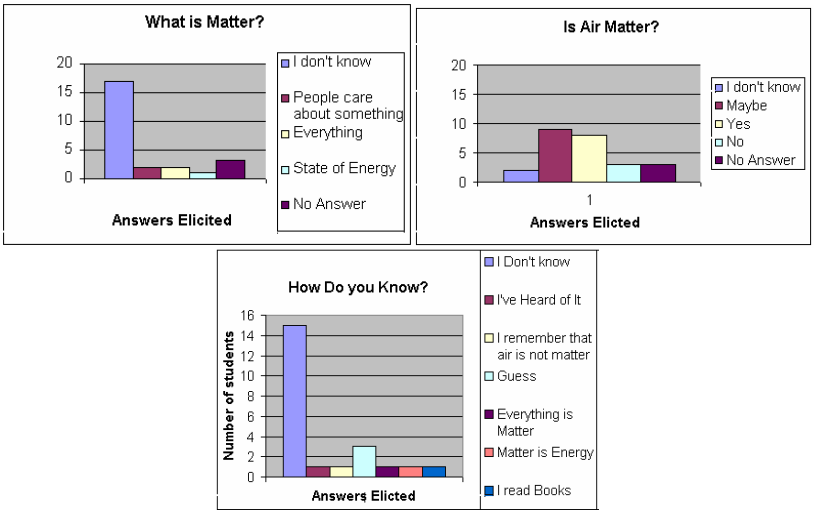
to what the students knew." When she implemented her lesson, Diane learned that the students knew very much about solids, liquids, and gases and the differences between them. Diane was surprised that students knew so much about matter and concluded that she failed to pre-assess what students did know. As a result of this experience, she revised her pre-assessment so that it could provide a greater opportunity for students to tell her what they did know about matter. To probe her students' experienced-based knowledge about matter and the states of matter she revised her pre-assessment question in the following way:

> On a hot summer day you decide to set up a lemonade stand. You bring out a bowl of ice cubes and a pitcher filled to the top with fresh lemonade. As you sit down, waiting for your first customer you realize that you forgot the cups. When you finally get back you find a bowl full of water rather than a bowl full of ice and you pitcher of lemonade is not as full as it was. If no one touched your stand while you were gone, what happened to the ice and the lemonade?

This example provides evidence of Diane's attempt to move beyond the mere elicitation of student prior knowledge and utilize it to inform her models of students' knowledge of mater and her instructional plans. It also provides us as teacher educators with evidence of Diane's ability to distinguish between isolated terminology and connected concepts associated with matter and the states of matter. Although we found evidence of this type of change in PSTs conceptions of student prior knowledge, we also found that the blank slate model of cognition is particularly resistant to change.

This second example is drawn from Vicky's final sixth grade unit on matter. Vicky states that, "it is clear that students did not know anything about matter" and we inferred that she was using a a blank slate model of student cognition.

> Vicky: I asked the students: "What is matter?," "Is air Matter?," and "How do you know that?" I felt that these questions would let me know if the students know what matter is, and how air fits into their model of thinking. I was also curious as to how they knew what they did because I know that they did not study matter or its states in the particular school system up to the present.
>
> 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 their lack of knowledge on the subject was not a shock. The following graphs illustrate the answers that the students gave to the three questions.



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 or air as a state of matter when I created my lesson, I am not going to change or modify my lesson. I was somewhat surprised by a couple of the answers that the students gave. Two students thought that when discussing "matter" I was talking about "something important" instead of a subject of science. I was impressed that some of the students knew that everything was made of matter and that the students who answered that knew so because of reading.

These comments reflect a blank slate model where students did know anything because they answered the question with, "I don't know." An alternative perspective is that the question simply did not ask students to tell what they do know. The assessment does measure students' knowledge of the definition of the term "matter" but it says little about student conceptions of and reasoning about solids, liquids, and gases.

