OUR PHYSTEC PROJECT: COLLABORATING WITH A RESIDENT TEACHER TO IMPROVE AN ELEMENTARY SCIENCE FIELD EXPERIENCE

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Abstract

The goal of Towson University's 2004-2005 Physics Teacher Education Coalition (PhysTEC) project was to improve a field experience course for elementary education majors ("Teaching Science in the Elementary School"). The improvements were focused on (1) making the different sections of the course more uniformly aligned with the course goals, and (2) increasing the amount and quality of inquiry in the undergraduate interns' science lessons. The project team, including a full-time teacher-in-residence, engaged in a number of activities to improve the course: the re-establishment of clear course goals, the teaching of certain course sections by the project faculty, mentor teacher workshops, and a course instructor meeting. Data collected from observations of the interns' lessons and end-of-semester surveys revealed that the project was generally successful. In Spring 2005, compared to the previous semester, the interns spent more time teaching (and less time observing), the interns more frequently taught modified science lessons (rather than teaching the official lessons as-is), and the interns' science lessons had an increased focus on scientific investigations and the communication of ideas (rather than scientific demonstrations, lectures, and the verification of ideas).

Background and Context

The PhysTEC Project

The Physics Teacher Education Coalition (PhysTEC) project is a nationwide project sponsored by the American Physical Society, the American Institute of Physics, and the American Association of Physics Teachers that has the goal of improving science preparation for K-12 teachers. At each of the PhysTEC sites around the United States, science faculty, education faculty, and a full-time teacher-in-residence (TIR) work together to implement local teaching reforms that emphasize interactive engagement and a student-centered approach to learning science. At Towson, the PhysTEC project team consists of Dr. Cody Sandifer and Dr. Laura Lising, two full-time science education faculty in the Department of Physics, Astronomy, and

Geosciences, and a full-time elementary TIR. The 2004-2005 TIR was Ms. Lisa Tirocchi, a Baltimore County elementary teacher.

Towson University

Towson University, a member of the University System of Maryland, is the second largest university in the state. Towson graduates more preservice elementary teachers than any other Maryland school: approximately 200 per year. As a result, the education faculty at Towson -- the majority of which reside in content departments rather than education departments -- focus primarily on elementary-level science teaching.

Science in Towson's Elementary Education Program

Before being officially admitted into the elementary education program, pre-elementary undergraduates at Towson are required to take an introductory physical science course, Physical Science I (PHSC 101). In this course, students learn basic concepts of physical science through guided inquiry.

Immediately before the student teaching semesters, elementary education majors at Towson are required to complete a "math and science" semester, which is a semester solely dedicated to content and methods related to math/science instruction. The Department of Physics, Astronomy, and Geosciences offers two courses during this math/science semester: Earth-Space Science (PHSC 303), which is an inquiry-focused content/methods course, and Teaching Science in the Elementary School (SCIE 376), which is the elementary science field experience. Student cohorts are enrolled in these two courses concurrently.

SCIE 376: Teaching Science in the Elementary School

The field experience course (SCIE 376), which is the central focus of our PhysTEC project, is perhaps the most important science course in Towson's elementary education program.

Recent surveys have shown that approximately 25% of Towson's elementary student teachers do not teach any science during their student teaching semesters, and that only 35-40% of Towson's elementary student teachers teach science frequently. This means that SCIE 376 may be the last real opportunity for many elementary education majors to improve their science teaching skills and their understanding of educational theory in an authentic classroom setting.

In terms of general course structure, there are 6-7 sections of SCIE 376 offered each semester; each section meets once per week for four hours at a nearby elementary school. The course is structured to help preservice elementary teachers (whom we refer to as "interns") learn and practice methods of science teaching and engage in self-reflection and improvement. Course activities include an hour of teaching time with the elementary children, coaching from the classroom mentor teacher, lesson planning under the supervision of the course instructor, and methods/content discussions and activities.

The Need for Course Improvement

Towson's elementary education program is meant to provide a coherent experience for the many preservice teachers who enroll in our science courses every year. While this coherence had been partly achieved by the focus on inquiry in both PHSC 101 and PHSC 303, it was not clear at the project's start whether SCIE 376 was also in alignment with the program's overarching focus on inquiry-based science teaching. A critical issue was that, at the beginning of the project, it was unclear as to whether the interns' science lessons in the elementary schools were inquiry-based, or were instead more traditional types of science lessons.

