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"I Know It's So Good, But I Prefer Not To Use It" An Interpretive Investigation of Jordanian Preservice Elementary Teachers' Perspectives about Learning Biology Through Inquiry

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Many researchers emphasize the significance of employing inquiry learning in shaping preservice elementary teachers' tendencies to teach science. Using an interpretive research methodology, this study examined the influence of employing an inquiry-based teaching approach on teaching biology to preservice elementary teachers at the Hashemite University in Jordan. The purpose was to explore 3 teachers' perspectives of the teaching approach as well as to examine the effect of taking such courses on their future intentions to use inquiry. Findings indicated that participants were generally supportive of an inquiry-based learning strategy as they saw value in the inquiry experience provided from their course. Finally, the study suggested that support should be devoted to encourage the continuation and development of inquiry-based laboratories to better prepare prospective teachers. Furthermore, collaboration between postsecondary science teachers and science educators should be established to promote understanding of inquiry learning.

Throughout the past five decades (1960s–present), the field of science education has witnessed several calls for reforming the whole process of science teaching and learning at schools. More recently in the United States, for example, several documents that aimed at reforming science teaching were produced: *Project 2061: Science for All Americans and Benchmarks for Science Literacy* (American Association for the Advancement of Science [AAAS], 1990, 1993)*; The National Science Education Standards* (National Research Council [NRC], 1996). In Canada, *Common Framework of Science Learning Outcome* (Council of Ministers of Education, Canada, 1997) was produced. The justification for these reforms was based on the nature of science as inquiry and the effects of hands-on/minds-on approaches (Shymansky, Kyle, & Alport, 1983). Similarly, calls were observed in other countries worldwide. Jordan was one of these countries that have taken positive steps towards reforming its process of science education (*Science Curriculum and its Guidelines at the Basic Educational Cycle* [SCGBEC], 1988). According to the SCGBEC, one of the main goals of teaching science in Jordan, as stated by the scientific team at the Ministry of Education, is

> In selecting the methods of teaching science, it is essential to emphasize the active role of the student through making him/her the effective element in performing class activities, conducting laboratory experiments, carrying out discussions, exploring knowledge through individualized reading. Meanwhile, the teacher plays the role of a facilitator in providing the appropriate learning environment and the needed stimulating experiences. (p. 26)

One of the reform recommendations included the task of modifying the methods of teaching science. This task falls upon the teachers, who are recognized as the central factor in the successful implementation of the reform. Accordingly, teachers should be acknowledged as facilitators of knowledge, and students are expected to actively participate in learning experiences with their hands and minds and get involved in *inquiry-oriented* investigations (NRC, 1996).

The term *inquiry learning* "refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (NRC, 1996, p. 23). Inquiry also "refers to the activities students engage in to develop their knowledge of scientific ideas and to investigate the natural world within their developmental capacities" (Sunal & Sunal, 2003, p. 13). Other researchers went even further to say "inquiry is one of the practices that characterizes science" (Rowell & Ebbers, 2004, p. 916).

Because of the significance of learning through inquiry (or inquiry whose focus is on the creation, testing, and revision of scientific models and explanations) to the creation of new knowledge and to scientific reasoning, one might expect that it would be emphasized from the earliest years of instruction and developed over time, not postponed until high school or beyond (NRC, 2000).

Enacting inquiry-based teaching in schools depends on elementary science teachers, who begin the preparation process of students for a scientific and technological future. A host of researchers have suggested that teachers hold images of teaching from their experiences as students and they tend to teach the way they were taught when they were students (Brown & Borko, 1992; Calderhead & Robson, 1991; NRC, 1996). More research indicates that the likelihood that the way teachers will teach science depends on their undergraduate preparation (Abell & Roth, 1992; Appleton, 1997; Loucks-Horsley, 1998; Wenner, 1993). Evidently, traditional science teaching experiences impact the way in which science is taught, where teachers learn science through the traditional methods in a period called an apprenticeship of observation (Stuart & Thurlow, 2000). As a result, they develop their own teaching beliefs based on their in-class experiences at school, which is strongly tied to their attitudes about teaching science (Bohning & Hale, 1998; Gibson, Bernhard, Kropf, & Van Strat, 2001).

