2002

Building Bridges and Crossing Borders: Using Service Learning to Overcome Cultural Barriers to Collaboration Between Science and Education Departments

Kevin Carr

Search Results

Call Number: 150/E/CAR/2002

Title: **Building Bridges and Crossing Borders: Using Service Learning to Overcome Cultural Barriers to Collaboration Between Science and Education Departments**

Author: Kevin Carr

Date: 2002

Abstract: Science faculty and teacher education faculty need to coordinate in order to prepare teachers to teach science. This article describes several successful and unsuccessful collaboration efforts between scientists and educators that took place during the creation of an interdepartmental service learning project, Science Outreach, at George Fox University.

Key Words: Academic, Collaboration, College, Education, Faculty, Higher Education, Science, Service Learning, Service Learning -- General, Service-learning, Teacher, Teacher Education, Teachers

Format: serial article

Content Type: academic research

Pages: 13

Journal/Analytic Source

Source Title: School Science and Mathematics

Identifier: v. 102(6),Oct. 2002, 285-298.

#22

Building Bridges and Crossing Borders: Using Service Learning to Overcome Cultural Barriers to Collaboration Between Science and Education Departments

Kevin Carr
George Fox University

Powerful preparation of elementary educators in teaching science involves significant contributions from both scientists and teacher educators. Ironically, faculty and students in science and teacher education departments are often isolated from one another not only across the physical boundaries of the university, but across the cultural boundaries of academe. Coordination and collaboration between science and education faculty and students requires a careful negotiation of these cultural boundaries. This paper presents several illustrations of both successful and unsuccessful collaborative episodes documented during the creation of an interdepartmental service learning project, Science Outreach. The illustrations are interpreted in terms of a cultural difference model, and recommendations are made for successful interdepartmental collaboration.

Both science faculty and teacher education faculty influence the science teaching preparation of elementary educators. Future teachers typically learn science content in introductory courses taught by scientists, while they learn science pedagogy in methods courses taught by educators. The courses, as well as the faculty members themselves, are often isolated from one another not only across the physical boundaries of the university, but across the cultural boundaries of academe.

Collaboration between traditionally independent stakeholders has been shown to be a powerful tool for change (Gordon, 2001). Coordination and collaboration between scientists and educators in preparing teachers is a central feature of several national programs (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 2000; NASA Project NOVA, 2002).

Strong institutional collaboration between scientists and educators requires a careful negotiation of the boundaries separating distinct academic cultures. George Fox University, a small, regional, liberal arts institution in the Pacific Northwest, has undertaken the development of a collaborative, interdepartmental service learning project, Science Outreach, involving science and teacher education students and faculty. This paper presents illustrations of both successful and unsuccessful collaborative episodes, so-called "critical events," (Arhar, Holly, & Kasten, 2001) documented during three semesters of Science Outreach. In this article, the critical events are interpreted in terms of a cultural difference model (DuPraw & Axner, 1997), and recommendations are made for successful interdepartmental collaboration.

Collaboration as a Tool for Reform

One outcome of recent educational reform is recognition of collaboration as a tool for change (Gordon, 2001). Collaboration especially suits the higher education setting, where institutional structures and cultures are so ingrained that change is often hampered by the sheer inertia of tradition (Carlson-Dakes & Sanders, 1998). Processes in which multiple stakeholders develop both the agenda for and the shape of change have been recognized as having the power to overcome long-standing patterns of independence within institutions.

Recent calls to reform in the preparation of science teachers have highlighted the interdependence of science and teacher education departments in colleges and universities. For example, the NRC (2000) listed several characteristics of effective teacher education in math and science, all of which point to strong collaboration between science and teacher education departments (see Appendix A). The NRC's Committee on Science and Mathematics Teacher Preparation views teacher education as a partnership involving multiple stakeholders, in which "scientists and mathematicians, and science and teacher educators would serve as core participants in this new type of partnership" (NRC, 2000, p. 91).

Traditionally, at George Fox University (GFU), collaboration between teacher education and science departments has been limited. GFU is not unique in this regard (Cole, Ryan, Serve, & Tomlin, 2001). Science Outreach was developed at GFU as a tool to promote change in the preparation of elementary teachers by increasing collaboration between the departments of science and teacher education.