PST's proposed and implemented lesson plans often included the didactic transmissionof terminology and concepts. In many cases the proposed lesson plan differed greatly from the implemented lesson such that the proposed lesson described reform-based approaches but during implementation PSTs relied on? traditional, didactic methods of teaching. As a third example we see how Gregory's plan for a fourth grade unit was to actively engage students in the construction of knowledge about three different types of volcanoes. Gregory pre-assessed students' recognition and definition of terms such as "sea level," "silica," and "lava." In his reflection he stated, "My pre-assessment word splash told me that many of the kids had heard of volcanoes and the

terms I presented to them, but were hesitant as to what actual definitions were. In his reflection on the pre-assessment, Gregory stated, "In my time in class I was also aware of what they had already been studying so I knew that I would be building off the prior knowledge that the class would have." This is an example of a belief that instruction leads to learning/prior knowledge comes from prior instruction. During the implementation of Gregory's volcano lesson, students did engage in the construction of volcanoes but there was little evidence that they engaged in the construction of knowledge about volcanoes. Gregory's objectives were to have students identify three different types of volcanoes, to identify magma and lava, and to trace magma as it moves from inside to outside the Earth. In his implementation he did the following:

- He first described a picture of the three main types of volcanoes.
- Then he drew and explained a diagram of how magma actually moves from the inside to the outside of the Earth and why it does this.
- He then showed a picture of three volcanoes and explained the different types of Earth debris that form the three types of volcanoes.
- Then the students were given construction paper, clay and drawings of volcanoes so that they could work in groups to construct models of volcanoes.

Gregory concluded his revised lesson plan by stating, "Spend time explaining the likes of volcanoes and how they form, but remember to make the bulk of the lesson about the hands on experience. Here they learn by doing as well as by having you re-teach what it is that they need to know." In Gregory's lesson it is not clear how the learning objectives are reflected in the hands-on portion of the activity nor is it clear how this activity addresses or builds on students' prior knowledge. It is clear that the bulk of the lesson information is given to the students by the teacher. Gregory's lesson is an example of a situation in which students' prior knowledge had little connection to planned learning activities.

Quantitative results. Although we identified several common themes of PSTs' understandings' of student prior knowledge that are not consistent with reform-based philosophy and methods, we also measured growth throughout the semester. PST growth was measured on the basis of movement from pre-instructional ideas to ideas that reflect

reform-based philosophy and methods. Final ideas were identified after instructor feedback and after implementation of the instructional plan.

Pre-Service teachers' initial and revised levels of attention to prior knowledge were ultimately coded for the presence or absence of references to various aspects of these important concepts in learning and instruction. Prior knowledge codes were established to identify three general facets: (a) attempts to elicit what students do know instead of what students do not know (i.e. contrary to a *blank slate* model for instruction), (b) use of student prior knowledge as *resources for teaching and learning* (e.g. designing instruction that addressed student prior knowledge), and (c) lesson design that allows for the gradual construction of connected concepts (i.e. contrary to science knowledge as fragmented vocabulary terms and the belief that any type of instruction leads necessarily to learning).

Blank slate and *isolated terms* were common conceptions of students' prior knowledge, appearing an average of 1.4 times per PST in the initial unit plan. PSTs tended to elicit student prior knowledge for the purpose of finding out whether or not students already knew the content addressed in their lesson. PSTs conceptions of student knowledge as *blank slate* and *science knowledge as isolated vocabulary terms* decreased to an average of 0.39 per PST in the final plan, a statistically significant drop, $t(22)=5.0$, $p<.001$. PSTs conceptions of student knowledge as *resources for learning* and of science as *connected concepts* increased from an average of 0.9 per PST in the initial unit plan to an average of 1.9 per PST in the final unit plan, a statistically significant increase, $t(22)=5.0$, $p<0.001$.

Collaboration

Our analysis revealed that PSTs initially conceived of collaborative activity as a tool for engaging students and ensuring participation and meaningful learning among groups. The qualitative analysis of PSTs initial conceptions of collaboration yielded three common themes: (1) collaboration itself is a tool for engaging students and ensuring participation, (2) collaboration can be accomplished simply by putting students in groups, and (3) collaboration facilitates meaningful learning on its own. Initially, PSTs simply stated that students would be put in groups but they provided little or no description of

how students would be guided to effectively interact within the group and meet the goals of the lesson. The following PST comments serve as examples, "The students will be put into groups of two and will be given the worksheet and the objects" and "This lesson has lots of hands-on work that allows the kids to work in groups of three or four, which is very effective for small group as well as whole class discussion. Due to the fact that the students are in small groups they (will feel) comfortable sharing with each other and eventually sharing with the whole group." From comments such as these we inferred that PSTs held the conception that collaborative activity itself is a means for engaging students and motivating participation in meaningful learning.