Many researchers emphasize the importance of teachers' beliefs in shaping elementary teachers' tendencies to teach science (Bonnstetter & Yager, 1985; Downing & Filer, 1999; Eiriksson, 1997; Lumpe, Czerniak, & Haney, 1999). These and some other studies recommend that preservice science programs should include revised science courses that (a) combine content and methods (NRC, 1996; Prestt, 1982; Yager & Penick, 1990), (b) provide exposure to a variety of teaching experiences (Lunetta, 1975; Sunal, 1980), (c) foster improvement in preservice teachers' attitudes regarding science teaching (Cox & Carpenter, 1989), and (d) develop informed views of scientific inquiry and the nature of science (Crawford, 2007; Yore, Florence, Pearson, & Weaver, 2006).

Although these studies investigated the influence of an authentic inquiry experience on students' beliefs and attitudes toward using inquiry, they mentioned several limitations (Brown & Melear, 2006). Exploring the factors that inhibit the use of inquiry was one of these limitations. Investigating the use of inquiry at the postsecondary level is another limitation that Brown and Melear mentioned. Therefore, this study came to address these gaps in the literature by investigating the influence of employing an inquiry-based teaching strategy on teaching by two biology courses for preservice elementary teachers at the Hashemite University in Jordan. The purpose of the study was to explore the sort of obstacles that preservice elementary teachers face as a result of learning biology through inquiry. Moreover, this study intended to examine the effect of taking two courses of biology on the students' future intentions to adopt inquiry strategies in their future teaching.

Inquiry-based Biology Courses

The introductory biology courses (I & II) are offered in sequence over two different semesters to preservice elementary teachers in the Faculty of Educational Sciences. These two required courses were originally designed to be taught without a laboratory and using traditional teaching strategies. However, at the time of this study, a new instructor, the first author of this study, joined the faculty and decided to teach these courses using inquiry teaching strategies during the Fall 2006 and Spring 2007 semesters.

The courses involve engaging students in various investigations with minimal guidance from their instructor. Through inquiry-based strategy, students were expected to learn to ask researchable questions on a determined topic, design experiments to find answers for their questions, collect data, and use evidence to formulate knowledge claims and explanations of the science phenomenon that they investigated. It is important to note that students were not forced to follow these specific steps in order.

Each unit of the two courses shared a common format consisting of relevant guided inquiry investigations in consecutive class meetings, followed by an extended whole-class investigation. Guided inquiries are investigations that follow a protocol worked out mutually between learners and the instructor or as prescribed by the instructor to arrive at a particular concept, process skill, or both. Each laboratory session was designed to be a hands-on, minds-on experience through the use of prelaboratory discussion (Clough, 2002), relevant and application-oriented laboratory studies (Rutherford & Ahlgren, 1990), and postlaboratory discussion of findings (Tobin, Tippins, & Gallard, 1994).

Purpose of the Study

The main purpose of this study was to explore the sort of obstacles that preservice elementary teachers face as a result of learning biology through inquiry. Moreover, this study intended to examine the effect of taking such a series of courses on their intentions to implement inquiry strategies in their future teaching. Specifically, we sought to answer the following questions:

1. How do preservice elementary teachers evaluate the inquiry-based approach to science learning?
2. What are the obstacles that inhibit preservice elementary teachers from using inquiry in their teaching?
3. What are these preservice elementary teachers' intentions to utilize the inquiry-based approach in their future teaching of science?

To answer these questions, a qualitative research approach was chosen to guide the overall conduct of this study. This type of research strategy suits the nature of the research problem that demands, as Taylor and Bogdan (1998) stated, an understanding of a social phenomenon from the actor's own perspective and examining how the world is experienced. Thus, based on this assumption, the researchers relied solely on the qualitative approach, where in-depth interviews and participants' observations represented the main source of data.

Participants

Participants of this study were 11 preservice elementary science teachers, who were selected from three 40-student sections, enrolled in two biology courses during the fall and spring semesters of the academic year 2006/07 in the College of Educational Sciences at the Hashemite University, Jordan. The participants were purposefully chosen based on their positive and negative attitudes after answering a professor's quick question of "To what extent do you like inquiry-based teaching?" (Fraenkel & Wallen, 2003). After answering that question, students were asked to express their willingness to participate in the study. At the end, 11 females, who demonstrated various attitudes (7 with positive attitudes and 4 with negative ones) toward the use of inquiry in teaching science, agreed to participate in this study.

