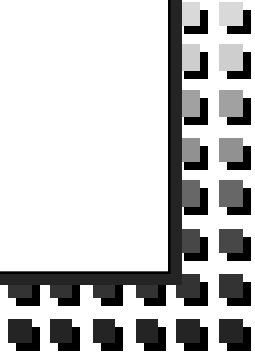


PERC 2000  
Guelph, Ontario

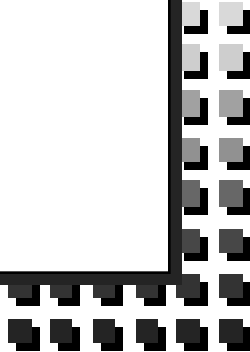
*Learning by Inquiry in a Physical Science  
Course for Prospective Elementary Teachers:  
What do the Students Think?*

Roger Nanes  
Vincent K. Smith  
Department of Physics  
California State University  
Fullerton, California





## *Phys/Chem 102*

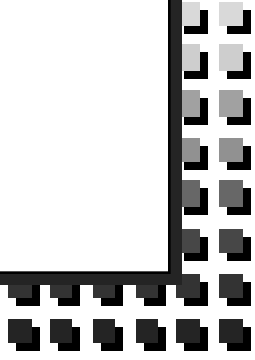
- » Taught jointly by Physics and Chem faculty
  - » 27 freshmen—25 female/2 male
    - Self-declared future elementary teachers
  - » 6 hrs./week - 3 two-hour sessions
  - » Inquiry-based, active- learning
  - » Simple equipment
  - » Minimize lecture
  - » Collaborative Groups
    - Students work in 3-4 person groups
    - Collaboration as discussion and sharing of ideas
  - » A lot of writing
- 



## *Pedagogy*

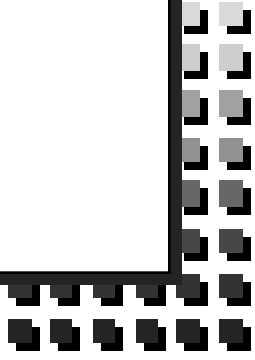
- »»» "P-O-E" pedagogy used extensively
- »»» Interactive Demonstrations
- »»» Use of Whiteboards

## *Sources of Data*

- »»» Pre- and Post- Episto Surveys
  - »»» Journals
    - Some open-ended, some with directed question
  - »»» Learning Commentaries
    - Three during semester
  - »»» Student Interviews
- 



## *Interviews*

- »»→ Volunteers selected during first week of semester
    - Nine Volunteers — four selected based on brief indications of expressiveness during first week
  - »»→ Three hour-long interviews
    - Weeks 3, 8, 16 of a 16 week semester
  - »»→ Open-ended
    - Directed questions about previous work, discussions of students' perceptions of their learning
    - Questions about possible teaching strategies
  - »»→ Students received \$10/ interview
- 



# *Outline of Analysis*

## »»» Constructivist Learning Environment

- Overall Perceptions of the Constructivist Environment
- Value of Predictions
- Integration of Content
- "Seeing and Doing" Means Understanding

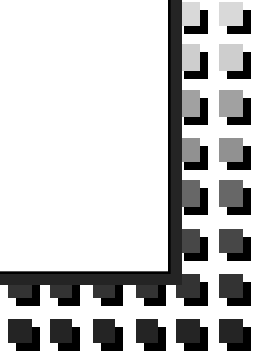
## »»» Collaborative Learning Environment

- Overall Perceptions of the Collaborative Environment
- Use of Feedback
- Questioning and Broadening One's Thinking
- Verbalization of Thinking

## »»» Attitude Toward Science Learning

- Connections to the Real World
- Role of Learner
- Overall View of Science and Science Learning

## »»» Attitude Toward Teaching Science

- Initial "Affective" Perceptions of Teaching Science
  - Confidence and Security
  - Acquisition of Tools and Strategies
- 



## *Constructivist Learning Environment*

### »»» Overall Perceptions of the Constructivist Environment

- Students perceived that they attained a more complete understanding of science concepts because they constructed an understanding for themselves instead of having the concepts presented to them by someone else.