Cultural Difference as a Barrier To Collaboration

"Because each partner sees things differently, each imagines different solutions to the same problem. This is at once the opportunity and the risk associated with collaborative renewal" (Osguththorpe & Patterson, 1998, p. xix).

When groups of people develop their own sets of beliefs about themselves and others, such groups constitute, functionally, a "culture" (Kuh & Hall, 1993, p.2). Cultural differences between academic departments can be significant but not insurmountable barriers to increased interdepartmental collaboration (Carlson-Dakes & Sanders, 1998; Duggan-Haas, Smith, & Miller, 1999). One approach to overcoming barriers to collaboration is to think of collaboration within a cultural perspective, what Kuh (1993) called "thinking culture" (p. 112). The challenges experienced by science and teacher education collaboratives may also be interpreted in terms of cultural difference and overcome by employing a cultural perspective.

Patterns of Cultural Difference

As people from different cultural groups take on the exciting challenge of working together, cultural values sometimes conflict. We can misunderstand each other and react in ways that can hinder what are otherwise promising partnerships. Oftentimes, we are not aware that culture is acting upon us. Sometimes, we are not even aware that we have cultural values or assumptions that are different from others! (Dupraw & Axner, 1997, p. 1)

DuPraw and Axner noted that cultural boundaries are marked by differences in (a) communication style, (b) attitudes toward conflict, (c) approaches to completing tasks, (d) decision-making styles, (e) attitudes toward disclosure, and (f) approaches to knowing (see Appendix B). These patterns of cultural difference define a framework within which cross-cultural collaboration can be viewed and interpreted.

The Cultures of Science and Teacher Education

Differences between teacher education culture and science classroom culture have been well documented. For example, Duggan-Haas (1998) examined the perspectives of new teachers transitioning between science departments and teacher education programs and found a dichotomous relationship between cultures with regard to teaching and learning. "It seems that every instructional characteristic [use of lecture, cooperative learning, textbook use, methods of assessment] of one program is reversed in the other" (p. 3). Science classroom culture has been described as teacher centered, lecture based, competitive as opposed to cooperative, and primarily valuing objective methods of assessment (Seymour & Hewitt, 1997; Tobias, 1994). In contrast, teacher education classroom culture is characterized as student-centered, discussion-based, cooperative, and valuing multiple, subjective methods of assessment (Duggan-Haas, 1998).

Barriers to Collaboration Between Teacher Education and Science

Although the need for collaboration between science and teacher education departments is clear, barriers exist that often make such collaboration difficult. Tensions inevitably arise when creating new partnerships, if for no other reason than our very human resistance to change (Osguthorpe & Patterson, 1998). Some barriers, such as those imposed by the structural alignment and policy of the institution, are often beyond the control of groups of professors and students. Other barriers, though, involve factors that participants in collaboration can understand and overcome.

At a recent Association for the Education of Teachers in Science (AETS) Conference, members of eight groups of scientists and teacher educators listed the obstacles they faced in carrying out collaborative projects (Duggan-Haas et al., 2000). Three common obstacles emerged from the reports: (a) "differing perspectives on the knowledge base for teaching and learning," (b) "a lack of understanding of the disciplines, workings, and goals of 'foreign' departments," and (c) lack of departmental release time and support (Duggan-Haas et al., 2000, p. 2-15). Some recommendations for collaboration made by the AETS group were as follows:

- "The amount of organizational skills and interpersonal communication turns out to be far more than expected. We did know that such matters would be of significant importance, but there has been much more 'ego massaging' than we had envisioned" (p.3).

- "Diplomacy is essential" (p.6).
- "...Knowledge for developing a common language, trust, the habit of collaboration..." (p. 8)
- "The amount of time spent in meetings and navigating the landscape of interdepartmental turf would be great, far more than expected" (p. 15).

The obstacles to collaboration reported by the AETS group correspond well to typical obstacles appearing in the literature. For example, Bondy and Brownell (1997) suggested that three critical factors, (a) beliefs about ourselves and others, (b) professional isolation, and (c) weak collaboration skills, often cause difficulty in collaboration.

Some authors interpret such obstacles as indicators of the role cultural difference plays in collaboration (Osguththorpe & Patterson, 1998). This study seeks to illuminate the role that cultural differences between science and teacher education played in developing the Science Outreach program.

