Examining Preservice Teachers' Ability to Attend and Respond to Student Thinking

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Abstract: In order to effectively implement inquiry practices in science, teachers must be able to attend to student thinking and adjust their lessons to build on and respond to student ideas. Research on experienced teachers suggests that their understandings of learners influence their instructional decision-making. However, the research on teacher education has mixed results about preservice teachers' ability to attend to students' ideas (Davis et al, 2006). Although preservice teachers may recognize that learners have prior knowledge they usually do not take into account students' ideas in their teaching practices (Friedrichsen et al, 2009). In this paper, we report on preservice teachers' ability to notice students' ideas (as manifested in written models) and respond to these ideas in subsequent instructional planning. Our data is drawn from clinical interviews conducted with 15 preservice teachers at the end of each of four consecutive methods courses (total of 60 interviews) in a two-year certification program.

Introduction

Standards documents and recent policy reports have called for a nationwide emphasis not only on the content and processes of science but also on the epistemology and the practices of scientific inquiry (AAAS, 1993; NRC, 1996; Duschl, Schweingruber, & Shouse, 2007). Inquiry based instruction entails a student-centered classroom in which teachers attend to and work with students' ideas to develop models and explanations of natural phenomena. A key factor in implementing inquiry-based practices is the ability to attend to and interpret student ideas and to use that interpretation to guide instructional design (Hammer, 2000; van Zee & Minstrell, 1997; NRC, 1996; AAAS, 1993). Researchers have found that when teachers attend to student understanding and adjust instructional practices this can help minimize the gap between desired student performance and observed student performance (Bell & Cowie, 2001; Black & William, 1998). Davis, Petish, & Smithey (2006) conclude that although experienced teachers' understanding of learners influences their instructional decision making, the research on preservice teachers does not have any conclusive findings.

Some studies report that preservice teachers foresee few student learning difficulties when planning lessons (De Jong & van Driel, 2001; Simmons, 1999; Geddis, Onslow, Beynon, & Oesch, 1993). Other studies have found that preservice teachers do acknowledge the significance of students' ideas about science (Davis et al, 2006; Russell & Martin, 2007; Van Driel, De Jong, & Verloop, 2002). However, even when preservice teachers recognize that learners have prior knowledge they usually do not take into account students' ideas extensively in their teaching practices (Friedrichsen, Abell, Pareja, Brown, Lankford, & Volkmann, 2009). In a 1999 study, Tabachnik and Zeichner found that preservice teachers were interested in uncovering their students' understandings of particular concepts in science, but they did not take this information into consideration when designing their lessons. Moreover, Davis et al (2006) concluded that new teachers do not have very clear ideas about what to do with regard to students' ideas once they have surfaced them.

van Es and Sherin (2002) argue that reform based practices call for a new understanding of teaching and learning which requires teachers to develop new ways of interpreting the classroom. Furthermore, they claim that current teacher education programs do not focus on helping teachers to interpret interactions that take place in the classroom. In our research, we investigate the development of preservice teachers' ability to notice student ideas in written work, as well as the ways in which they subsequently respond to student ideas in their instructional plans.

Theoretical Framework

According to van Es and Sherin (2002) the skill of noticing for teaching consisted of three aspects: (a) identifying what is important in a teaching situation, (b) making connections between specific events and broader principles for teaching and learning, and (c) using what one knows about the context to reason about the situation. The aspect of identifying what is important in a teaching situation refers to the ability of the teacher to select what they will attend and respond to in the class. Because there are so many different things going on in a classroom at any given point, the teacher must decide what is important and use this information to guide their instruction. Leinhardt, Putnam, Stein, and Baxter (1991) found that experienced teachers have "check points" and use these "check points" to judge how the lesson is going and decide how to proceed. Therefore, experienced teachers are more capable of recognizing and attending to what is important in the lesson (van Es & Sherin, 2002).