Procedures, Data Sources, and Collection

This study was an interpretive within-case analysis of learning for the 11 case participants described above, relying on qualitative data. The first researcher, who was the course instructor, acted as a participant observer in each class. The elementary sources of data included the researchers' in-depth interviews and classroom observations. The interviews took place in the researchers' offices and each lasted for approximately 30–45 minutes, where each participant was interviewed two times toward the end of each semester. The interview questions were adapted from Tsai (1998), and each interview included three sets of questions (see Appendix). The first set dealt with learning beliefs to determine their views of the techniques of learning science. The second set dealt with their reasoning about inquiry, including their understanding of experiments, and their initial ideas for experimental design. The third set dealt with their intentions to employ inquiry-based learning strategies in their future teaching of science. All interviews were digitally recorded and transcribed verbatim.

Data Analysis

Data collection and data analysis occurred throughout the period of the study. Right after finishing each interview, the interview was transcribed and analyzed in three major stages: open coding, selected emergent themes, and focused coding (Emerson, Fretz, & Shaw, 1995).

In open coding, we read transcripts of data for each participant line-by-line to identify and formulate all ideas, themes, or issues they suggested, no matter how varied and disparate. During this stage, we wrote initial memos reflecting a variety of ideas to begin the preliminary analysis of data. After arranging all data and coding them, we again reviewed the data and attached meaningful notes, defining the core themes and subthemes that emerged from the analysis. In the focused coding, we subjected our data to fine-grained, line-by-line analysis on the basis of topics that we identified as of particular interest from the open-coding analysis. In this stage, we combined the coded data under our selected themes and wrote reflective memos on each theme (Bogdan & Biklen, 1998). In reviewing the interview transcripts, we identified patterns or themes emerging from the data (Glesne, 1999) and organized them into broad categories. We carefully cross-checked the themes that emerged from each subject's transcripts to enable ourselves to link related data from different interviewees. Then we grouped them under one theme and marked them with accompanying interpretive notes.

As in any qualitative study, rigor is a major factor that shapes data analysis. To ensure the rigor of the findings of this study, the researchers followed Patton's (1990) strategy of triangulation. Patton recommended considering multiple data sources to support proposed themes. In this study, both participants' interviews and researchers' observations were considered to be the main sources of data gathering. Member checking was another strategy that the researchers used to ensure the rigor of their findings (Glesne, 1999). To do this, the tentative results of the data analysis were checked by a number of authorized faculty members to ensure that the data were analyzed correctly.

For the purpose of this article, since the language of all collected data was Arabic, all interview excerpts used in the Results section below were translated into English (Sperber, Devellis, & Boehlecke, 1994) by three bilingual faculty members from the Faculty of Educational Sciences at the Hashemite University. Furthermore, to confirm that the translation process was accurate and reflected the meaning that the interviewees intended, each participant was given a draft of the translation, and their feedback was considered in correcting any comments from the participants.

Results and Analysis

The analysis of the collected data revealed three important themes: (a) the merits of learning biology through inquiry, (b) the mismatch between beliefs and actions, and (c) suggested changes in the course. The following passages discuss these general themes in detail.

Theme One: The Merits of Learning Biology through Inquiry

Most participants mentioned that the inquiry-based biology courses were beneficial. However, their responses were focused on both the value of the course content as well as the way that these courses were taught. Most (7 of 11) participants—who were given pseudonyms (Ala'a, Bayyan, Amal, Reem, Elham, Rawan, Sameera)—favored the content of the course and explained that their topics were connected to their everyday lives. Moreover, they indicated that the content was comprehensive, easy to understand, and a good source of valuable information that helped them in reasoning many natural phenomena that they encountered.

> The material of our course is tightly related to our real life. I greatly benefited from it and used it to explain some of my surrounding phenomena … smoking, for example, was one of the most favored topics that I liked. From that topic I had a good understanding of how the lungs of a smoker person appears and how difficult for him to exchange gases via his alveoli. (Bayyan)

> The content of our course was very easy to comprehend. The topics are organized in such a way to help the student follow up. The content is practical and activity oriented and speaks to our real-life perspectives … I personally made use of it many times in my life. (Amal)

On the other side, the other four participants (Sameera, Bayda'a, Rawan, Areej) disagreed. These participants mentioned that the material was not relevant to their everyday lives and was not interesting to them at all.