Our analysis of final states revealed that PSTs did increase their attention to the purpose of collaborative interaction as well as their attention to the need for procedures that could facilitate meaningful interaction. However, the actual procedures were infrequently included in their revised plan. PSTs often *described* effective strategies in their final project but failed to implement them or to include them as legitimate parts of their lessons and unit plans. In many cases, such as in these examples, the final phase of the project included comments that provide evidence to support the claim that PSTs may develop a sense of the importance of structuring collaborative activity even though the actual procedures for doing this were not included in the final plan.

> Sylvia: Most importantly, students will have the opportunity to apply what they have learned, to work together cooperatively to create their own model digestive systems and finally to share what they have learned with their peers. The creation and sharing of their own models of the digestive system allows students to truly examine the conceptual understanding that they have of a functional system and its components. I believe that this creation and collaboration stage is where the real education will take place, because students will be learning from each other and exploring their ideas. Through this process students can begin to think critically not only about the digestive system and its function, but also inform their thinking about the choices they make (specifically regarding food) and the functions/implications of these choices.

> Pablo: To participate in hands-on activities in small groups, students must be familiar with working in such settings and be able to remain task-oriented. Students should be comfortable working with others and communicating their ideas. Students will be successful if they are familiar with the general process of small group work and how to be responsible for contributing to the group and the assignment (i.e. various tasks assigned to each member of the group). If students are able to compromise and make decisions collaboratively they will be able to work together to complete the task successfully.

> Linda: Students will observe and record data each day over the period of a month. They will observe the Monarch butterfly throughout every cycle of its life. The objective of this lesson is for students to work cooperatively throughout the process of collecting information, and for students to improve their writing skills through daily journal and chart entries. This exercise also helps to further develop community based cooperative learning.

In the examples above, PSTs were able to articulate the importance of group activity, but their units did not show evidence that they were prepared to structure these collaborative interactions. Other PSTs did incorporate actual procedures for facilitating cooperative activity. Some examples are given below:

> Youn: That is why I have structured the small groups the way that I have—each student has individual responsibility and accountability, while also working together as a group. Ideally in whatever class this lesson is being taught, cooperative learning will be an established part of the classroom routine. Students will be familiar with each of the roles, understand the importance of each role, know the importance of listening to each other speak.
>
> Bill: Therefore, an instructor should go over with their students what group roles are, appropriate behavior that should exist in group work, and ways groups work the best together.
>
> Drake: In order for the above to work effectively, a classroom must be open to this type of collaborative learning. The norms which I expect to be developed, as were developed within the classroom that I taught this lesson, are that students will be taught to take risks, make mistakes, and will be open to feedback. I expect the classroom to be one that is comfortable, in which no put downs of others will be accepted, and the idea that there is no right or wrong answers will be encouraged. All students will feel comfortable in talking amongst peers. This type of open classroom environment will encourage all students to want to contribute in discussion.

Although we identified the common theme that PSTs tended to initially view collaborative learning as a *mechanism* for facilitating meaningful learning and expected that students would be able to arrange meaningful collaborative interactions largely on their own, we did measure growth in PSTs attention to the role of the teacher in structuring and maintaining collaborative environments. PST growth was measured on the basis of movement from pre-instructional ideas to ideas that reflect reform-based philosophy and methods. Final ideas were identified in various points throughout the assignment, after instructor feedback and after implementation of the instructional plan. Pre-Service teachers' initial and revised levels of attention to structuring collaboration

were ultimately coded for the presence or absence of references to various aspects of these important concepts in learning and instruction.

Collaboration codes were established to identify six facets: (a) specific attention for how to encourage and monitor participation of all group members; (b) attention to the form that collaboration takes (e.g., jigsaws) (c) importance of introducing and reinstating classroom norms for collaboration(d) plans to scaffold or guide students collaborative activities, including directing how groups should form and specifying goals for collaboration per se (such as sharing students' ideas or solution strategies); (e) assignment and discussion of the roles addressed by members of a group; (f) discussion, practice, and evaluation of collaborative skills, including those for active listening and making effective presentations.