Science Outreach: Building Bridges Between Academic Cultures

Science Outreach is an ongoing program in which introductory science majors team with senior-level elementary education majors each semester to teach science courses as a service to local, homeschooled children, ages 6-18. The 8-week science courses are taught once per week on the GFU campus using university labs and facilities. Each year over 200 community children are served by Science Outreach.

GFU undergraduate student teams, made up of teacher education and science students, are made the primary developers and teachers. While community service is the primary goal, Science Outreach also challenges teacher education majors, science majors, and faculty to effectively collaborate, as characterized by clear communication, strong consensus building, and shared responsibility and accountability.

This study seeks to understand better how the cultural differences between the GFU science and teacher education departments impacted collaboration on Science Outreach. Behind the scenes of Science Outreach, faculty and students worked through a difficult cross-cultural exchange, fraught with unexpected barriers and misunderstandings. Several of DuPraw and Axner's patterns of cultural difference were evident in the experience of Science Outreach participants, including differences in the way conflict was approached, in the way certain key words were used, and in the way tasks were completed. These patterns appear to emerge from differences in the way students and faculty from the science and teacher education departments view teaching and learning, and by extension, each other. By working through and understanding these differences, bridges have been built between departmental cultures that have not only resulted in more powerful science teacher preparation, but a clearer understanding of the process of becoming a science teacher.

Methods

The purpose of this research was to document, analyze, and interpret the experiences of participants in Science Outreach during an 18-month period beginning in fall 2000. The methods employed reflect many of the values of teacher action research, as summed up by Arhar, Holly, & Kasten (2001):

> There is no attempt on the part of the action researcher to maintain an illusion of objectivity or to remain value-neutral. Rather, an action researcher's job is to bring to light assumptions, beliefs, and actions; to examine them; and to bring their actions into closer alignment with their values. (p. 31)

Action research as undertaken in this study is distinct from other types of research in that it (a) is often conducted mainly by insiders and participants rather than by outside observers, and (b) includes self-critical inquiry, with interpretations and judgments made by the participants themselves (Arhar, Holly, & Kasten, 2001). The intent of this research is to use the voices and experiences of the Science Outreach participants to bring to light and examine beliefs and actions related to the role of culture in collaboration.

Participants

The major participants in the study included 50 elementary education students, 1 education department faculty member, 20 science students, and 1 science faculty member. At any given time approximately 15 education students and 6 science students were involved in the project. In addition, data were gathered from a graduate assistant involved in administering Science Outreach, as well as from several faculty members not directly involved with the program.

Data Collection

Data were gathered using a variety of qualitative methods, including field notes, interviews, student work, student self-reporting, and an on-line survey. Sources were then cross-checked, or triangulated, in order to provide for reliability and credibility (see Ely, 1991; Hitchcock & Hughes, 1989).

Field notes. The daily activities of Science Outreach were chronicled, including classroom observations of teaching, self-reflection, and informal conversation with participants. Many "critical incidents" (defined by Arhar, Holly, & Kasten, 2001) were recorded in field notes as they occurred. These notes served as the basis for many of the illustrations forming the foundation of this study. Field notes as used in this study also served as an overall framework, providing context for the other data sources.

Individual interviews. Several key project participants were formally interviewed. Interviews were audiotaped and transcribed whenever possible. Some interviews were conducted electronically via email. The interviews served to provide insight into how the participants themselves viewed critical incidents and allowed them access to interpretation of the events discussed.

Online surveys. Student participants completed an online survey consisting of four open-ended questions (see Appendix C). The surveys were used to validate and support the analysis of field notes and interviews.

Student work and self-reporting. Education students completed a "reflection assignment" regarding their experiences in Science Outreach. The students were asked to reflect on (a) "What I used to know about teaching science," and (b) "What I now know about teaching science." These responses were used to help support conclusions drawn about how elementary education majors regard science.

Data Analysis and Interpretation

Data analysis followed the procedure of qualitative inquiry suggested by Harry Wolcott (1994). Three steps were followed in analyzing the study data—description, analysis, and interpretation. Description, in Wolcott's framework, addresses the question "what?" Descriptive data consists of observations made by the researcher and/or reported to the researcher by others. Analysis addresses the identification of essential features and the systematic description of interrelationships among them. Analysis was employed in this study evaluatively to address questions of why a system is not working or how it may be made to work better. Interpretation addresses questions of meaning and contexts, that is, "what does it all mean?"