> I think that most of our topics are redundant and known by myself at least. (Bayda'a)

> I don't see, at least from my perspective, that the topics we learned can be applied in my everyday life. (Rawan)

> I guess the course added some new information for me, but I think that some of the topics are redundant as we took them during high school. (Sameera)

However, with respect to the way the courses were taught, a large majority (9 of 11) of the participants agreed that the inquiry-based teaching strategy helped them in building a better understanding of the content and the way it can be applied in their life situations.

> My previous knowledge about science learning was really different than what I had experienced throughout the semester. The way we learned this course changed my beliefs about the whole process of science teaching and learning. I believe that inquiry teaching strategy is so helpful and I am planning personally to employ it in my future teaching. (Amal)

> Inquiry-based teaching strategy is the best way to teach science because it compels the students to think and investigate for the sake of arriving to the needed knowledge. Therefore, that knowledge stays in the student's mind longer. (Elham)

> The inquiry-based teaching strategy is so helpful as it encourages the student to search for the knowledge himself. It also increases the self confidence of the student and pushes the student to rely on himself to find the knowledge. (Bayyan)

Theme Two: The Mismatch between Belief and Actions

Although most participants valued the use of the inquiry-based teaching strategy, further analysis of their interview excerpts showed a level of contradiction between what they believe about learning biology through inquiry and their actions about using it in their future teaching of biology. For example, Sameera conveyed a high level of contradiction with regard to the use of an inquiry-based teaching strategy: "I did not like the inquiry-based strategy employed in this course. I, personally, feel more comfortable with the traditional way of learning science." But she believed that trying new strategies of science teaching (e.g., inquiry) is worthy. She said, "It is not wrong to use inquiry-based learning strategies, as learning science mainly depends on experimentation."

Similarly, Bayda'a expressed a high confidence in the traditional way of learning science: "I prefer to learn science using the same old traditional strategies as I believe it will benefit me more." But this personal belief did not prevent her from expressing her conditional support to continue using an inquiry strategy by employing both the traditional and inquiry-based strategies at the same time. She said, "Because, I think that science differs from other disciplines, as it requires understanding more than memorization, I encourage the use of both the traditional and the inquiry-based science learning strategies." Likewise, Areej, who believed that learning biology should be through laboratory activities, she did not believe that every topic in biology requires the use of the laboratory: “I believe that the use of lab in teaching biology is very important but I don’t believe that every topic in biology needs to be learned in the lab.”

Theme Three: Suggested Changes in the Course

The preservice elementary teachers who participated in this study provided suggestions for course changes that would make it more meaningful. From their suggestions, four areas to focus on for improvement emerged: (a) the existence of an assigned textbook, (b) a slight increase in the complexity of inquiry activities, (c) more time, and (d) more equipment in the laboratory.

Bayda’a, Areej, Sameera, and Rawan expressed the need to have an assigned textbook for the course. Sameera confirmed that inquiry methods were beneficial; however, she discovered that inquiry was “very difficult to implement because of the need of a written document or textbook.” Rawan complained that without a textbook she “feels lost and confused” as she is accustomed to using traditional science learning strategies. Bayda’a also confirmed that “teaching this course would be more beneficial if the professor provided a written textbook for the students.” Areej demanded “a written manual of all the activities that the student will learn throughout the semester.” Ala’a wanted more time allocated to do the inquiry activities. She appeared to believe that the more time spent inside the laboratory would enhance her learning: “spending more time inside the lab would probably make the biggest difference in our quality of learning.’’ Bayyan asked for more equipment in the laboratory: “we need to have more equipment in the lab in order not to bring any additional stuff from our homes.”

Discussion

The participants in this study were generally supportive of the use of an inquiry-based learning strategy as they saw value in the research experience provided from their courses. The following section includes two major issues related to the three previously discussed themes. In addressing the first finding regarding the course value, we discuss (a) the experiences in the course and (b) the beliefs and practice to explicate the finding of mismatch between participants’ expressed beliefs and their observable actions.

Experience in the Course

Overall, participants in this study expressed appreciation for the course climate in that it provided opportunities to experience similar frustrations to what their students would possibly encounter in the future. These experiences appeared to be valuable as they were looking to employ progressive teaching strategies in teaching science. Therefore, this experience offered them the opportunity to experience the difficulties of conducting inquiry laboratory activities, which had not been presented to them during their earlier educational preparation. The benefits of experiencing inquiry-based learning for these participants revealed their limited knowledge and exposure to alternative teaching approaches. It was noticeable especially during the early meetings in the course, where most participants began experiments by testing one variable per single sample without considering the other interfering factors.

