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Educating Teachers for the Future: A roundtable discussion on biology lab curriculum for pre-service elementary and middle school teachers

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Introduction

The National Research Council has recognized that teachers who learn science through an investigative (inquiry) approach are more likely to use such a method in their own classroom (1996); therefore, by exposing the pre-service teachers to scientific inquiry in the laboratory classroom, we provide the potential that they ultimately will use inquiry in their future classrooms. The use of investigative teaching in classrooms is desirable because hands-on, investigative experiences help students master content better and improve their attitude about science. Furthermore, school children become more interested in science and confident in their science processes skills when their teachers can successfully use inquiry-based learning (IBL) to peak student curiosity (Dunn and DeBello 1999).

In 2004, the science departments at the University of Dayton received money from Project Sustain to develop science lab curriculum specifically for pre-service teachers. A pilot introductory biology lab section was designated as "education majors only" to focus on the science teaching needs of future elementary and middle school teachers. The new curriculum for this "education majors only" lab is based on The National and Ohio Academic Content Standards and is taught in an interactive, inquiry based, hands-on format. Providing the lab curriculum in this format exposes the pre-service teachers to state science competencies, inspires and excites the students, and encourages them to teach science similarly in their future classrooms.

This workshop was presented as a follow up to past ABLE mini-workshops (Lyke 1995; Martin 1996). During the workshop, participants discussed methods used in their biology labs to educate and excite future (pre-service) teachers. The discussion began with an outline of a pilot biology lab curriculum for pre-service teachers at the University of Dayton. The goals, objectives, and curriculum for the pre-service biology lab were shared. Furthermore, information about the national science content standards and inquiry-based teaching was provided along with a list of resources for those developing similar labs/courses. Participants of the workshop were asked to

exchange ideas, to support each other ventures, to provide additional resources, and to explore thoughts on our role in educating future teachers. The fruits of this discussion are provided below.

These are the goals, objectives, and activities for the pilot biology lab for pre-service teachers at the University of Dayton:

Goals of pre-service teacher biology lab:

- Ultimate goal: to produce science-literate citizens and better teachers of science.
- To develop the scientific process skills of the students.
- To enhance the science teaching competencies of the students
- To promote an increased familiarity with and deep understanding of the scientific concepts outlined in the state science standards

Teaching objectives:

- Provide investigative lab opportunities for students to develop their scientific process skills
- Provide numerous hands-on activities to enhance understanding of key biological concepts
- Foster scientific literacy through application of biological concepts and use of "real" data
- Enhance the development of inquiry-based teaching skills by modeling this type of teaching and exposing the students to inquiry-based activities
- Expose the students to the national and state academic content standards by having them identify the standards that match each lab topic
- Support the use of science in the students' future classrooms by helping them modify the lab activities into activities that they can use in their future classrooms.

Classroom Activities (in addition to investigative labs):

- *Service Learning Project:* In teams of 3-4, students design and lead an inquiry-based lab activity for the after school Honors program at ICS middle school. Students will submit a final paper which will include an introduction, a lesson plan, basic background information on concepts covered in the lab, indication of how the activity meets the National Science Education Standards for the grade chosen, indication of how it is inquiry-based, reference list, list of useful resources, and a personal reflection on teaching the lab in the after school program. The students will present their lesson plan and the success of their lab to the other pre-service teachers.

- *Weekly Post Lab Activity:* After each lab, the students will write out the academic content standards that were met. Also, the students will describe how to modify one part of the lab into an age appropriate activity for their future students.

- *Classroom "Pets":* Students will be expected to do research on a simple organism that could be kept in their future classroom. They will have to present (orally and in writing) a detailed description on how to care for the organism, basic information about the organism, and ways that the organism could be used for classroom investigations. Also, the students will order, take care of, and run an investigation with the selected organism. Examples organisms include: *Daphnia*, *Gammarus*, pillbugs, fish, protozoans, earthworms, snails, blackworms, etc.

Curricular Suggestions from Workshop Participants

- College science lectures and labs for pre-service teachers should be integrated
- Lecture should not be didactic – it should be interactive and inquiry-based using many active learning strategies
- Many pre-service teachers lack the skills and confidence to seek out and learn new information about science. These skills need to be taught in the college classroom.
- Pre-service teachers need information on how to find reliable resources on the internet
- Establish many activities that require the pre-service teachers to take initiative and responsibility for their own learning
- Challenge pre-service teachers to be more involved in obtaining supplies for science activities
    - May need to have them do such an activity in class/lab
- Course should model what they should be doing in their future classrooms
    - Lecture and lab together, inquiry-based teaching, active learning
- Start a college science club for teachers = pre-service teachers run club and put labs together
- Middle school teachers bring class to university
    - Faculty and senior education majors help
- Teachers should think ahead to trigger questions and support critical thinking during class
- Help pre-service teachers think outside of the box
- Focus on teaching pedagogical content knowledge (PCK):
    - Knowing the best ways to teach science content to a specific age group with specific background knowledge/skills
    - help students realize common misconceptions that their future students will have, test for presence of these misconceptions, design activities to overcome the misconceptions, and assess students to see if they have indeed overcome the misconceptions
- Cover topics that are identified by the praxis tests and content standards, but teach these concepts at a college level. If you must teach all of biology in one semester, focus only on the topics that will be relevant to them in their future classrooms and those that are needed to deeply understand what they will be teaching.
- Encourage deep learning rather than surface learning
- Use an STS (science, technology, and society) approach – issues based approach
- Model the 5E Instructional Model (engage, explore, explain, elaborate, evaluate) to encourage pre-service teachers to use this model in their future classrooms
- Have students identify how the lab relates to science as inquiry and how the concept has changed through time (history of science)

Classroom Curriculum Design Ideas from Workshop Participants

1) Dr. Ralph Preszler, New Mexico State University, Introduction to Natural Sciences (biology class for pre-service teachers)

The course goals and activities that follow were provided by and used with permission from Dr. Ralph Preszler.