The data sources were analyzed to identify examples illustrating the theme of collaboration. The key findings of the study emerged from a reflective analysis of the critical events in light of the theoretical framework of cultural difference.

Results: Critical Stories of Cross-Cultural Collaboration

Using stories to illuminate the results of a research study demands that the reader keep a few qualifications in mind (Arhar, Holly, & Kasten, 2001). All data may not fit easily into the stories told, and not all parts of the story may be useful for all readers. The findings may not be as clear and unequivocal as is implied in a traditional research report. On the other hand, stories engage the imagination and intuition of the reader and make possible multiple levels of understanding within the same text.

The Science Outreach collaboration involved 2 professors, 1 graduate student, 60 undergraduate students, and over 400 community children. Emerging from the data are a number of case studies or "critical stories" that serve to illustrate how cultural differences played a role in the Science Outreach collaboration. In recounting these stories, role of cultural difference in the collaboration is illustrated.

Fall 2000: Dave

"Dave" is a senior science teaching faculty member at GFU, a small, liberal arts institution in the Pacific Northwest. He has been awarded teacher of the year at both the college and state levels for excellence in biology teaching at the undergraduate level. Oddly, Dave often introduces himself at meetings by stating "I don't know anything about science education. My first love is science; education is a hobby."

Dave is best known among science educators for initiating and developing GFU's Science Outreach program, in which 200 or more homeschooled children take science classes taught by GFU science majors using campus facilities. Science Outreach has for several years been successful at serving community children with quality science experiences. It has also, in Dave's words "rescued many pre-med majors from careers as physicians." Dave takes pride in the fact that many of the brightest and highest achieving science majors at GFU institution choose careers as teachers. Many students attribute their decision to become teachers to teaching in Science Outreach.

Ironically, Dave's nationally recognized efforts in establishing the Science Outreach program are lightly regarded by his colleagues in the science department. "They don't care much what I do," Dave stated bluntly, "and they often encourage me to cut back or drop the program entirely." Dave's enthusiasm in converting future physicians to teachers is not shared by his colleagues. "In science," he suggested, "we measure our success by how many students get into medical schools and graduate programs in science. Producing teachers isn't even on the map."

Kuh (1993) offered several suggestions for working within a cultural perspective. Kuh writes that one must "become an expert on institutional culture" (p. 122). Dave is an expert not only in institutional culture, but also in successfully negotiating the cultural terrain. Dave's experience as a scientist is that he has to work "undercover" within his own department, carefully framing to science colleagues what he does in culturally acceptable language, and downplaying his own commitment and involvement with science education and with teacher educators. In his own words he "works quietly." In this way Dave is able to converse successfully with educators and the teacher education department while maintaining credibility within his own cultural circle.

Fall 2000: Kurt

Kurt is an ex-high school physics teacher who returned to graduate school after 7 years in public school, earning a master's degree in physics and a Ph.D. in teacher education. Kurt was recently hired as an assistant professor in the Teacher Education Department as a science education specialist, taking the lead in teaching science methods courses.

Just prior to fall 2000 Kurt was tapped by the science department to teach general physics, as an "emergency substitute" for the engineering faculty member usually responsible for the course. Kurt, looking for new ways to develop relationships with the science department, accepted the offer with great enthusiasm. Although not a requirement for any major, general physics is taken most often by junior biology, chemistry, and math majors, along with a smattering of students who simply like physics. Kurt's vision for the course was to provide for inquiry-based activities modeling strong pedagogy, covering current topics in cosmology and quantum physics, in addition to what Kurt described as the usual "grind" through the "ancient catechism" of problems in classical mechanics. Such an approach, Kurt claims, meets a variety of student needs, while maintaining rigor and staying within the boundaries outlined in the course catalog.

Kurt felt that the science department had a great deal to learn, and he made aggressive plans for his incursion into science department territory. He would not be "quiet" as Dave's motto suggested. Kurt soon discovered many minefields ahead.

Kurt's unwritten objective for the physics course was to join Dave's mission of converting science students to future teachers. In addition to adopting an inquiry-based pedagogy, Kurt created a Science Outreach-style assignment in which each of 10 senior elementary teaching majors enrolled in Kurt's elementary science methods course was grouped with two-three physics students to team-teach a science lesson in a local elementary school.