The next aspect of noticing, making connections between specific events and broader principles for teaching and learning, refers to the ability of the teacher to make connections between events that occur in the classroom and the broader ideas that they represent (van Es & Sherin, 2002). Similarly to the first aspect of noticing, as a teacher becomes more experienced, he or she will be able to determine how specific events relate to the process of teaching and learning. However, given the same situation, preservice teachers tend to only describe literal events that take place and miss making the connections to the bigger picture (van Es & Sherin, 2002). The last component of noticing, using what one knows about the context to reason about the situation, entails being able to take their knowledge of the subject and knowledge of how students think and apply it in the classroom. In our case its identifying relevant aspects of students' models, like accuracy of explanation or representation, explanatory power, use of evidence, and justification. The preservice teachers then evaluate these identified components to determine the students' understanding. Once the preservice teachers have evaluated the components in regards to student thinking than they determine what course of action is necessary, such as a class discussion or experiment, to clarify any misunderstandings.

In addition to learning how to notice, it is important for teachers to be able to take what is noticed and adjust their instructional practices. The activities that teachers undertake during instruction in order to produce information that can facilitate adaptation to on-going instruction are known as formative assessments (Sadler, 1989). Formative assessment can take many forms such as asking probing questions or class discussions, but it always includes a component of attending to and assessing student ideas in relation to the learning objectives and then adjusting instruction. In 1998, Black and Williams concluded that formative assessments improved student learning, especially for those students who were having difficulty with the content being taught. Formative assessment helps to prevent persistent student misunderstanding because the teacher is looking for evidence of student learning and adjusting instruction as needed (Erickson, 2007). Friedrichsen et. al (2009) found that teaching experience influenced the types and timing of assessments and that novice teachers did not readily implement formative assessments. For example, more experienced teachers tended to enact informal questioning throughout the lesson to check for understanding, while novice teachers waited to grade worksheets and only then revised subsequent lessons. Similar to the development of noticing, the ability to implement formative assessments are difficult and novice teachers struggle with making the connections between what students do not understand and what types of activities would promote student learning. In our study we are trying to help preservice teachers develop the competencies they would need to engage in the complex practice of formative assessment. The competencies they need to have are the ability to notice student thinking in written work and to design instruction that adequately responds to these interpretations.

A way to promote the development of noticing student thinking and designing instructional plans that correspond to these interpretations is through the analysis of student artifacts. The uses of artifacts of practice, such as video and student work have received a lot of attention in teacher education research (e.g. Kazemi & Franke, 2004). Several studies have advocated the use of student work as a tool for professional growth (e.g. Ball & Cohen, 1999; Little, 2002). Using student work has the potential to engage teachers in a cycle of experimentation and reflection and to shift teachers' focus from general pedagogy to one that is connected to their own students (Kazemi & Franke, 2004). However, empirical research on this topic is very limited (Kazemi & Franke, 2004).

In this paper, we hope to expand the research on the use of student work by examining the development of teachers' ability to notice and attend to student thinking as manifested in written artifacts. During clinical interviews, preservice teachers were given a task in which they were asked to analyze student models. We examined the development of teachers' ability to notice and interpret and respond (through instructional planning alone) to students' ideas in these student models. Specifically, our research questions are: (a) What do preservice teachers notice about student thinking as manifesting in student artifacts? (b) In what ways do preservice teachers attend to student thinking in their instructional design?

Methods

Study Context

This study was conducted in the context of a two-year Ed.M. certification program for secondary biology teachers at a large public university in the North East. The program included four life science specific methods courses that were taken in sequence. These courses were geared towards helping preservice teachers develop the knowledge and practices of inquiry-based teaching. The first course, *Methods I,* focused on the nature of scientific research and theory building. *Methods II,* the second course was essentially a design course in which the teachers worked in groups to design an extended inquiry based unit. *Methods III*, which accompanied the teaching internship, focused on the implementation of inquiry based lessons and on assessment strategies. Finally, the fourth course, *Methods IV,* engaged teachers in action research and the analysis of data collected during the teaching internship. All courses, especially the last two, included an emphasis on student thinking (including analysis of student work) and the importance of attending and responding to students' ideas. There were 15 preservice teachers who were enrolled in the program and completed all four courses in sequence.

