Using PBL to Integrate Content and Pedagogy in an Interdisciplinary "Science Semester" for Future Elementary Teachers

Panelists:
Deborah Allen, Richard Donham, Steve Fifield, Danielle Ford, and George Watson
University of Delaware
Newark, DE 19716, USA

The Science Semester is a curriculum for elementary education majors at the University of Delaware that uses interdisciplinary problem-based learning (PBL) investigations to integrate students' learning about earth science, physics, biology and elementary science education methods. The goal of the Science Semester is to foster future teachers' understandings of science, teaching, and learning to support their use of inquiry-based instructional approaches in their own classrooms. In this panel discussion we will describe the design, implementation and evaluation of the Science Semester, and invite discussion about the prospects and problems associated with interdisciplinary teaching using PBL-based approaches.

The Structure of the Science Semester: Richard S. Donham, Ph.D., Mathematics & Science Education Resource Center

The Science Semester integrates three science courses and an elementary education methods course into a unified 15 credit-hour experience. The Science Semester is built around a series of four PBL investigations. Students collaborate in these investigations in long-term groups of 4-5 members. Each week is structured by a variety of class meetings. Students attend five 2-hour class meetings that involve a diverse array of learning activities, including small-group and whole-class discussions, concept application/problem-solving, concept mapping, informal writing, student presentations, and whole class lectures and discussions. Each science course includes a weekly 2-hour laboratory linked to the topics of the current PBL investigation. The methods course meets for 90 minutes two times each week.

Instructors from each discipline collaborate in the development of curriculum materials, instructional approaches, course policies, and classroom instruction. Each instructor takes the lead for one of the investigations, but all the instructors remain engaged in day-to-day instruction throughout the semester. On a typical day there are 3 or 4 instructors in the classroom leading activities, presenting material, working individually with students, or simply observing. This provides numerous ad hoc opportunities to comment on issues that arise and to make interdisciplinary connections that enrich the classroom experience for students and faculty alike. The instructors interact and adjust instructional plans day-to-day, and meet formally at the end of each week to review the week's activities and to fine-tune plans for the coming week.

PBL Investigations: Deborah E. Allen, Ph.D., Department of Biological Sciences

Each PBL investigations integrates perspectives from all disciplines, but each brings a different disciplinary perspective to the surface as the primary focus (Table 1). For example, in the earth science investigation, students study the horseshoe crab, which lives in the nearby Delaware Bay. Students explore how coastal geology, beaches, ocean sediments, water chemistry, tides, phases of the moon, and climate change are related to the life cycle and human uses of the horseshoe crab and how the crab interacts with other organisms, such as migrating shorebirds. Each PBL investigation is a several week-long, staged set of learning experiences, including both individual and group assignments. There are multiple opportunities for instructor feedback prior to the end-of-investigation products and the hourly examinations. These investigations encourage students to integrate concepts and perspectives across the disciplines, and challenge them to reconsider what they believe about teaching and learning in science.

Table 1. Interdisciplinary PBL investigations in the Science Semester.

Investigation	**Topics**
Physical science: "What is Energy?"	Sources of energy; Electricity; Environmental consequences of energy use; Energy in chemical reactions; Energy transformations
Biology: "Kids, Chemicals, and Cancer"	Environmental health; Cells & DNA; Causes, effects & treatment of cancer; Cancer clusters and epidemiology
Elementary science education methods: "Did my Students Learn what they were Supposed to Learn?"	Goals for science teaching; Assessment at national, state, & classroom levels; Selecting & customizing science curricula; Aligning curriculum, instruction, assessment, & standards
Earth science: "*Limulus polyphemus*! Science Semester Investigates Delaware's State Marine Animal"	Horseshoe crab lifecycle & habitat; Seasons; Tides; Coastal geology; Water chemistry; Technology & science

Teaching Education in the Science Semester: Benefits and Challenges: Danielle J. Ford, Ph.D., School of Education

As I approached the design of the education course, I had several issues that I needed to address. First, I did not want students to lose sight of the education course amidst the three science courses and the majority of time dedicated to science issues. While all instructors were careful to integrate educational issues and content throughout their curricula, I was concerned that without explicit discussion of education, the students would not be able to recognize educational strategies within these integrations. Second, while I respected and admired all my colleagues, I had never actually seen them teach. I was not sure if our pedagogical perspectives would mesh, and I was worried about sending mixed messages to our students if we modeled conflicting styles of teaching. Third, I was concerned that, as the only instructor from the School of Education, I would become the "voice" of education, and that students would fail to

recognize sound educational models or information from the science professors, or expect me to have definitive answers on education issues.