After communicating his goals and strategies with Bill, the senior engineering professor normally assigned to the course, Kurt received a curt email message requesting a phone meeting about some "concerns." During the ensuing conversation, the department's similarly unwritten objective for general physics was clearly communicated: "The course was created to prepare pre-med students for medical school admissions (MCAT) exams. Our students score very highly on the physics section of the MCAT," Bill explained with pride. "We stick with only the material they need to know to score well." Kurt explained that the course as he planned to teach it was in harmony with the university course catalog. He also assured Bill that the students would still be spending a great deal of time preparing for MCAT examination, doing what Kurt termed "their problem-solving chores." "Physics isn't a chore," Bill replied.

As the semester progressed, the general physics students formed two groups polarized around the issue of Kurt's pedagogy, some finding it a "breath of fresh air," and others writing remarks such as "I doubt if Dr. Kurt even knows physics, let alone how to teach it" (student course evaluations). The class settled into these two groups, one interacting enthusiastically with Kurt, and the other sitting in the back of the small classroom, accepting instruction with quiet resignation.

Student evaluations of Kurt's version of general physics reflected many students' feelings that their needs were unmet by the course. One student commented, "I don't know why we had to talk about all this astronomy and star stuff. I was here to learn real physics." Another student reported, "I appreciate Dr. K's efforts to make class interesting, but I have a BIG test coming up, the MCAT. That is why I took this class." One student even suggested, "Dr. Kurt should go back to teaching in the education department, where he belongs."

A science faculty member observing Kurt's teaching for that year's peer review remarked,

> I could see that the conceptual approach you used in class created interest, but I'm concerned that this could be coming at the expense of rigor. For

example, one girl, who I know is a very good student, worked on other projects during the class I observed, and later commented to me that she often even skipped class on Fridays because she knew that the material wouldn't be on the final exam.

Kurt tried to focus on the positive aspect of the comment, but couldn't shake the feeling of being misunderstood, both by his colleague and by the student.

Kurt spoke frequently with Dave, as well as his colleagues in teacher education, about what he was experiencing. Dave suggested that all Kurt really had was a "PR problem" and that he needed to think of ways to convince students that his class really *was* their ticket to the medical profession, even if it did not appear to be on the surface. Dave's advice notwithstanding, Kurt was discouraged and humbled by the cultural misunderstandings that had taken place. He also felt that the opportunity to teach general physics had likely been a setback in collaboration between the two departments.

Kurt's experience revealed some of the differences between cultures of teacher education and science. Kurt failed to negotiate successfully the cultural landscape (see Table 1). Kurt failed to "think culture." He also underestimated the depth of the difference between his own expectations for the physics course, and the expectations of other stakeholders. Kuh (1993) wrote that such differences, if rooted in culture, are often more tenacious and difficult to change than is expected by outsiders.

Even more damaging to the effort was Kurt's inability to effectively communicate his goals and objectives in ways that could be understood and accepted by science students and faculty. Kuh (1993) suggested that once faculty "think culture," they must "teach culture," helping different students adapt to new expectations.

Fall 2000: Stephanie

Stephanie was an elementary education student enrolled in Kurt's elementary science methods course. Like many of the physics students, the education students also responded to the assignment to pair up with physics students and teach a science lesson with quiet resignation. Their body language and expressions, however, spoke clearly: The assignment had caused great distress. In his resolve to carry out the plan, though, Kurt chose to ignore the signals and press forward.

Kurt's impressions that the students were uncomfortable were confirmed. Later that same day, a group of three students from the education group appeared at Kurt's door. Stephanie, the spokeswoman, stated, "My teacher says that you can't teach science to kindergartners. I just don't see how we are supposed do this project." The others nodded their aggreement. Kurt offered to help Stephanie find resources and ideas, and recalled that he had a list of science web sites geared to kindergarten teachers to share with her.

The three young women shifted nervously, "Well, another thing is the time," Stephanie continued, "How are we supposed to meet with *these people*." Something about the way she said "these people" caught Kurt's attention. He pressed the issue.

Kurt: What do you mean, "these people"?

Stephanie: Well, I mean, aren't *they* really busy? Do *they* even want to work with us? [italics added. More nods of agreement.]