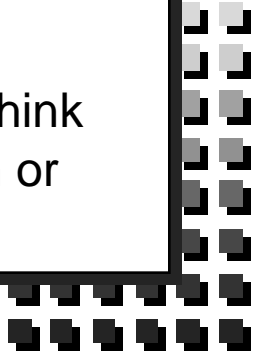
### »»» Use of Predictions

- The students were not initially comfortable with the predict-observe-explain process but later adapted to it. But, they did not make effective use of their predictions

### »»» Integration of Content

- Students were not efficient in integrating individual concepts to form a unified understanding of the big picture.

### »»» "Seeing and Doing" Means Understanding

- The hands-on nature of this curriculum has led some students to think that they understand a physical process once they "see it" happen or once they "do it" themselves.
- 



## *Collaborative Learning Environment*

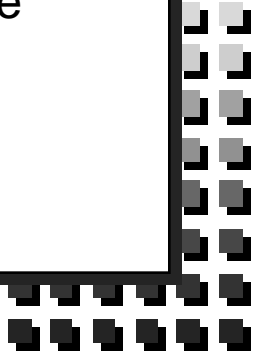
### »» Use of Feedback

- The collaborative environment facilitated learning by continuously giving students necessary feedback about their ideas as well as helping to broaden their thinking.

### »» Questioning and Broadening One's Thinking

- Because the students had the opportunity to discuss their thinking and listen to their classmate's thinking, they considered ideas they had not previously considered.

### »» Verbalization of Thinking

- The students expressed a clear need to verbalize their thinking as an important element in developing understanding about science concepts.
- 



## *Attitude Toward Science Learning*

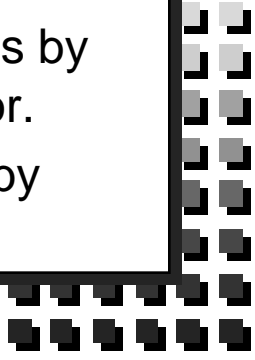
### »»»→ Connections to the Real World

- The learning environment has allowed students to make connections with real world phenomena without being encumbered by mathematical formulas and memorization of facts and information. They readily accepted concepts with which they were very familiar but did not necessarily connect with the contextual approach of global warming.

### »»»→ Role of Learner

- They saw that they had different responsibilities in this course as compared to their previous high school science courses but still, to a large extent, looked to the instructor as an "authority".

### »»»→ Overall View of Science and Science Learning

- The students have changed in the way they view learning science; they now see the experience of learning science as a process of doing something or looking at something and then learning what it means by processing their observations with their peer group or the instructor.
  - The students' overall view of science seems relatively unaffected by the curriculum.
- 



## *Attitude Toward Teaching Science*

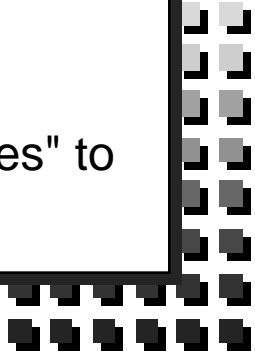
### »» Initial "Affective" Perceptions of Teaching Science

- Students expressed a positive attitude towards teaching science to elementary students.
  - Two of the interview subjects gave embraced the inquiry-based learning and were excited to share it with their students.
  - Two students did not relate to the inquiry-based learning with the same attitude and formed a less-positive, in one case fearful, attitude towards teaching science to elementary students.

### »» Confidence and Security

- Students have more confidence and security to teach science to elementary students because they now have participated in a process that validates a model for learning science that they hadn't experienced before.

### »» Acquisition of Tools and Strategies

- The students thought that they now had more "tools and strategies" to teach science to elementary students.
- 




## *Use of Evidence*

»» PA, Interview #3

I guess it's helped me to see things as not so black and white anymore... Um, a big eye opener was when he [the instructor] had made that comment that some scientists might argue that the world is getting warmer and some might argue that is not. Well, how can you not know? You are a scientist, you're supposed to know everything, you're supposed to know if it is getting warmer. What does your data say? Does your data say that it is getting warmer? If it is ,it is—if it's not, then it's not. Well, but when you look at the graph it makes sense, well, some can interpret it one way and some can interpret it another, so I guess it's just a matter of interpretation.