Data Collection and Analysis

At the end of each of the four courses we conducted clinical interviews with all the teachers. A faculty member and trained graduate students conducted the interviews. Although somewhat different protocols were used in each set of clinical interviews, there was a common student-model critique task, which is the data source analyzed for this paper. In this task the teachers were presented with three student models explaining how a cut heals (cellular division) or why ice floats (density); two versions were used for counterbalancing purposes. We created the student models to closely mimic student thinking and representations. The models consisted of a drawing with an explanation written underneath. Models varied in terms of level of details, scientific accuracy of explanation, use of evidence (from students' prior knowledge) and justification of how the evidence relates to the explanation provided by the model. The teachers were then asked to identify (a) good aspects of the models; (b) problematic aspects of the model; (c) description of their next instructional move if these were naïve models (done at the beginning of a unit); and (d) description of their next instructional move if these were revised final models (done at the end of a unit). Interviews lasted 30-45 minutes and were videotaped and later transcribed verbatim and blinded for analysis.

We conducted a content analysis and through an iterative process of constant comparison we developed a coding scheme to capture four emergent themes of the models the teachers critiqued. The four themes were: (a) model representation (e.g. labeling); (b) mechanism in model (e.g. model shows a before and after or progression); (c) use of evidence or justification in models (e.g. student supports belief with data); and (d) accuracy of ideas of the models. To capture the quality of the preservice teachers' critiques of the models, we focused on two aspects of the critique: (a) the specificity of information they provided and (b) the noticing aspect- what themes were noted by each teacher. In terms of specificity, the preservice teachers' responses were coded as one of three categories: (a) identification; (b) description; or (c) interpretation of student thinking. A statement was coded as identification if the teacher stated what was good or problematic about the model without providing any additional details about why that aspect of the model was good or problematic (e.g. "the explanation is good"). A comment was coded as a description if it involved both identifying an aspect of the model and describing what was positive or negative about this aspect (e.g. "the explanation is good because it contains some empirical evidence") . Finally, an interpretation comment involved identifying, describing, and interpreting a certain aspect of the model in regards to student understanding. A statement such as "the explanation is lacking because cells do not stretch in the healing process; the student is missing the concept of cellular division" would be coded as interpretation since the preservice teacher identified an aspect of the model (explanation), described the problem (cells do not stretch), and interpreted what this means in terms of the student's understanding (missing concept of cellular division). We also counted how many of the themes described above were discussed in the critique to obtain a value for the noticing aspect of our analysis. At the end of the analysis for the critique part of the model, each interview had a two part code (specificity code and a count of themes mentioned).

We then analyzed the last two parts of the interview task, in which the teachers were asked about their next instructional move given two conditions: students models were naïve or students models were final models. We developed a coding scheme that captured three aspects of these revisions: (a) attention to student ideas, (b) specificity of instructional moves, and (c) alignment with model based inquiry. The first aspect, attention to student ideas was coded as: (a) no mention of student ideas which was coded as a "1"; (b) mentioned specific students ideas in regard to a particular model which was coded as a "2"; and (c) mentioned specific student ideas and provided an instructional move that addresses these ideas which was coded as a "3" (e.g. "model #1 did not understand molecules so I would have the students draw out the molecular structure of water to show the polar bonds of water"). The second aspect, specificity of instructional moves, was coded as: (a) stated general activity with no further example which was coded as a "1"; (b) stated a specific activity which was coded as a "2"; and (c) stated a specific activity that has a logical progression in attaining the lesson objectives which was coded as a "3" (e.g. I would give the students data and have them work in groups to make a group model from this data and then present these models to the class and come up with a class model so that all the students are on the same page). The third aspect, alignment with model based inquiry, was coded as: (a) no alignment which was coded as a "1" (e.g. lecture, teacher centered questioning); (b) slight alignment which was coded as a "2" (e.g. demonstration, cookbook lab); (c) alignment which was coded as a "3" (e.g. collaboration with peers, argumentation).