Kurt: Sure, they are busy in a certain way. Not like you guys are, with your placements, and your curriculum work samples to write. This is an assignment for them just like any other.

Stephanie: I just don't want *them* to be forced to work with *us*.

Kurt: I'm getting a lot of sort of *them* and *us* here. Tell me more.

Stephanie: We [education students] have had all of our courses together for 2 years. My freshman

Table 1
Illustrations of Cultural Difference From Kurt's Experience

Pattern of Cultural Difference	Illustration from Kurt's Experience
Communication style	Words were used such as "problems," "rigor," and "physics" that held different meanings by various individuals.
Approaches to completing tasks	Kurt asked students to spend time collaborating with others on the teaching project, rather than sticking to the task at hand.
Learning, knowing and teaching	Kurt sought to emphasize subjective outcomes and content not objectively quantified on MCAT exams. Kurt's teaching style was misunderstood by students, engineering faculty, and the peer review committee member.

roommate used to laugh at our assignments, like they aren't even real work.

Kurt: Well, it sounds like its time to get back in touch with "these" people! Why do they scare you?

Stephanie: They will make me feel stupid. *I mean, what are we supposed to do with these brainiacs?*

Stephanie later overcame her initial fear of working with the science students, eventually describing them as "normal, even nice." Stephanie's cooperating kindergarten teacher Mrs. Gilson wrote, "This was a fun experience for my kindergarten class. The students were well-prepared and professional...I watched them re-explain or re-teach a concept or phrase to ensure that the kindergarten students understood. That was great!" Bob, a physics student, noted that

> Stephanie did a wonderful job of being organized and following up...she contributed good ideas and was fun to work with. Perhaps one of the biggest things I came away with is a heightened respect for teachers, especially elementary teachers.

Gaining respect for teaching and education was a theme repeated throughout the reflections of the physics students.

Differences in the ways teaching and learning were viewed by science and education students created a significant barrier to collaboration. Stephanie's experience, echoed by others in the teacher education group, reflected a history of estrangement and misunderstanding rooted in how those in other majors on campus view the activities and learning of teacher education students. Natalie, a senior science student whose story is told later in this paper, explained her perceptions this way: "Science majors tend to want to feel superior, like we do more work than anyone else." Involvement in Kurt's project brought some needed change and correction to both the elementary education students, who regained a view of science majors as "normal" people, and to the science majors, who regained a view of teaching as complex and worthy of respect.

Spring 2001: Kurt and Dave Collaborate, Part One

The next semester Kurt taught elementary science methods again, this time with group of 28 teachers. Dave and Kurt decided to take the next step, which was to incorporate the elementary education students into Science Outreach as full teaching partners. The Science Outreach courses were already planned and staffed with science majors, to which Kurt added two-to-three teacher education students per course. Kurt had Dave introduce the project to the teacher education group, distributing a sign-up sheet showing the homeschool courses to be taught and the science majors responsible. After some hesitation and a few questions, 26 of the 28 students signed up. Two students claimed that scheduling issues prevented them from participating.

Karen and Lindsay, two elementary education students earning Spanish minors, signed up for a class that was to be taught in Spanish. They reported back to the group that the first class went very well and that they felt like a vital part of the teaching team, because their fluency in Spanish made a key contribution. They planned to continue participating for the remaining class sessions.

Michael and Carolyn reported a different story. They reported to the fifth-grade science class they signed up to co-teach only to find that the science majors considered themselves "in charge" and were not sure why the education students were there. According to Michael, "The first thing they did was pass out a syllabus to the fifth graders and inform them they would be quizzed on the syllabus the following week. They told us they had everything planned out. I don't even want to go back there."

Other teaching students told similar stories after the first week, many claiming to have discovered "scheduling conflicts" with future Science Outreach sessions. When asked whether she had directly approached the science students with questions or concerns about the way things had gone, Carolyn answered, "You can just tell they didn't want to listen, so I kept quiet."

Dave and Kurt, desiring a more student-centered pedagogy in Science Outreach, imagined that collaboration with teacher education majors would provide the science majors with needed ideas and expertise. In most cases this collaboration failed to happen, and the classes were taught much as before. After the semester was over, Dave and Kurt agreed that they had set up the students to struggle in the way the project was administered. By allowing the science students to organize the courses in advance, an imbalance of perceived power and expertise was created that neither the science nor education students had the tools to overcome.