»» SS, Interview #3 (In response to question: "...from all your experiences in this course or previously, does it give you any picture of how scientists work or how science works?")

Um...I guess you gotta apply it to really know how it works. It's not just...there's other things it may just be like the right or wrong answers. I mean...I guess in science that's how it is, but you gotta do it to know if it's real...um...I don't know.





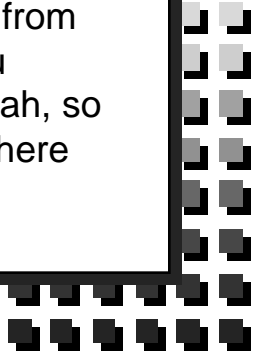
## *Constructivist Learning*

- » PA, Interview #1 (Discussing experiment to find  $\pi$  from measurements of circumference and diameter of circular objects.)

Yeah, [laughs] there was...I was really excited about the one about, pi. I was ...'cause he never told me if I was right but I was so...like...adamant 3 point something...you know...its gotta be pi, its gotta be pi and then it has to do with circles and he [instructor] never said yeah you're right it is pi. He kind of just left me floating around but I was...hey...I figured it out and I would have never thought in a million years that I would have figured something out but I was really excited about that because here you are...like...measuring circles.

- » Later, same interview (elaborating on an earlier response relating to the role of the instructor as a guide)

...I was talking to a teacher the other day and he told me...like...the Socratic method or something...like that...where you let the student figure it out by themselves by asking them questions. And that is kind of like a guide...you know...'cause they're...like...they're, they're just...like...kind of paving the way for you but you're...like...you're learning it by yourself. You know...kind of...like...how the teacher does it now. He doesn't tell us what we're going to find or what we're going to do or how...what the answer is. He just says this is the activity...um...and whatever you come up with at the end and...you know what I mean...and he kind of goes from there. Like...um...the pi one. I didn't know I was going to come up with pi at the end. You know...he kind of...just like...guided us toward it. Like...he would come over and say—Yeah, so where have you seen that number before? And then he would leave. And I'm thinking, where have I seen that number before? Ohhh...you know...pi, or whatever.





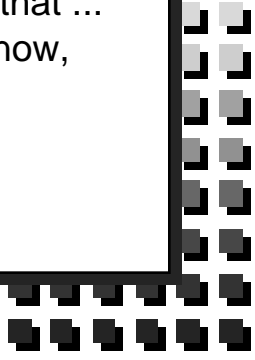
# *Collaborative Learning*

## »» JC, Interview #2

...I think out loud and just by bouncing ideas off people like my group, I can become more confident in what I'm thinking and not be quick to say, "oh that's really wrong," even though sometimes they can be. Um...I think that's the main thing. Usually, I prefer to work by myself because I don't like my grade resting in other people's hands, like in terms of other classes. But this particular class I really like working in...with groups because sometimes I'm way off...you know...and the other group members can help me to stay focused and...um...to really think about what we're doing and not just half-heartedly but you know that each others grades are depending on that too.

## »» PA, Interview #1

...at first when I . . . when I heard about this group thing I . . . oh this isn't going to be it because in a group presentation . . . in a group presentation . . . group whatever . . . there's always one person that does all the work and all the thinking and I have a problem with that because I'm always the person who gets stuck doing all the work . . . um . . . and that's not fair but an' . . . so I thought this was going to be a group thing. That was going to be the one downfall about the class. . I don't want it to be group because all they're going to do is talk about this and that and we are not going to get anything done. But I find that in my group...um...it's not like that ... we kind of just like help each other 'cause none of us, not one of us, is ever right...you know, we are each almost there but we put all of our ideas together and we...like...figure it out.





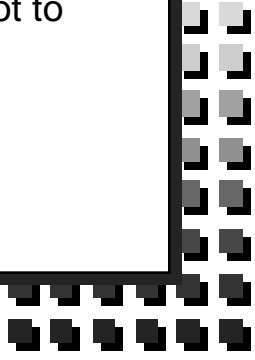
## *Attitude Towards Science Learning*

- »» EM, Interview #3 (In response to question: “Do you see any change in your...in your attitude towards science... why bother studying this stuff?”)