Results and Discussion

What Preservice Teachers Notice in Students' Models

Our analysis of the teachers' critique of the student models, allowed us to determine what teachers noticed in students' work and in what ways they could interpret the models in relation to students' understanding. In terms of the aspects of students' work teachers attended to, we found that their comments pertained mostly to the mechanism and explanatory nature of the model (e.g. "model has no explanation"; "model shows wrong grain size"; "model has a before and after"). Comments that pertained to model representation were statements about the components that made up the model (e.g. labeling) and were the second most frequent theme. Finally, statements about the use of evidence and justification (e.g. "model is supported by data"; "student justifies their model") and accuracy of ideas in terms of the thoughts expressed in the models (e.g. "student's thinking about cells stretching is incorrect"; "student understands the concept of density") were less frequently noted (see Table 1).

We then examined how many different themes teachers noted in analysis of students' models. On average, we found that there were approximately 2.3 themes noted per interview; thus teachers, on average, discussed two such aspects of students' models. We found no difference in terms of whether their comments were on positive (e.g. "it is good that all the students know that ice does float") versus the negative aspect of students' work (e.g. "model #1 doesn't explain what happens to a molecule which is what the question is asking"). Although there was only slightly more themes mentioned in *Methods III*, overall the number of themes mentioned by teachers at the end of each course was the same. The preservice teachers tended to focus more on representational aspects of the models (e.g. labeling) in the first methods course and did not attend to the accuracy of the ideas or the use of evidence and justification. However, after *Methods II*, the teachers began to focus more on accuracy of ideas and use of evidence and justification.

Table 1: Frequency count of themes noticed in the students models by methods course

Themes	Methods I	Methods II	Methods III	Methods IV
Mechanism in Model	15	12	14	14
Model Representation	12	4	7	7
Accuracy of Ideas	0	9	8	7
Use of Evidence and Justification	4	6	8	7

Aside from analyzing what teachers noticed we also wanted to understand how teachers discussed what they noticed. Specifically, did they merely identify a problem (or leverage) in student thinking, or were they able to reason about, or explain, how what they noticed relates to student learning (for example, explaining what exactly the student confused about based on their model). We found that most of the teachers' comments were of the identification and description type (91 comments out of a total of 120) and that there were far fewer comments in which they elaborated upon and explained student thinking (29 comments out of a total of 120). Thus, the preservice teachers seemed to be more facile with describing what is problematic about a specific model, but were less able to explain what this means in terms of the student's state of understanding. However, it is the latter capability that is crucial to designing lessons that address students' ideas.

We also looked at whether teachers tended to provide more elaborate comments about positive or negative aspects of student models. We wanted to explore this to see if there was a significant difference between the good versus the problematic components noticed. There was a small, but consistent, difference between the number of identification comments made about positive versus negative aspects of the models (21 positive vs. 25 negative) and the interpretive comments made about the positive and negative aspects of the models (13 positive vs. 16 negative). However, we noticed that there were many more descriptions of positive aspects of the models provided by the teachers than descriptions about negative aspects (32 positive vs. 13 negative). Therefore, it seems that the preservice teachers were able to describe the positive aspects of the models more readily than the negative aspects, even though they generally did not notice many more positive aspects.

Our findings reveal that preservice teachers tended to focus on identifying and describing components of the student models rather than interpreting the models in regard to student understanding. In reference to van Es and Sherin 's (2002) components on the aspects of noticing, it seems that the preservice teachers are not making the connections between the specific events, or ideas, in the models and how that relates to the broader principles of teaching in learning. Our teachers did not seem to be attending to written responses as evidence of specific cognitive obstacles (or leverages) in student learning, rather many of them tended to analyze the models in a very literal and contextual manner. Additionally, it was evident that the teachers struggled to interpret what they saw in the models in relation to student understandings of the phenomenon. For example, one of the teachers realized that the model did not portray the phenomenon at the correct grain size, but was unable to see this was potentially due to a lack of knowledge about molecular structures. A plausible explanation for this trend was that the teachers may not have had strong subject matter knowledge about the modeled phenomenon (e.g. density and cellular division).