Another interesting observation of these participants was their preparedness to conduct their experiments using appropriate scientific methodology. Due to their limited experience with open inquiry, some of them expressed disdain in designing and controlling the variables of their experiments. For example, Areej stated, “I truly regret taking this course through inquiry strategies but I honestly found no way but to take it this semester.… I really don’t know how to employ the scientific approach in my science learning.” A similar complaint was expressed by Rawan:

> I did not like the way I learned this course, although I am open to change, but I prefer the traditional way of learning as I see it easier and I know exactly what to do without going onto the hassle of designing an experiments and controlling the variables.

However, later in the semester, these participants slowly realized that the answers were not going to be given to them directly and that they would have to learn from each other and use the scientific approach to find their answers. Therefore, they had to ask the questions, design the experiments, analyze the results, and then present conclusions. By forging through the awkward and uncomfortable feelings of the experimental unknown during the inquiry-based science course, the participants experienced an authentic inquiry environment. Elham commented on her initial feelings:

> At the beginning of the course I was lost; I did not know what to learn and what to do. But later in the semester, I realized that inquiry approach is a very good way to learn science and especially biology … therefore, I highly encourage other teachers to use it as it helps learners keep their information longer.

The fact that several participants reported that they enjoyed experiencing some reform-based pedagogical strategies (e.g., inquiry-based learning) further supports the notion that the science education courses had positive effects on learners. Admittedly, the extent to which participants implemented inquiry consistent with the international reform-based science teaching strategies is not addressed by the data collected in this study; but, based on the descriptions of instructional practices provided, it seems likely that the participants claiming success with the use of inquiry were at least moving in the right direction (i.e., less emphasis on traditional approaches and more emphasis on student-centered approaches).

The participants' views on teaching, particularly with respect to reform-based pedagogies, can be interpreted in at least two ways. Rust (1994) suggested that it is not uncommon for prospective science teachers to maintain their idealistic views of teaching. For example, the new teachers often approach their first-year classrooms clinging to two of the most commonly held beliefs about teaching, which are (a) that teaching is not really that difficult and (b) that learning to teach is something that is accomplished in college during preservice teacher education programs (Huling-Austin, 1992; Murphy & Moir, 1994). However, these views typically change as they transition to full-time professionals

This perspective suggests that the participants' focus on inquiry and other student-centered pedagogies will be overwhelmed by the perceived impediments. While some participants certainly did cite several reasons that inquiry did not work with them, most still appeared to believe that it was an ideal approach to teaching science. Loughran (1994) provided a different, slightly more optimistic interpretation:

> The effect of preservice education is not so much 'washed out' as repressed. Among the competing demands and complexities of teaching, the ideals once held in preservice education lose out in the real world of school. There is not so much an attitude shift (they still espouse to the notions of learning encountered in their preservice program), rather an acceptance of what is possible at this point in their careers. (p. 383)

Moreover, Richardson (1994) emphasizes that the careful selection of mentor teachers who model inquiry-based approaches appears critical. He mentions that alternative ways to provide models of inquiry-based environments may include video-based case studies of what this instruction might look like. Furthermore, research into constraints encountered by first year teachers that might deflect a preservice teachers appear necessary for preservice teachers to sustain the gains made in their understanding of how to craft inquiry-based instruction (Gilmer, Hanh, & Spaid, 2002; Lunsford, Melear, & Hickok, 2005; Schwartz, Lederman, & Crawford, 2000).

Beliefs and Practice

Some participants in this study demonstrated a mismatch between their beliefs and predicted actions with respect to employing inquiry-based teaching strategies. This mismatch was not surprising as these participants had never been exposed to using inquiry-based teaching strategies before. However, that mismatch could mean that their experience with these two inquiry-based courses helped them challenge their traditional beliefs about science teaching.

Research literature has widely shown that preservice teachers hold strong orientations and beliefs about teaching before they come to university. In order to enable prospective teachers to begin teaching model-centered scientific inquiry as opposed to using primarily didactic approaches, and in order to help them develop their skills and practice in this approach, these prior teaching orientations need to be addressed, reflected on, and challenged (Friedrichsen & Dana, 2003; Gess-Newsome, 1999; Hayes, 2002).