Beyond issues of programmatic coherence, there was also the issue that instructor and student complaints about SCIE 376 had been steadily increasing in the semesters prior to the grant. Follow-up discussions with instructors and interns revealed that the different sections of

the course were no longer uniform (in terms the number of science lessons taught per intern, the number of interns per classroom, and feedback on the interns' science teaching), and also that there was a general lack of communication about the goals, structure, and logistics of the course. For example, in some sections of the course, there were 4-6 preservice interns per elementary classroom, with each intern in charge of teaching science to her own small group of elementary students; the teaching structure in these sections guaranteed that each intern taught every week, which was the desired outcome. In other sections, interns from a classroom group would take turns teaching science to the entire class, which meant that these interns would teach only 3 or 4 times per semester.

Faced with an array of different problems, the primary focus of Towson's PhysTEC project became clear: to improve the elementary field experience course. In this case, "course improvement" was to be measured by the degree to which the different sections of the course became more uniformly aligned with course goals, and also by the extent to which the undergraduate interns increased the amount and quality of inquiry in their elementary science lessons at the field experience school sites.

The Role of the Teacher-in-Residence

Teacher-in-residence (TIR) Lisa Tirocchi was responsible for key project activities at Towson: she made weekly visits to field experience sites, served as liaison for the sites and the PhysTEC team, and also served as a resource for the SCIE 376 course instructors, interns, and mentors teachers. In addition, Ms. Tirocchi participated in many other project activities, all of which were collaborative efforts between Ms. Tirocchi and the science education faculty members; these activities included weekly project meetings, planning and implementing instructor and mentor teacher workshops, developing and administering surveys and teaching

observation protocols, data collation and analysis, recruiting and retaining field experience sites, and planning and organizing a curriculum resource folder for the field experience course instructors. In each area of grant activity, Ms. Tirocchi was able to draw on her general teaching expertise, her practical classroom experience, her understanding of inquiry-based science instruction, and her knowledge of the Baltimore County school system to guide and inform the project's efforts.

Project Activity: Course Improvement

After becoming aware of the problems associated with SCIE 376, the project team engaged in a number of activities to improve the many different sections of the course, including the re-establishment of clear course goals (Summer 2004), the teaching of certain course sections by the project faculty (Fall 2004, Spring 2005), mentor teacher workshops (August 2004, December 2004), and a course instructor meeting (December 2004). The project team chose to spend a significant amount of effort on workshops and meetings due to the fact that Towson University offers as many as 7 sections of SCIE 376 offered each semester – many of which are taught by part-time instructors; consequently, any reforms related to SCIE 376 involve strong coordination between the multiple course sections, and new training for part-time instructors and mentor teachers.

Our Definition of Inquiry

The focus of the science component of Towson's elementary education program is the notion of *inquiry* -- the idea that students should learn science by engaging in the process of science themselves. To further clarify what is meant by inquiry-based science instruction, our PhysTEC team adopted the approach taken by the National Science Education Standards (1996), which defines inquiry learning and teaching through a series of "emphasis" summaries that contrast

inquiry-based teaching with more traditional teaching methods. Samples from the NSES Science Teaching and Science Content emphasis summaries (see pp. 52 and 113) are shown in Table 1.

Table 1

Emphases in Inquiry-Based Science Instruction, as Defined by the NSES

Less Emphasis Should be Placed on:	More Emphasis Should be Placed on:
Verifying science content	Investigating and analyze science content
Getting an answer	Using evidence to develop or revise an explanation
Providing answers to questions	Communicating science explanations
Rigidly following curriculum	Selecting and adapting curriculum
Focusing on acquisition of information	Focusing on understanding and use of scientific ideas and inquiry processes
Lecture, text, and demonstration	Guiding students in active and extensive scientific inquiry
Asking for recitation of acquired knowledge	Providing opportunities for discussion and debate

Establishing SCIE 376 Course Goals

Having clarified our definition of inquiry, our next task was to create an updated list of course goals and share these goals with the SCIE 376 mentor teachers, university instructors, and interns:

- Interns will understand and apply inquiry-focused theories of science teaching and learning
- Interns will become exposed to local, state, and national content and teaching standards
- Interns will observe their mentor teacher infrequently (0-2 times)
- Interns will teach science as often as possible (9+ times for each intern)

- The interns' science units/lessons will generally consist of modified versions of the official school units/lessons, with all modifications being driven by the course's focus on inquiry
- Interns will receive in-depth feedback on their teaching from their mentor teachers and university instructors
- Interns will engage in self-reflection on their teaching and make steps toward improvement

These goals were used to guide every aspect of the project's efforts to improve SCIE 376.