Attending to Student Thinking in the Instructional Design

We next focused on whether and how the preservice teachers took into account and addressed student thinking in their instructional plans. In order to answer this question, we focused on the last part of the interview task in which the teachers were asked what they would do the next day in the classroom if the student models presented were (a) typical naïve models (created prior to formal instruction) and (b) typical final models (created after formal instruction). We analyzed three aspects of teachers' instructional designs: (a) attention to student ideas; (b) specificity of activities suggested; and (c) alignment with the model based inquiry pedagogical approach.

In regards to attention to student ideas, we gave each teacher a score, from 1-3, to reflect the extent to which they took into account student ideas in their plans. We found that, for the most part, teachers did not attend much to student thinking and that they did not substantially improve, in this regard, over time. The average scores for each course (for both naïve and final model questions) had only a slight difference (1.25-1.8). For example, during *Methods III* Sean was presented with the student models about why ice floats. He commented that the students were not using the correct grain size to represent the phenomenon that ice is less dense than water. When asked what he would do in class the next day if these were naïve models, he stated "I think the first thing I would do is ask them to collaborate with each other. Some have better ideas than others and after that perhaps the groups can do experiments themselves". While Sean felt that a major problem with students' models was that they were not at the molecular structure of ice and water (and hence their models were not at the correct grain size); his instructional move does not relate to this analysis in any specific way. The instructional move he suggested is a viable one (and we suspect that such a move may result in some discussion of molecular structures in some groups); however, it is a rather generic move and it doesn't take into account what he noticed about students' thinking.

In contrast, during *Methods II,* Catherine evaluated student models that focused on the healing of a cut. She commented that all the models had explanations but that some were incorrect. Catherine described her next instructional move as stemming from her interpretation of students' understandings: "Model #1 may understand that cells are involved [based on the written part of the model] but didn't incorporate it in the model. It is important that they know cells are involved so that is where I would start off". Catherine identified "cells" as the missing piece of the puzzle, and thus noted that her next instructional move would address the role of cells in the phenomenon. Unlike Sean, Catherine used her interpretation of students' understanding based on the models to inform her next instructional move, this sort of response was infrequent in our data set. Table 2 shows the teachers that received at least one score of "3" in regards to taking into account student thinking (a score of 3 corresponds to comments that mentioned specific student ideas and provided an instructional move that addresses these ideas). Out of the fifteen teachers, only eight of them received at least one score of 3. In comparing the different courses, the lowest average score (1.25) was during *Methods I* and the highest average (1.8) during *Methods IV*. We then calculated the overall average for all four courses for the instructional move after being presented with the naïve model and the instructional move after being presented with the final model, and found that the teachers took students' ideas into consideration slightly more when the plan was for the naïve versus final models (1.65 vs. 1.48). However, overall the teachers did not readily take into account student thinking when planning their next move in the classroom. This mirrors findings by Friedrichsen et al (2009) and Tabachnik & Zeichner (1999).

Table 2: Selected teachers that did attend to student thinking in their instructional design

Teachers (pseudonyms)	Methods I Naïve	Methods I Revised	Methods II Naïve	Methods II Revised	Methods III Naïve	Methods III Revised	Methods IV Naïve	Methods IV Revised
Catherine	2	2	3	1	3	1	2	2
Anna	1	2	3	1	3	2	1	2
Ava	1	1	1	3	1	2	1	3
Patrick	1	2	1	1	1	3	1	1

Jackie	1	1	3	1	3	1	1	1
Nina	1	1	1	3	1	1	2	1
Jack	1	2	3	1	3	3	3	2
Claire	2	2	1	1	1	1	2	3

We next analyzed the specificity of their next instructional move; that is, how clear and specific were they about what they planned to do. We found that the last two methods courses had higher average specificity scores compared to the first two, with the highest average score of 2.07 for the instructional plan for final models in *Methods IV.* For example, after being presented with the student models about why ice floats during *Methods IV*, Bani discussed her next instructional plan for these naïve models as: "I would give them more data" a rather unspecified move; Bani didn't explain: (a) what type of data or (b) what she would have the students do with that data. However, Sean, after critiquing student models during *Methods III*, was much more specific with his instructional design. He stated that "I would have the kids get in small groups and share their models in small groups. I would then have the group create a consensus model and share them in front of the room and we would argue them". Sean's description of his next instructional move included information about the specific activities that would be performed in the classroom and these activities followed a logical progression.