Quantitative results. PSTs attention to collaboration in their initial unit plan showed important areas of omission. Despite the attention this topic received in both the educational psychology and science methods courses (as well as prior courses in literacy, mathematics methods, and educational foundations), PSTs omitted an average of 3.6 of the 6 facets of collaboration. Omission of norms, roles and attention to collaborative skills were the most frequent, followed by attention to participation, scaffolding, and then discussion of the forms of collaboration used. Scaffolding was the facet most often addressed by PSTs in their initial plans, but it was mentioned by only 5 participants.

There was much change recorded in the revised plan. PST assignments had only 1.7 omissions per participant on average, a statistically significant drop, $t(22) = 3.4$, $p=.001$. Skills and Norms remained the most omitted facets. Scaffolding and forms of collaboration were the most often mentioned. The level of omission and inclusion was far from perfect. While gains were made in explicitly guiding students into effective collaborative structures, PSTs tended to then leave students somewhat on their own, expecting that the organization and collaborative activity by itself would engage students, and students would know enough to participate effectively and equitably.

Gains noted in PSTs conceptions of the role of student prior knowledge in teaching and learning and the need to structure collaborative environments are significant and encouraging. However, our analysis suggests that PSTs retained some of their initial conceptions.

Discussion

This investigation shows that second semester, elementary PSTs in our teacher education program arrive with notions of students' prior knowledge and collaborative teaching methods that are not completely consistent with reform perspectives and not very useful for guiding instructional practices aimed at deep learning, but that these measurably improve during the semester. This is a positive finding for this program and for teacher education programs in general.

Our PSTs also clearly resist change in some aspects of their thinking. They continue to see collaborative activities as a solution to problems of participation and learning and neglect proper planning and oversight. PSTs need to review norms of interaction and impose some structure so students may take advantages of the valuable resources provided by their peers. Some PSTs also continued to believe that the purpose of eliciting student prior knowledge was to determine whether their students already knew what was about to be taught so they could decide whether or not to "teach" it to them.

Views that are resistant to change need to be targeted in methods instruction and teacher education courses that allow students to apply such perspectives in their practicum experiences and modify them through their teaching. We found a significant level of success doing so throughout this study. However, more work needs to be done to document the common preconceptions that PSTs have about student prior knowledge and collaborative instruction so that these ideas can be explicitly addressed within teacher education programs. Results of this study suggest that PSTs conceptions of the role of student prior knowledge and the need for teacher involvement in structuring collaborative environments are resistant to change. We make this inference based on the quantitative change-analysis presented in this paper as well as on our qualitative data that identifies PSTs pre-instructional knowledge of reform based theory and methods. When this study took place, PSTs had already participated in one full semester of teacher education courses where similar concepts about reform-based teaching and learning were targeted. They had also experienced a full semester of practicum placements. This leads us to

believe that the instructional methodology included in many courses in our program might be failing to directly address, and attempt to build on, our PSTs' prior knowledge of some of the central issues in reform based teaching.

Drawing on the findings of this study we have made several attempts to create lessons that build on the prior knowledge of PSTs for our own theory and methods courses. Through collaboration with colleagues from physics departments around the nation, we have prepared a set of lessons called "Elementary Students Ideas"[1] that can be used directly in the elementary science methods course. The sequence of lessons is designed to create awareness of PSTs' own views of elementary students ideas and to challenge these views through video-cases of elementary students learning similar content presented in the elementary science methods course. Additionally, these lessons utilize some of the data obtained through this study where PSTs are expected to evaluate comments, pre-assessments, and analyses made by former pre-service teachers. Although we are still field-testing and developing these lessons results are encouraging. We hope that these types of lessons will help provide a mechanism for teacher educators to use the methods and procedures that we teach to our PSTs, in our own classrooms.

This investigation has several limitations that we intend to address in future studies. First, the depth and reliability with which we ascribed PSTs' initial and changing notions about teaching and learning were based primarily on their written unit plans. In the future, we plan to conduct pre- and post-course interviews with each PST to gain deeper insights into their evolving conceptions of prior knowledge and collaboration. A second limitation is that we used PSTs' own record and assessment of their teaching as data for our investigation of their changing conceptions. We are exploring ways to record students' teaching activities more directly, including using teams of PSTs to observe and record their peers' instructional practices.

[1] NSF funded EHR-0096856 Project Title: "Professional Development Materials for Constructing Physics Understanding among Prospective and Practicing Elementary Teachers."