Ironically, some the other cultural norms taught in teacher education (i.e., an avoidance of conflict), tended to inhibit the education students from having a powerful influence. One stated, "These people are our friends; I don't want to mess up that relationship by telling them they are doing everything wrong." The failure of the education students to directly communicate their values about teaching and learning contributed directly to feelings of "not being needed." The science students interpreted the silence at face value, failing to decode the more subtle messages communicated by the teacher education group. The result was frustration and further alienation experienced by both groups, with many education students avoiding further involvement. Karen and Lindsay were notable exceptions. Their expertise in Spanish, a skill badly needed by the team, effectively placed them in a position of equal value and authority.

Fall 2001: Kurt and Dave Collaborate, Part Two

Refusing to give up on the idea that both sets of students would benefit from working together in Science Outreach, Dave and Kurt resolved to learn from their mistakes. The first elementary science methods class meeting of the following semester began with Dave and Kurt explaining together the Science Outreach program. They asked the students to brainstorm what courses they would like to teach. Suggestions were offered, including Layers of the Earth and Inquiry Science. Dave wrote the titles on the whiteboard. By the end of the session the 10 students had developed four course descriptions, two for grades 1-3, and two for grades 4-6.

Later that week, Kurt was called into the office of Madge, a teaching colleague working with the elementary education group. She asked him for some information about the elementary science methods course, specifically the Science Outreach program. Kurt's professional relationship with Madge had been strong and trusting, so he asked her to explain her concerns directly. She said,

> You were the subject of a student prayer request before this morning's class. Some of the students feel very stressed about the Science Outreach program and the time commitment they believe it will involve. I asked them if they had communicated this to you. They said "yes" at first but Barbara, you know, the older woman in class, reminded them that they hadn't started worrying until after class was over and that you may not be aware of their concerns. I told them that I didn't want to be part of any conversation until they had talked to you first.

Kurt resolved to wait for the students to bring up any concerns. By the following week it was learned that all of the science majors wished to teach older (middle school and high school age) children, leaving the elementary teachers with "helpers," science students who would not teach but act as "consultants." Angie, the graduate science student-coordinator of the program, explained, "The science people don't think they know how to talk to younger kids. They want to teach the things they are learning in their college courses, and the little kids scare them."

Immediately at the start of their second class session, Angie took the teacher group and their consultants on a tour of the science facilities. The equipment designated for Science Outreach included many large, plastic anatomical models, skeletons, slides and microscopes, petri dishes, a VandeGraff generator, and a small shelf of kitchen supplies. The teacher education students recognized that most of the items they were shown would not be appropriate for their courses. They informed Kurt of this in private after the tour. Kurt and the teacher education students developed a large, alternative list of supplies and found a place to store them. After the tour, Shauna reopened the issue of participation in Science Outreach:

> I don't see how this is a reasonable requirement. Last semester [the science methods students] only had to do one lesson and we have to do eight. I don't see how we can do it. It is going to take 8 to 10 hours each week just to research the science just so we know what are talking about. I can't have a kid asking me a question I don't know the answer to!

Kurt was now well experienced in this line of conversation and wanted to very gently bring Shauna on board.

Kurt: What if I did the research? I mean, I'm an expert, so I could save you a lot of time. If you felt stuck, I could do a web search and find resources that kids would understand.

Shauna: Are you sure? What if we all come to you at once with questions and...

Kurt: I'm willing to go the extra mile! [He was trying not to interrupt. He carefully tried to discern where the other students stood.] What if we brought in some computers and you had the kids look things up if they have questions?

Shauna: I don't know. It still sounds impossible.

Kurt: How about this: We are teaching the Outreach classes during our normal class time. That means I will be here to help. I'll be floating through the groups, making suggestions and helping you reflect on your teaching. I'll be teaching you to teach as you teach.

Shauna: What if one of us gets sick, like, with mono or something? The parents have paid for these courses...

Kurt: I'll take over and teach your course if you need to be absent. No problem.

Shauna sighed and agreed to give the program a try.

By the third class session, with one week remaining before the Science Outreach program was to start, the elementary education group had engaged thoroughly with planning for the first meeting with the kids. Kurt spent a day preceding the first homeschool class sessions shopping for the supplies teachers requested. One hundred fifty-five dollars in expenses later he had a trunk loaded mostly with art supplies and sundry household goods.