We expected that the teachers may tend to be more specific about what they planned when confronted with "final models" because had the teachers attended to student thinking the specifics of the instructional designs would probably have related to specific challenges students' demonstrated in their models. Therefore, the activities being described in their next instructional move would be specific to the misunderstandings in the student model. For example, if the teacher critiques the models for not being the correct grain size, an activity that would be coded as a "3" for specificity would outline how doing X would improve student's understanding of grain size. However, there were very small differences (1.85 vs. 1.80) in terms of the specificity with which teachers described their next instruction in the context of the naive versus final models. This could be because the teachers did not readily attend to student thinking or understanding, and therefore, the specificity of the activities did not change during moves for the naïve versus final models because the teachers were not evaluating the models in regards to student understanding. Thus, the activities that the teachers described were most likely common activities, for that content, that they had implemented successfully before.

The last aspects of teachers' next-instructional-moves we examined were the alignment of these plans to the model-based inquiry approach which is the focus pedagogy of the teacher education program. This method entails a student centered classroom in which teachers attend to and work with students' ideas to develop models and explanations of natural phenomena. When looking at each of the four methods courses in turn, we found that during the first course the teachers' plans were not aligned with inquiry-based practices but were mostly teacher centered in nature (e.g. lecture). During the second and last course, the instructional plans were much better aligned with model-based inquiry practices (2.85 and 2.57 respectively). For example, during *Methods I,* Ava described her next instructional move as "I would talk about how a scab forms so that they [students] understand that the scab isn't doing the healing". Ava's practices are teacher centered and showed no connection to model based practices. However, the teachers' lessons began to align more with model based inquiry during *Methods II* and *Methods IV.* Patrick, during *Methods II,* stated that, "The best thing to do is have the students explain their models to the rest of the class and justify them. The class could work out the rest of the problems and allow them [students] to argue and allow other students to argue why that model would be incorrect". Patrick's solution of collaboration and argumentation are consistent with the principles put forth in the heuristic for progressive disciplinary discourse (HPDD) framework that aims to foster learners' participation in material and discursive activities characterizing the work of scientists (Windschitl, Thompson, and Braaten, 2008).

Comparison of the overall averages for the naïve-models instructional move and final-models instructional move, revealed that the teachers' plans were slightly more aligned with model-based inquiry practices for the naïve-models condition (2.36 average) versus the final-models condition (2 average). Thus the preservice teachers tended to suggest more model based inquiry practices when they were designing lesson activities assuming their students were just beginning to study the topic. For example, Molly discussed her instruction after the naïve models during *Methods I* as:

> "I would have a class discussion and everyone shares their naïve models to get everything out and then after the discussion we would do some sort of introduction or look at some kind of experiment. We will draw the raw models, discuss it, and then change the models after the class discussion and then have them [students] do some sort of experiment."

Implementing practices that Molly has outlined above, such as peer collaboration and interpreting data, are part of model-based inquiry instruction. However, for her instructional move given the final model, Molly stated "I would need to go back. I feel that I should go back and do some kind of activity or discussion with them even if it is a five to ten minute lecture". Molly, who previously advocated for student centered activities, now changed the focus of her instruction to lecturing." Molly's responses are not unique and in fact many of the teachers reverted back to teacher-centered activities after they assumed that an initial constructivist approach did not work. Grossman, Wilson, and Shulman (1989) concluded that teachers may revert back to the way they were taught if they are uncomfortable or uncertain of their abilities. Therefore, many of the teachers, including Molly, were unsure of other constructivist approaches to implement; thereby, reverting back to their comfort zone, teacher centered approaches.