Mentor Teacher Workshops

The goals of the mentor teacher workshops were: to help the mentors develop a better understanding of inquiry and the scientific process; to clarify for the mentors the roles and responsibilities of the university instructors and mentor teachers; and to hold open discussions about course goals, course logistics, providing post-teaching feedback, and other issues of concern. An important point is that many of the workshop topics were introduced in direct response to questions, concerns, and ideas that had been shared by the mentor teachers. Sixteen mentor teachers attended the summer workshop, and five teachers attended the winter workshop.

Specifically, the half-day mentor teacher workshops included the following content/activities:

- An overview of the elementary education program at Towson
- The goals and structure of the course
- A sample of a semester-long course timeline
- A description of the roles/expectations of the university instructors and mentor teachers

- A demonstration of a methods activity, in which mentor teachers participated in the analysis and modification of different science lessons
- Open discussions about the different aspects of the course

Workshop comments and a comparison of pre/post workshop surveys indicated that the workshops were successful at communicating the course goals, answering the mentor teachers' questions, and establishing contacts between Towson University and the local school systems.

Instructor Meeting

In December, just before the spring semester, the project team held a meeting for course instructors. The goals of the meeting were: to help the instructors develop a better understanding of inquiry and the scientific process; to increase communication between the PhysTEC team and the instructors; to establish a team atmosphere for course improvement; to solicit more input about course needs; and to hold open discussions about course goals, course logistics, and other issues of concern. The meeting was attended by one full-time instructor and three part-time instructors.

Specifically, the two-hour meeting included the following content/activities:

- Our reasons for updating the course goals, including the emphasis on inquiry in the National Science Education Standards (1996) and the lack of inquiry observed in the interns' science lessons in Fall 2004
- An overview of the course goals, with particular emphasis on the newly established inquiry goals, and the goal of helping the interns modify curriculum to make it more inquiry-based
- A discussion of the "changing emphasis" summaries from the National Science Education Standards (1996, pp. 52 and 113), which outline traditional and reform

approaches to science teaching and science content

- Examples of science lessons that have been modified to be more inquiry-focused
- Open discussions about the different aspects of the course

Unfortunately, at the time of the meeting, we could not supply the instructors with supporting resource materials, as they had not yet been developed. We also did not plan any follow-up meetings or discussions during the spring semester, other than informal contacts with the project team. We went into the meeting assuming that any outcomes would be severely limited by these shortcomings.

Accomplishments and Continuing Challenges

Course Activity

A multiple choice survey was administered to all SCIE 376 interns at the end of the Fall 2004 and Spring 2005 semesters to ascertain the type of activity occurring in the different sections of the course, as well as to determine if there had been any course improvements from Fall to Spring. The PhysTEC team had not attempted to make any curricular changes to SCIE 376 in Fall 2004 (except in Dr. Lising's section), and so the Fall 2004 results represent the baseline data for the course before any significant PhysTEC-related course improvements were instituted. The results of the survey are presented in Table 2.

Table 2

SCIE 376 course activity: Fall 2004 and Spring 2005

	Fall 2004 (89 interns)	Spring 2005 (108 interns)
Interns who observed their mentor teacher teaching 4 or more times	19%	18%
Interns who taught less than 4 times	28%	11%
Interns who indicated that their lessons were mostly official school activities implemented as written	20%	10%

The percentage of interns who taught less than 4 times in Spring 2005 (11%) is significantly less than the percentage of interns who taught less than 4 times in Fall 2004 (28%), $\chi^2(1) = 9.2$, $p < 0.01$. The percentage of interns who implemented unmodified activities in Spring 2005 (10%) is significantly less than the percentage of interns who implemented unmodified activities in Fall 2004 (20%), $\chi^2(1) = 3.9$, $p < 0.05$. Therefore, our project's efforts appear to have had a significant positive impact in Spring 2005: the interns taught more frequently than before, and the interns more frequently modified the official science lessons rather than teaching them as written.