Course Goals

This course is designed to provide elementary education majors with an introduction to, ranked by emphasis in the course, biology, chemistry, physics, and geology. The primary goal of this course is for you to achieve a self-sustaining level of scientific literacy. This means that by the time you have completed NSC 121 you should be able to read, critically evaluate, discuss, explain, and apply scientific discoveries as they are reported in the secondary literature. To attain such an advanced level of scientific literacy you will need to develop the following skills and understanding.

- A critical understanding of scientific process.
- The ability to write and talk about science with clarity and precision.
- The ability to make constructive contributions to group activities.
- An understanding of general principles of the natural sciences.

Student-led laboratory activities

Each student receives the opportunity to work with a group of 3 students to organize and lead one laboratory session. For their activity, the student group acts as the teachers. The activities can be derived from outside sources or they may be original activities. Each group will write 3 related documents: a proposal, a student's guide, and a teacher's guide. The ideal activities have the following characteristics:

- clearly related to course goals and objectives;
- engaging and effective teaching methods;
- hands-on activities;
- inquiry-based methods;
- interdisciplinary approach.

2) Dr. Marshall Darley, University of Georgia, Department of Plant Biology

Dr. Marshall Darley is currently a member of a state-wide team that has just started to develop a life science course that in-service elementary teachers could add as an endorsement to their certificate. Other teams are developing courses in The Nature of Science, Physical Science and Earth and Space Science. Eventually these four, 3 unit courses will probably be part of the pre-service curriculum.

The following material includes direct excerpts from a draft of a set of guidelines for developing the life science course and an incomplete draft of a possible first lesson for the course (both provided by and used with permission from Dr. Marshall Darley):

Guidelines for developing in-service teacher life science course

The course developers believe the following pedagogical principles should be adhered to by those teaching this course as they adapt it to their own campuses.

1. This is not a lecture-only course. Course should include interactive activities and cooperative learning.
2. This course should model activities that teachers will be using in their own classrooms. In other words, this class should emphasize activities that: a) are inquiry-based; b) are hands-on; c) involve cooperative-learning; d) are relevant to the lives of K-5 students; e) include field experience as much as possible; f) are useful in their classrooms; g) anticipate questions K-5 students are likely to ask.
3. The physical setup of the classroom must allow continuous interaction between students. Ideally, groups of 4-6 students will each be seated around a round table.
4. This course should not try to teach, nor even attempt to survey, all of life science. To do so, would only confirm elementary teacher's preconceptions that science is too complex, too hard, and too vast to ever comprehend.
5. This course should focus on the major concepts related to the Georgia Performance Standards and should provide students with enough background information to feel comfortable with the concept. In other words, emphasize the Big Picture, not the vocabulary, but provide students with greater in depth knowledge and experience than they will actually use in their classrooms.
6. Instructors, probably Arts and Sciences faculty, must learn from the experience of in-service teachers taking the courses. For future reference with pre-service teachers, instructors should record questions K-5 students are likely to ask and . . . .
7. This course should be coordinated with the other K-5 Science Endorsement courses taught on your campus.

Possible first lesson for in-service teacher life science course

Is It Alive and How Do We Know?

This lesson, probably the first lesson in the course, focuses on 5 characteristics of life, the central theme of the course. It is important that the first lesson sets the tone for the course, modeling many of the pedagogical principles that will be used throughout the semester. As written it is heavily plant oriented, but it easier to bring plants into the classroom and experiment with them than it is with animals. In addition, students are more familiar with animals and can use more prior knowledge.

Overall outcomes:

Students experience and learn about characteristics of life in greater depth than they need for their classrooms, but they should be more comfortable with it because of the greater depth.

Activity:

Given the materials on the table, appropriate questioning from the instructor and some curiosity and speculation based on prior knowledge, students should be able to come up with 5 characteristics of life (in bold below) and link them in a concept map. Materials placed at each lab bench are dependent on the grade level that the in-service teachers are teaching. After the activity,

students write up what they've learned in this activity, how they can use it in a K-5 classroom, and questions that their students are likely to ask during the activity. If you are interested in this lesson plan, please contact Dr. Marshall Darley for appropriate instructor questions, materials to be placed at lab benches, and learner outcomes for each characteristic of life.

Resources for Developing Biology Lab Curriculum for Pre-Service Teachers

- Association for Supervision and Curriculum Development (http://ascd.org)
- National Science Education Standards (http://www.nap.edu/readingroom/books/nses/html/)
- Ohio Science Education Standards (http://www.ode.state.oh.us/academic_content_standards/http://www.ohiorc.org)
- North Dakota Curriculum Project – guidelines for educational leaders working with teachers to develop standards based units (http://www.ndsu.nodak.edu/ndci/NDTaskBank/glatthorn/)
- National Science Teachers Association (www.nsta.org/standards)
- Eisenhower National Clearinghouse (www.enc.org)
- Association for the Education of Teachers of Science (http://aets.chem.pitt.edu/)
- Lawrence Hall of Science Professional Development Programs and instructional materials (www.lhs.berkeley.edu/profdev/programs.html)
- Electronic Collaborative for Excellence in the Preparation of Teachers (www.ecept.net)

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