In contrast, I believed the overall design of the science semester would benefit students immensely. The immediacy of the science content meant that I would have rich examples of science learning and teaching to draw on when my class discussed educational theories and practices. In our traditional courses, students do not have common science experiences, and their science courses are a distant memory. With the science semester, I could take science experiences from the very same day and point out educational issues.

My first decision was to schedule my course as a stand-alone course within the semester. I felt there were obligations I had to the content of my course that I did not want students to lose sight of in the integrated sessions. Students were able to link the more abstract ideas about science curriculum and instruction from my class to their overall experiences in the science semester. Final evaluations for the course indicated that students wanted even more time in methods, which I think is a good sign that they found it beneficial as a stand-alone course.

Using examples of science content and instruction from the science semester to illustrate educational principles worked very well. However, to be able to draw on the students' experiences in all aspects of the science semester meant that I needed to attend nearly all large class and problem-based classes. This meant sacrificing a great deal of my time. In the future, I may look for other ways to draw on students' experiences without the cost of attending every session.

My concerns about mixed pedagogical messages from a variety of instructors were unfounded. What actually happened was an excellent model of the diverse ways in which instructors can structure problem-based learning and still be within the realm of acceptable pedagogical methods. I took advantage of the differences among us to point out to students the variety of ways of teaching, how different methods fit with different content areas, personalities, or places within the curriculum.

Project Evaluation and Research: Steve Fifield, Ph.D., Education Research and Development Center

The Science Semester is a rich opportunity to study the impact of interdisciplinary, PBL-based approaches on students' (and professors') understandings, beliefs and attitudes. We use the development of pedagogical content knowledge as a framework within which to conceive our teaching, and as an analytic lens through which to study students' developing understandings of science, science education, and themselves as learners and future teachers (Gess-Newsome & Lederman, 1999, Loughran et. al, 2004). Table 2 summarizes our major research questions and methods.

We are in the early phases of data analysis, and some interesting insights are emerging, particularly concerning how students perceive, adopt, and resist new ways of teaching and learning. Interviews with students reveal how their experiences with new ways of teaching and learning challenge them to consider new ways of understanding what it means to 'know' about a subject matter, and to make sense of unfamiliar roles and relationships for students and teachers. The ways students make sense of the Science Semester are complex, shaped by their individual life histories, and evolve over

the course of the semester. We can offer some preliminary conclusions about what students make of their experiences in the Science Semester. Some students see their experiences in the Science Semester as enriching and liberating. They perceive opportunities to exercise more independence as learners, to extend the ways they learn, and to reach deeper levels of understanding. Others wonder when their professors will finally decide to teach them something. They interpret their experiences in terms of familiar teacher and student roles, and through their self-understandings (i.e., identities) as 'successful' students in more traditional educational contexts. Some complain that they "teach themselves" most of what they learn in the Science Semester. Especially early in the semester, these students perceive not a rich learning environment, but a lack of substantive content and other opportunities to learn. We have encouraging evidence, however, that as the semester progresses, these initial perceptions are challenged and begin to change, as students come to recognize more diverse possibilities in what it means to teach and learn science.

Table 2. Research questions and methods in the Science Semester.

Research Questions	Methods
1. What is the impact of the Science Semester on students' science content and pedagogical understandings?	pre- and post-instruction content assessments; course assignments; reflective writing; small-group interviews
2. What is the impact of the Science Semester on students' beliefs about their abilities as future science teachers?	Pre- and post-instruction Science Teaching Efficacy Belief Instrument – B (Enochs and Riggs, 1990); reflective writing; small-group interviews
3. How do students adopt and/or resist interdisciplinary, PBL-based approaches to teaching and learning? In what ways do students' reactions entail efforts to retain and/or reshape their understandings of themselves (their self-identities)?	reflective writing; small-group interviews
4. How do professors make sense of new roles for themselves, students, science subject matter, and science pedagogies in the Science Semester?	observations of project meetings; classroom observations; course materials; individual & group interviews
5. How does participation in the Science Semester influence students' beliefs and practices as student teachers?	classroom observations of student teachers; interviews; reflective writing

References

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