Science Teaching by the Interns at the Field Experience Sites

To assess the degree to which the interns' science lessons were inquiry-focused, our TIR (Ms. Tirocchi) conducted approximately two observations per course section. For each observation, Ms. Tirocchi would choose an intern at random and then observe that intern's entire science lesson, during which time she would make notes about the intern's lesson and the elementary students' responses. A day or two within observing each lesson, Ms. Tirocchi coded her observations with a Standards-based observation protocol that had been developed by the

project team. This method of observation and data coding was used to collect baseline data during Fall 2004, and to collect follow-up data during Spring 2005, the semester in which the course reforms were introduced. Because the interns are novices at science teaching, the observations were coded for intent toward inquiry as well as for success at implementation.

In Fall 2004, observations of the interns' science lessons revealed that, in most cases, the lessons tended to be unmodified city/county activities that focused on verifying science content and obtaining answers through the use of text, demonstrations, or lecture. Very little about these lessons approached evidence-based inquiry into scientific ideas and scientific phenomena. In contrast, the Spring 2005 teaching focused much more frequently on the investigation and analysis of science content, public communication of science ideas, scientific discussion and debate, the use of evidence, and the selection and modification of science activities. Table 3 (next page) illustrates sample differences in the interns' intended science lessons between the two semesters.

Setting a minimum acceptable threshold of "mixed" (a mixture of traditional and inquiry-oriented methods) for each lesson characteristic, and omitting any NA data values, we see that the Spring 2005 lessons were more inquiry-oriented than the Fall 2004 lessons. For example, 10 out of 14 lessons in Spring 2005 focused on investigation and analysis (as opposed to verification and demonstration), in contrast to 2 out of 11 lessons in Fall 2004, $\chi^2(1) = 7.0$, $p < 0.01$. Similarly, 10 out of 13 lessons in Spring 2005 (one N/A lesson omitted) focused on communicating science explanations (as opposed to providing an answer), in contrast to 3 out of 11 lessons in Fall 2004, $\chi^2(1) = 8.3$, $p < 0.01$.

Table 3

Distribution of the SCIE 376 Interns' Intended Science Lessons, Categorized by their Focus (Traditional, Inquiry, Mixed) on each NSES Lesson Characteristic: Fall 2004 and Spring 2005

			Lesson Focus							
			Fall 2004				Spring 2005			
Lesson Characteristic: Traditional	Vs.	Inquiry	NA	Trad	Mix	Inq	NA	Trad	Mix	Inq
Verifying science content	Vs.	Investigating and analyze science content	0	9	0	2	0	4	5	5
Getting an answer	Vs.	Using evidence to develop or revise an explanation	0	8	1	2	0	5	0	9
Providing answers to questions	Vs.	Communicating science explanations	0	8	1	2	1	3	5	5
Rigidly following curriculum	Vs.	Selecting and adapting curriculum	0	5	4	2	0	5	5	4
Focusing on acquisition of information	Vs.	Focusing on understanding and use of scientific ideas and inquiry processes	0	7	2	2	0	5	4	5
Lecture, text, and demonstration	Vs.	Guiding students in active and extensive scientific inquiry	0	8	1	2	0	5	6	3
Asking for recitation of acquired knowledge	Vs.	Providing opportunities for discussion and debate	0	9	0	2	0	5	6	3

Note. Eleven lessons were observed in Fall 2004 and 14 lessons were observed in Spring 2005. Originally, each characteristic of inquiry was rated on a 0-5 scale for each lesson. Ratings at the 0 or 1 level were recategorized as "traditional", denoting that the particular lesson characteristic was aligned with traditional teaching methods. Ratings at the 2 or 3 level were recategorized as "mixed", denoting that the particular lesson characteristic contained aspects of both traditional and inquiry teaching methods. Ratings at the 4 or 5 level were recategorized as "inquiry", denoting that the particular lesson characteristic was aligned with inquiry teaching methods. NA denotes that the characteristic did not apply in the lesson.

Continuing Challenges

Towson's PhysTEC project faces a number of ongoing issues and challenges that may make it difficult to achieve our goal of making widespread sustainable changes to the SCIE 376 course.