Appendix A

The Coding Scheme: Representative examples from the data

"After I gave students their prior knowledge…"

The statement above, "after I gave students their prior knowledge…" appeared in a final report from the previous year and was not a part of this study. However this statement, and statements like this, motivated the present study.

The examples included in this appendix are representative of the coding scheme but they do not represent all of the data that were considered for the code to be established. The data were coded on the basis of the entire initial and final product. The codes themselves are reproduced below.

Table 1: Initial and final Prior Knowledge Codes

Conceptions of Prior Knowledge Initial Codes	Reform-Based Ideas Final Codes
(P1) Blank slate model of cognition	(P-a) Attempts to elicit what students do know instead of what students do not know
(P2) Little connection to lesson objectives or planned activities	(P-b) Use of prior knowledge as resources for learning in lesson plan
(P3) Fragmented, isolated terms-view of science/you either know it or you don't	(P-c) Lesson design that allows for the gradual construction of concepts
(P4) Instruction leads to learning/prior knowledge comes from prior instruction	*This was final-coded as (P-c) but as a conception it differs slightly from Fragmented, isolated terms.*

Table 2: Initial and final Collaboration Codes

Conceptions of Collaboration Initial Code	Reform-Based Ideas Final Code
(C1) Is itself a tool for engaging students and ensuring participation	(C-a) Specific attention to how to encourage and monitor participation in groups
	(C-b) Attention to the form that collaboration takes (e.g. jigsaw)
(C2) Is accomplished by putting students in groups	(C-c) Importance of introducing and reinstating classroom norms
	(C-d) Plans to scaffold or guide students in collaborative activity
(C3) Facilitates meaningful learning on its own	(C-e) Assignment and discussion of the roles addressed by members of the group
	(C-f) Discussion, practice, and evaluation of collaborative skills (e.g. active listening)

<table>
<tr><th>Code</th><th>Example from the data</th></tr>
<tr><td colspan="2">Prior Knowledge Codes</td></tr>
<tr><td>Code P-1: Blank Slate Model of Cognition</td><td>

Diane's Pre-assessment data

Diane: For the pre-assessment on matter and the states of matter the class will contribute to a KWL chart. First, I will make sure that all of the students in the class are familiar with a KWL chart. This 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 responses are given below.

What I know

"I know that everything is matter. There are three main types of matter: solid, gas, and liquid."	3
"I don't know what that means."	19

What I want to know

"I would like to know if there are more types of matter."	1
"I want to learn everything."	21

All of the students participated and seven out of twenty-two students voluntary shared "what they knew" and "what they wanted to know" about matter. The students wrote down and shared even if they did not know anything about matter.

</td></tr>
<tr><td>Code P-a: Attempts to elicit what students do know instead of what students do not know.</td><td>

Diane's Revised Pre-assessment plan

Diane: To access students' prior knowledge I will give them a scenario:

On a hot summer day you decide to set up a lemonade stand. You bring out a bowl of ice cubes and a pitcher filled to the top with fresh lemonade. As you sit down, waiting for your first customer you realize that you forgot the cups. When you finally get back you find a bowl full of water rather than a bowl full of ice and you pitcher of lemonade is not as full as it was. If no one touched your stand while you were gone, what happened to the ice and the lemonade?

Diane: This scenario stimulates prior knowledge… This question is also open-ended but it gives the student enough direction to share everything they know about the subject…