In summary, our analyses suggest that the preservice teachers tended not to take students thinking into account when designing their next instructional practice, which could be due to a lack of content knowledge and/or pedagogical content knowledge. Without such knowledge, the teachers may not recognize problematic ideas expressed in the models, and they would not know what types of activities could help address the misconceptions they did identify in the student models. Erickson (2007) contends that teachers fail to make formative use of assessment data because the teachers do not know how to interpret the information to pinpoint alternative pedagogical "moves." Additionally, Davis and Smithey (2009) argue that further support is needed to help preservice teachers consider the factors that contribute to students' ideas or the resilience of those ideas, as well as to connect student ideas to instructional experiences. This resonates with our findings in this study. We did notice a slight increase in attention to student ideas during *Methods IV* which may be attributed to the action research activities teachers engaged with during this course. As part of their research projects teachers analyzed student artifacts from their class and had to relate their analyses back to their research questions and learning theories.

The instructional practices discussed by the teachers were often well aligned with model based inquiry practices. One important aspect to note is that after *Methods III,* the alignment to inquiry practices slightly decreased in comparison to *Methods II* and *Methods IV.* It was during *Methods III* that the preservice teachers were completing their student teaching practicum. Through several class discussions it was apparent that many mentor teachers did not implement these inquiry practices in their class and some were overtly against their use. It could be that some of the preservice teachers were influenced by this and may have begun to mimic the practices of their cooperating teacher. Therefore, this drop in inquiry practices could be contributed to the experiences they were facing during their student teaching, and perhaps a shift in their philosophical stance regarding effective pedagogy. Overall, during *Methods IV* showed improvements in all three categories- attention to student thinking; specificity of activities; and alignment with inquiry based practices. Although the improvement was small, it does show promise that action research projects do promote changes in preservice teachers' attention to student thinking in instructional design.

Conclusions and Implications

Research has shown that beginning teachers typically focus on themselves as teachers, often at the expense of paying close attention to student learning (Meskill et al, 2002). Our findings support this assertion and illustrate the ways in which preservice teachers may begin to develop this skill. We believe that teacher education programs can encourage the shift from teacher (self) to student learning by engaging teachers in the practice of looking for evidence of student understanding in written artifacts as well as classroom discourse. In our methods courses we provide opportunities for teachers to evaluate student work and student discourse. However, our findings suggest that these opportunities were either not substantive or not frequent enough to engender the kind of evidence-based approach to instructional design we had hoped teachers would develop.

It seems that the single most influential course on teachers' ability to attend and respond to student thinking was the last methods course with its action-research focus. During this course, teachers analyzed various student artifacts for student understanding that they had collected during their student teaching internship the previous semester. In follow up studies, we would like to engage the teachers in analysis of student work and help them develop more robust strategies for looking at evidence of student understanding and relating such interpretations to potential instructional strategies.

References

American Association for the Advancement of Science (1993). *Benchmarks for Science Literacy*, New York: Oxford University Press.

Ball, D. & Cohen, D. (1999). Developing practice, developing practitioners: Toward a practice based theory of professional education. In L.Darling-Hammond & G. Sykes (Eds.), *Teaching as a learning profession* (pp. 3-31). San Francisco: Jossey-Bass.

Bell, B., & Cowie, B. (2001). Formative assessment and science education. Dordrecht: Kluwer.

Black, P., & William, D. (1998). Assessment and classroom learning. *Assessment in Education*, 5, 7-74.

Davis, E.A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Researcher*, 34 (3), 607-651.

Davis, E.A., & Smithy, J. (2009). Beginning teachers moving toward effective elementary science teaching. *Science Education*, 93(4), 745-770.

DeJong, O., & Van Driel, J. (2001). The development of prospective teachers' concerns about teaching chemistry topics at a macro-micro-symbolic interface. In H. Behrednt, H. Dahncke, R. Duit, W. Graber, M. Komorek, A. Kross, & P. Reiska (Eds.), *Research in Science Education: Past, Present,and Future.* Dordrecht: Kluwer.