Developing a Shared Understanding of Inquiry

Given the limited amount of time that the project faculty are able to dedicate to close interactions with mentor teachers and part-time faculty (in the form of workshops, etc.), and also given the turnover associated with the mentor teacher and part-time faculty positions, it isn't clear to what extent the project will be able to help each and every mentor teacher and Towson instructor develop a shared understanding of standards-driven, inquiry-based science teaching. The lack of a shared understanding and valuing of inquiry-based instruction has far-reaching effects, such as in those instances when mentor teachers give advice to interns that directly conflicts with the advice from the university instructors, or when university instructors allow interns to implement the lessons they are given, as-is, without requiring the interns to modify the lessons to be more inquiry-based.

Coordination between the Field Experience and other Courses

Towson University uses a cohort system in its elementary education program, meaning that groups of undergraduates enroll in all of their courses together. A crucial aspect of Towson's elementary science education course structure is the fact that cohorts who are enrolled in the Teaching Science in Elementary School course (SCIE 376) are enrolled concurrently in an Earth-Space Science course (PHSC 303). Ideally, to provide the undergraduates with a coherent framework for science teaching and learning, cohorts have the same instructor for both courses. The intent is that, in the Earth-Space Science course, the preservice teachers learn science content and reasoning skills through inquiry, while at the same time reflecting on and explicitly

discussing the structure and value of inquiry-based instruction; the methods content from Earth-Space Science is then supplemented and reinforced with additional methods discussions in the practicum course, in which the interns are expected to teach science through inquiry at elementary school sites.

An advantage for full-time faculty is that they often have the same student cohort for both SCIE 376 and PHSC 303. Having the same cohort for both classes sets up a fluid situation where (a) the science content in the SCIE 376 interns' science lessons can become part of the course content addressed in PHSC 303, (b) the instructor can hold in-depth methods and planning discussions in PHSC 303 that, due to time constraints, might otherwise not occur in SCIE 376, and (c) the instructor can help the interns develop a deeper, more coherent understanding (and appreciation) of inquiry and science learning by having them make explicit connections between their teaching practices, their understanding of children's science learning, and their own science learning – which are precisely the types of connections that the educational community recognizes as being crucial aspects of successful professional development for teachers. By necessity, most sections of SCIE 376 are taught by part-time faculty who meet with their interns only once per week, at the school site -- and so these types of spillover content/methods opportunities aren't possible. This makes teaching SCIE 376 for part-time faculty, and full-time faculty in a similar predicament, much more difficult.

Looking Ahead: Standardized Science Testing in Maryland

There is currently no science-specific testing in Maryland, although that will change when standardized science testing comes on-line in 2007 or 2008. It remains to be seen whether teachers and administrators will allow SCIE 376 instructors to make modifications to the official curriculum (in alignment with the NSES) when teachers and administrators are faced with rigid

content and lesson requirements driven by the Maryland State Assessment. If we are ever in a position where curriculum modifications are not allowed, SCIE 376 may be unable to maintain its crucial focus on inquiry – a situation that would severely limit the effectiveness and utility of the course.

Summary

The ability of Towson elementary education undergraduates to understand and implement inquiry-based science instruction in their field experience course (SCIE 376) is a complicated interaction of different factors: (a) the expectations of the university instructors, interns, and mentor teachers, (b) the degree to which the university instructors, mentor teachers, and interns possess a shared understanding of inquiry-based science instruction, (c) the ability of the interns to put their inquiry teaching goals into practice, via their lesson planning and facilitation skills, and (d) the practical constraints of elementary classrooms and the practicum course, such as the availability of science materials and basic communication between the interns, university instructors, and mentor teachers.

During the 2004-2005 academic year, Towson's PhysTEC project team held workshops for SCIE 376 mentor teachers, and also held a SCIE 376 instructor meeting, in order to address two of the factors listed above -- course expectations and a shared understanding of inquiry -- with the ultimate goal of improving the field experience course. Surveys of the course interns and observations of the interns' lessons indicated that, by the end of the year, we made significant progress toward reaching our project goals: The SCIE 376 course has become more consistent across course sections, and the SCIE 376 interns' science lessons have become more inquiry-oriented. In our second year of the project, Towson's PhysTEC project will continue to make

progress towards our goals, document our efforts, improve our assessment instruments, and create additional resource materials for elementary science educators.

References

National Research Council. (1996). National science education standards. Washington, DC: National Academy Press.