A STEM Interdisciplinary Research Experience Program for Pre-Service Science Teaching and Science/Technology Majors: Introduction and Experiences from the Initial Scientific Inquiry Course

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ABSTRACT

At Weber State University, several faculty are developing a comprehensive and unique STEM-based interdisciplinary research program using a multi-pronged research experience encompassing curricular and co-curricular components. The goal of this program is to develop an effective pedagogic approach that provides faculty with a formal structure to teach/mentor undergraduates about research in the STEM fields. Part 1 of the 3-part model is the implementation of a scientific inquiry course focused on studying the nature of science and exposing students to different scientific approaches. The experimental course was first taught this spring semester. Students would then participate in a faculty-membered summer research experience, sharing their experiences in weekly discussions. Part 2 is included student reflection on their experiences and research dissemination as part of a thesis course. Assessment of the program will be based on evaluation of students’ answers to written questionnaires and faculty feedback.

BACKGROUND / JUSTIFICATION

Need for Comprehensive Undergraduate Research Experience Program

- As part of science education reform, key parts of scientific literacy should describe (1) the nature of science, (2) its process, and (3) its philosophical foundation (AAAS, 1990). National Research Council, (1996). National Science Teachers Association, 2000).
- Research has documented that most undergraduate students misunderstand the four key questions of science that are at the heart of what scientific knowledge is, how it is produced, and what it can do for society, putting students at academic and vocational disadvantages, especially pre-service science teachers (Lederman, 2001).
- Research also suggests that merely immersing students in an undergraduate research project does not result in their learning what science is and how it proceeds (Ryder, 1999).
- Solution: provide students with explicit and in-depth curriculum about scientific inquiry, with emphasis on interdisciplinary research in the STEM fields (basis of NSF COE/STS proposal).

NSF Proposal: STEM Interdisciplinary Research Experience Program (Figure 1)

- Main Goal: Provide pre-service science teacher and science technology majors with a comprehensive and unique interdisciplinary research experience using a multi-faceted pedagogical model encompassing curriculum and co-curricular components spanning 3 semesters.
- Program model framework (Figure 1):
  1. Three Phases
     a. The Nature of Scientific Inquiry course
     b. Conventions of program
     c. Faculty-mentored summer research experience
     d. Students work with faculty mentors on one of four research projects with strong interdisciplinary components
     e. Students will meet weekly for discussion & presentations of work
     f. Student thesis completion & research dissemination (Fall semester)
  2. Three-course: each student completes research, reflects on experiences, and writes a thesis.
  3. Research dissemination: department seminar, WSU undergraduate research symposium, regional/national conferences
- Program Assessment (Figure 1):
  a. Evaluate student understanding of attitudes towards science throughout the program (before, during, after completion) using framework of conceptual change theory applied to similar studies (Southernland, & Soellner, 2000; Johnson, & Soellner, 2000; Abd-Ellah & Ahmed, 2006). Methodology
  b. Student interviews (pre- & post-program experience)
  c. Observation of student research, document different cultures of research observed with faculty projects and relate to specific STEM content experiences (Spradley, 1980)
- Faculty mentor questionnaires & follow-up interviews – feedback on maturation of student researchers, realization of their expectations, and suggestions for program improvement.
- Broad dissemination of Program Results/Experiences

Figure 1. Model for the WSU STEM Interdisciplinary Research Experience Program

COURSE DEVELOPMENT

Curriculum (Figure 2)

- Provides students with conceptual anchor for developing an understanding of their research endeavors and gaining experience with an array of scientific methodologies.
- Prepracticum: completion of general math requirements
- Pilot Course
  a. Spring 2010 semester (4 seniors / 1 postgraduate)
  b. Pilot Course Objectives:
     i. Understand philosophical assumptions of science and scientific work
     ii. Distill science from pseudoscience and other ways of knowing (e.g., religion, philosophy, art); identify the attributes of scientific investigations
     iii. Understand the nature of scientific discourse (e.g., peer-review publications)
  c. Pilot Course Syllabus (Figure 2)
  d. Several key articles – stimulate reflection/discussion
  e. Provide broad perspective of science and why valued
- Pedagogy
  a. Seminar format
  b. Passive and active learning techniques
  - Reading pre-selected peer reviewed articles / writing “response” papers (guided critical critiques on questions posed by instructors)
  - Faculty-led discussions – individually selected research articles
  - End-of-course student reflections on how their views of science have changed over the semester (discussion & summary paper)
- Science Education: Pedagogical Content Knowledge and Development

Figure 2. Pilot course syllabus

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References


Pilot Course Evaluation

Student Assessments

- Demonstrated high levels of critical thinking positive about the course, stating that they expanded their view of science and appreciated the different perspectives brought from other disciplines.
- Students comment about the course:
  a. “After this semester I believe I am better able to see where I stand both as a participant in and witness of the history of the dynamical view of the scientific world”
  b. “I wasn’t really sure what I was expected to do. I don’t feel like I did very much science at all, but with each article it seemed we were challenged to do the same. I really have enjoyed being a part of this course.”
  c. “Being in our class and in the group discussing the things we read helped me to see problems I didn’t otherwise have missed and explore some of the science that I normally might just gloss over.”
  d. “I really liked the discussions and topics that we could come up with. However, I think some of my favorite topics were the type that people could discuss from opposite sides.”
  e. “I really don’t know how to teach the class this way to expect from others.”

- Instructors’ Reflections

- Both instructors very pleased with student reactions to the course and perceived knowledge / understanding they gained about science.
- Ideas instructors comment about the course:
  a. “An intriguing and motivating way to teach the students much more in depth about understanding the broader scope of science outside their discipline!”
  b. “It is always interesting to see science students write with a definition of science; they make it so that we don’t just gloss over, but realize there’s a lot more to it when students engage with these broader questions.”
  c. Important feature of this seminar – having students address philosophical questions based on their own science experiences, but then they are competing views and some holes in their thinking to work through.
  d. “I was feeling to see students in the recent periodic section of the library, and this is to be able to take them into a discussion through the semester about how scientists communicate and what works for you – a process that I never had as a student myself!”

Future Course Modifications

- Second course: for Spring 2011 semester.
- Provide students opportunities to learn more familiar with different scientific methodologies outside current experiences and be able to identify strengths of specific methods for use in different scientific research.
- Case studies presented by guest faculty from different disciplines (e.g., Astronomy and the interaction between observation, computation, and theory; Geological storytelling).
- Examine students to different spatial & temporal scales of research (e.g., subatomic to astronomical 10^9 to 10^27)

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