Duschl, R.A., Schweingruber, H.A. & Shouse, A. W. (Eds.) (2007). *Taking Science to School: Learning and Teaching Science in Grades K-8.* Washington, DC: National Academies Press.

Erickson, F. (2007). Some thoughts on proximal formative assessment of student learning. In P. Moss (Ed.), *NSSE Yearbook.* Hoboken: Wiley.

Friedrichsen, P., Abell, S., Pareja, E., Brown, P., Lankford, D., & Volkmann, M. (2009). Does teaching experience matter? Examining biology teachers' prior knowledge for teaching in an alternative certification program. *Journal of Research in Science Teaching*, 46, 357-383.

Geddis, A.N., Onslow, B., Beynon, C., & Oesch, J. (1993). Transforming content knowledge: Leaming to teach isotopes. *Science Education*, 77, 575-591.

Grossman, P., Wilson, S., & Shulman, L. (1989). Teachers of substance: Subject matter knowledge for teaching. In M.C. Reynolds (Ed.) *Knowledge base for the beginning teacher* (pp. 23-36). Oxford: Pergamon Press.

Hammer, D. 2000. Teacher inquiry. In J. Minstrell & E. van Zee (Eds.), *Inquiring into inquiry learning and teaching in science* (pp. 184-215). Washington, DC: American Association for the Advancement of Science.

Kazemi, E., & Franke, M.L. (2004). Teacher learning in mathematics: Using student work to promote collective inquiry. *Journal of Mathematics Teacher Education*, 7, 203-235.

Leinhardt, G., Putnam, R.T., Stein, M., & Baxter, T. (1991). Where subject knowledge matters. In P. Peterson, E. Fennema, & T. Carpenter (Eds.). *Advances in research on teaching.* Greenwich: JAI Press.

Little, J. (2002). Locating learning in teachers' community of practice: Opening up problems of analysis in records of everyday work. *Teaching and Teacher Education*, 18, 917-946.

Meskill, C., Mossop, J., DiAngelo, S., and Pasquale, R. (2002). Expert and novice teachers talking technology: Precepts, concepts, and misconcepts. *Language Learning and Technology*, 6, 46-57.

National Research Council. (1996). *National science education standards.* Washington, DC: National Academic Press.

Russell, T., & Martin, A.K. (2007). Learning to teach science. In S.K. Abell & N.G. Lederman (Eds.), *Handbook of Research in Science Education.* Mahwah: Lawrence Erlbaum Associates.

Sadler, D. (1989). Formative assessment and the design of instructional systems. *Instructional Science*, 18, 119-144.

Simmons, P.E., Emory, A., Carter, T., Coker, T., Finnegan, B., Crockett, D. Richardson, L., Yager, R., Craven, J., Tillotson, J., Brunkhorst, H., Twiest, M., Hossain, K., Gallagher, J., Duggan-Haas, D., Parker, J., Cajas, F., Alshannag, O., McGlamery, S., Krockover, J., Adams, P., Spector, B., LaPorta, T., James, B., Rearden, K., & Labuda, K. (1999). Beginning teachers: Beliefs and classroom actions. *Journal of Research in Science Teaching*, 36, 930-954.

Tabachnick, B.R., & Zeichner, K.M. (1999). Idea and action: Action research and the development of conceptual change teaching of science. *Science Education*, 83, 309-322.

Van Driel, J., DeJong, O., & Verloop, N. (2002). The development of preservice chemistry teachers' pedagogical content knowledge. *Science Education*, 86, 572-590.

van Es, B., & Sherin, M. (2002). Learning to notice: scaffolding new teachers' interpretations of classroom interaction. *Journal of Technology and Teacher Education*, 10, 571-596.

van Zee, E., & Minstrell, J. (1997). Using questioning to guide student thinking. *Journal of the Learning Sciences*, 6 (2), 227-269.

Windschitl, M., Thompson, J., & Braaten, M. (2008). How novice science teachers appropriate epistemic discourses around model-based inquiry for use in classrooms. *Cognition and Instruction*, 26, 310-378.