</td></tr>
</table>

Code	Example from the data
Prior Knowledge Codes	
Code P2: Prior Knowledge elicited had little connection to lesson objectives or planned activities Code P4: Instruction leads to learning/prior knowledge comes from prior instruction.	***Gregory's Elicitation of Prior Knowledge with reflection*** Gregory: The word splash is a drawing I made of a volcano erupting with 15 words coming out in all directions as the lava. I included some easy and some hard words to see where the majority of the class was. There are words such as "sea level" and "lava" that I figured most of the kids would know and then words like "silica" and "igneous" that I guessed they would not. …Their assignment was to circle the words that they thought they knew and then provide me with an explanation. My pre-assessment word splash told me that many of the kids had heard of volcanoes and the terms I presented to them, but were hesitant as to what actual definitions were. In my time in class I was also aware of what they had already been studying and so I knew that I would be building off the prior knowledge that the class would have.
Code P2: Prior Knowledge elicited had little connection to lesson objectives or planned activities.	***Gregory's Lesson Plan*** Gregory's plan was to actively engage students in the construction of knowledge about three different types of volcanoes. During the implementation, students did engage in the construction of volcanoes but there was little evidence that they engaged in the construction of knowledge about volcanoes. Gregory's objectives were to have students identify three different types of volcanoes, to identify magma and lava, and to trace magma as it moves from inside to outside the Earth. In his implementation he did the following: • He first described a picture of the three main types of volcanoes. • Then he drew and explained a diagram of how magma actually moves from the inside to the outside of the Earth and why it does this. • He then showed a picture of three volcanoes and explained the different types of Earth debris that form the three types of volcanoes. • Then the students were given construction paper, clay and drawings of volcanoes so that they could work in groups to construct models of volcanoes. Gregory concluded his revised lesson plan by stating, "Spend time explaining the likes of volcanoes and how they form, but remember to make the bulk of the lesson about the hands on experience. Here they learn by doing as well as by having you re-teach what it is that they need to know."
Code P1: Other examples of blank slate model	Arial: Due to the fact that students had zero prior knowledge…Seeing this lack of prior knowledge, I began with an introductory informative text in order to provide some basic information. Evona: Most of (the students) had no prior knowledge about (nutrition labels) at all.

Code	Example from the data
Collaboration Codes	
Code C1: Collaboration is itself a tool for engaging students and ensuring participation.	Jim: This lesson has lots of hands-on work that allows the kids to work in groups of three or four, which is very effective for small group as well as whole class discussion. Due to the fact that the students are in small groups they (will feel) comfortable sharing with each other and eventually sharing with the whole group. Linda: Students will observe and record data each day over the period of a month. They will observe the Monarch butterfly throughout every cycle of its life. The objective of this lesson is for students to work cooperatively throughout the process of collecting information, and for students to improve their writing skills through daily journal and chart entries. This exercise also helps to further develop community based cooperative learning.
Code C2: Collaborative learning is accomplished by putting students into groups.	Sandy: The students will be put into groups of two and will be given the worksheet and the objects.
Code C3: Collaborative interaction facilitates meaningful learning on its own.	Sylvia: Most importantly, students will have the opportunity to apply what they have learned, to work together cooperatively to create their own model digestive systems and finally to share what they have learned with their peers. The creation and sharing of their own models of the digestive system allows students to truly examine the conceptual understanding that they have of a functional system and its components. I believe that this creation and collaboration stage is where the real education will take place, because students will be learning from each other and exploring their ideas. Through this process students can begin to think critically not only about the digestive system and its function, but also inform their thinking about the choices they make (specifically regarding food) and the functions/implications of these choices.
Code C-d: Plans to scaffold or guide students in collaborative activity	Pablo: To participate in hands-on activities in small groups, students must be familiar with working in such settings and be able to remain task-oriented. Students should be comfortable working with others and communicating their ideas. Students will be successful if they are familiar with the general process of small group work and how to be responsible for contributing to the group and the assignment (i.e. various tasks assigned to each member of the group). If students are able to compromise and make decisions collaboratively they will be able to work together to complete the task successfully.
Code C-c: Importance of introducing and reinstating classroom norms Code C-e: Assignment and discussion of the roles addressed by members of group	Youn: That is why I have structured the small groups the way that I have—each student has individual responsibility and accountability, while also working together as a group. Ideally in whatever class this lesson is being taught, cooperative learning will be an established part of the classroom routine. Students will be familiar with each of the roles, understand the importance of each role, know the importance of listening to each other speak.

Code	Example from the data
Collaboration Codes	
Code C-e: Assignment and discussion of the roles addressed by members of the group Code C-f: Discussion, practice and evaluation of collaborative skills	Bill: Therefore, an instructor should go over with their students what group roles are, appropriate behavior that should exist in group work, and ways groups work the best together.
Code C-c: Importance of introducing and reinstating classroom norms	Drake: The norms which I expect to be developed, as were developed within the classroom that I taught this lesson, are that students will be taught to take risks, make mistakes, and will be open to feedback. I expect the classroom to be one that is comfortable, in which no put downs of others will be accepted, and the idea that there is no right or wrong answers will be encouraged. All students will feel comfortable in talking amongst peers. This type of open classroom environment will encourage all students to want to contribute in discussion.

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