Well, a little. Like...at first, before I could tie it together, the global warming, I didn't...yeah...I didn't really care. I didn't think it really mattered. I was...like...why am I learning this? Like...it doesn't make sense, but then...I guess...like...now after...like it helped. Look how long it took. Like...I finally understand what the whole concept is and now I can...like...now I know why it's such a big topic. I think it's good 'cause that's a current issue...

- »» SS, Interview #2 (In response to question: “Last time you indicated that science was scary to you... Does it still seem that way?”)

No, because I didn't think I was really good at science so I...it wasn't really interesting at all and then I didn't enjoy it. And now it's...it's interesting to me and I feel as if...you know...when we get done with stuff, I understand it more than I would have...like...when I had science a couple years ago. You know...sometimes I just wouldn't understand it even after the teacher got done explaining it. So now I understand, I understand it more than I would have last time and its interesting to me, so its not really scary to me anymore. Its still a little hard cause you got to think a lot but um yeah its not scary.





## *Attitude Towards Teaching*



### » PA, Interview #3

I wasn't really into it, it wasn't my thing...um...I wasn't excited to do physics but now, because I see it a little bit differently, I don't see it as hard, it's not . . . I don't think it's...like...impossible to get something that everybody could learn and especially children at a good age when they can be turned on to physics then, more physics majors. [laughs]"

### Later, same interview


I was excited about physics because I didn't know...like...if I was going to be able to teach it or...like...how I was going to teach it or what I was going to teach. But now that I have an idea of how things, of...like...what kind of things I could do and...like...how I could do'em [barely audible] it makes me excited about wanting to teach it.

### » JC, Interview #3

...In high school physics I could have cared less why the power formula or the work or the force or any of those formulas. I didn't give anything...I didn't care about what that was important for because all I thought...uhn...elementary school kids are never going to learn this so I don't care, I don't need to know this. But now...I don't know...just in terms of understanding concepts and the steps it takes to get there, it's important.

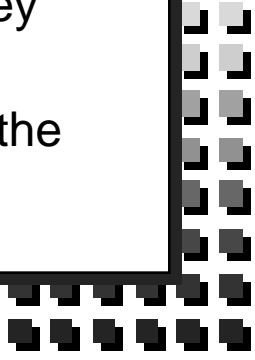
### » EM, Interview #3

I think I'm more scared [to teach science now] because I'm insecure with it. I'm not...I don't feel like I really understand everything...you know. If I understood, not everything but...I mean, like...if I understood a lot of it...then I...it would be easier for me to be encouraged to teach it 'cause I can't teach something that I don't know. Mostly...like...especially the fundamentals about it. Like...I can't...that's why...that's why I'm scared 'cause if...I don't know, like...they're going to see that I don't know it, they're going to know, so.





## *Implications for Instruction*

- »»» An instructor must continually request that students examine their own evidence to see how it helps them to answer their own questions.
  - »»» Lack of integration of concepts suggests that students need additional assistance or direction to help them see how concepts connect to previous ones. Conceptual learning does not necessarily imply connected learning.
  - »»» Students do see value in discussing their thinking; it is part of the feedback loop of learning. Collaborative learning helps students to broaden their thinking about concepts. Small group collaboration is very important.
  - »»» It is difficult to give "learning authority" back to the students. Instructor must clearly define the students' role in learning the content.
  - »»» In order to teach science to elementary school students, teachers need to have their own hands-on learning experiences for the content they will be teaching to their own students.
  - »»» Students often confuse familiarity with understanding. "I have done the experiment and have seen the result, therefore I understand it."
- 



## *Questions for Further Research*

- »→ It is difficult to take "learning authority" away from the instructor and give it back to the students.
    - To what extent does small group collaboration transfer "learning authority" away from instructor to the other members of a group?
  - »→ Some students "thrive" in an inquiry-based learning environment, others do not.
    - Are there identifiable characteristics that can be likely indicators of such compatibility that can be discerned from a survey instrument at the beginning of a course?
- 