Furthermore, prospective elementary teachers need several aspects of pedagogical content knowledge and skills for enacting reform-based science teaching approaches such as model-centered inquiry (Grossman, 1991; Shulman, 1986). They need to understand scientific knowledge and practices including understanding the nature and purpose of inquiry and modeling (Schwarz, Meyer, & Sharma, 2007), which is important for understanding the nature and purpose of reform-oriented pedagogy. Prospective elementary teachers must also have skills for enacting reform-based approaches in their science teaching (Schwarz & Gwekwerere, 2006).

This study hoped to help its participants to develop and refine their pedagogical content knowledge and teaching orientations through exposing them to an inquiry-based biology course. This exposure served as a way to both help remind them of what they needed to include in planning their lessons and to scaffold their beginning skills for inquiry-based science teaching. Indeed, and as indicated in the data of this study, this exposure did work with these participants and was successful in expanding their potential teaching orientation from a didactic orientation to a reform-based one.

Implications

This study tried to fill some of the gaps in the literature of inquiry teaching by focusing on prospective teachers. It mentioned some of the inhibitors that could potentially avert preservice teachers from using inquiry strategies in their teaching. Furthermore, it suggested some strategies that might help prospective teachers to overcome their challenges. However, it is important to note that considerable changes in preservice elementary teachers' pedagogical skills and orientations are often extremely difficult to foster but success in these areas is critical for reform-oriented science teaching. Therefore, tools and methods that encourage such change deserve our attention in preservice science courses for potential elementary teachers, in teacher education programs, and in professional development projects. The changes represent a relatively high level of adoption by participants in this study of reform-based teaching strategies. These transformations, while substantial within these courses, would undoubtedly change over time with the constraints and realities of schools (Bright & Yore, 2002). Nonetheless, we believe that the success of our science content and methods courses offers some intriguing and possibly fruitful use of such tools for other science methods courses.

Therefore, this study suggests that meaningful support should be devoted to encourage the continuation and development of inquiry-based laboratories in the science foundation component of teacher education programs. All participants left the laboratory with a better understanding of the processes and purpose of experiments in science. Initially, most participants were at least mildly interested in the laboratory, as indicated in their interviews where they expressed their preference to learning science through inquiry.

Another important suggestion is that instruction in reform-based strategies may be beneficial to preservice elementary teachers. This could take the form of teaching the thinking strategies of scientists, including forming alternative explanations, active questioning, and constructing new explanations. Collaboration between postsecondary science teachers and science education specialists could promote understanding of meaningful learning in science courses.

At the end, it seems important to carry out a follow-up study on the elementary teachers who participated in this course to find out whether they employ the inquiry-based approach in their classroom. Another important future research idea is conducting a training session to promote and enhance the inquiry-based approach to science teaching among both preservice elementary teachers and inservice teachers.

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Appendix

Part I: Learning Beliefs.

1. Describe a classroom situation where you felt you were really learning a subject well.
2. What do you think are your responsibilities as a student?
3. If you are studying a certain topic, like photosynthesis, how do you know when you really know the information?
4. Do you ever try to use science concepts in everyday life?
5. What motivates you to learn in science classes?
6. What was the science topic you found most difficult to learn and why? What did you do to learn that topic?
7. In your opinion, what is a good science teacher like?

Part II: Scientific Epistemologies.

1. What sets science apart from other disciplines, like literature or art?
2. Where do you think scientists get their ideas for what they want to research?
3. In astronomy, some scientists think the universe is expanding, some think it is contracting and others believe it is in a static state. How can these different conclusions be possible if these scientists are all looking at the same types of data?
4. Once scientists come up with an explanation or a theory, does it ever change? Why?
5. Please define scientific inquiry, based on what you already know.

Part III. Reasoning about Experiments.

1. In your opinion, is the following an experiment? Why?

Astronomer making predictions and then observing medical student dissecting a cadaver neurologist testing the effects of the concentration of a drug biology student making predictions and then observing a mini ecosystem field biologist covering one section of the meadow to investigate effects of light

2. Imagine a scenario in which fertilizer from a soccer field runs off into a nearby lake.
   - Will the fertilizer influx change the ecosystem in your opinion? Why do you think so?
   - What kinds of tests could you do to see if fertilizer changes the ecosystem?
   - Describe any other experiments you would do or data you would collect to see if fertilizer affects the ecosystem.