Kurt planted himself in the university lab being used as the Science Outreach classroom, observing as the children and their parents began to arrive. The education students had decorated the room with posters and "question boards." Various art supplies and materials were arranged around the room. Shauna, who had barely assented to the taking on the role of science teacher, took the lead in greeting parents and children at the door, distributing nametags, and engaging in small talk. Karrie, her teaching teammate, mingled and talked easily with the children as they browsed wall shelves piled with clear glass jars holding various anatomical samples and oddities. Mindy, the science major assigned to the group, conversed with several boys about some of the samples, quizzing them on the contents of the jars.

In observing another first-day class, Kurt was again struck by the competence displayed by the education students as they began to build the foundation for learning science over the next few weeks. "Are these the same people?" he thought. The transformation was remarkable. The following day a teacher education colleague approached Kurt and reported, "The students sure are excited about their science classes. They had to spend the first five minutes going back over how cute the kids were and the funny things they said."

Again Kurt felt that a major breakthrough had occurred. He was never asked to take over a class or provide any extra help. One student responded in a post-project reflection a sentiment echoed by nearly all of her colleagues: "I thought I would need to know everything about science before I could teach it. Now I know that kids can teach themselves if the proper environment and tools are provided."

As was true the previous semester, misunderstandings about teaching and learning science played a critical role in both the successes and failures of the collaboration. The teacher education students initially showed great resistance to the project, convinced that teaching science involved being content experts. They were reassured that content expertise would be provided if needed. The offer of help was never taken up by the students. The collaboration quickly and effectively brought about a revised understanding of what is necessary to teach science.

Spring 2002: Natalie and Roxie

Natalie, a junior biology major, signed up to teach Anatomy and Physiology in the Science Outreach program. Natalie, interested in becoming a high school science teacher, became interested in the Science Outreach program after hearing informally that it was a "requirement" for entry in the teacher education program. She also had experience as a science camp counselor and had visited her old high school science teacher during winter break. Natalie was confident in her content knowledge and looked forward to passing that knowledge on to students.

Natalie was teamed with Roxie, a junior elementary education major with whom she was somewhat acquainted through a mutual friend, Natalie's elementary education roommate Heather. Roxie, a strong elementary education candidate, believed that science involved a lot of memorization and terminology and was hesitant about her own knowledge.

Natalie and Roxie were each dressed in white lab coats as fifteen 12- to 16-year-old students filed into the university biology lab. Natalie began presenting information using the overhead projector as students began to take notes. As she progressed through cellular systems, organelles, energy transfer, protein synthesis, and many definitions and terms, students struggled to keep up. Reflecting on the first day, Natalie explained,

> My college courses were all lecture. I started with way too much. I had three weeks worth of material packed into one 2-hour class. The kids were dying. Roxie really helped out after class. She was assertive. She started coming up with ideas from her ed classes to break things up and make it more active. Most of her ideas were from books that seemed elementary, but they really worked with the older kids. We got together every week. Roxie was intimidated by the science part, but she wanted to present material so I assured her that you don't have to know it all and she did great.

Natalie and Roxie appeared the following week without the lab coats. When asked why, Natalie explained, "I think we were afraid at first. Once we got to know the kids the coats seemed stupid."

At the end of the 8 weeks Roxie concluded, "Students love to see energy and excitement about what I am teaching." Natalie explained, "I used to think that ed majors didn't do much, just a lot of coloring, like an art major. My respect for what teachers do has grown."

Discussion

Science Outreach participants experienced barriers typical to collaboration. Resistance to change was encountered regularly. This was especially apparent in the elementary educators when initially confronted with the task of Science Outreach. When asked during an early semester to give advice for implementing the program in the future, one student commented, "Don't tell them that this a new program! Act like you have been doing this for years." Predictably, adding a new collaborative effort to the teacher education and science programs created stress and tension in participants.

Other barriers brought to light by the Science Outreach collaboration can be framed in terms of DuPraw and Axner's patterns of cultural difference (see Appendix D). Using a cross-cultural framework in thinking of teacher education/science collaborations provides a language for interpreting successes, explaining failures, and making recommendations for future collaborative efforts.

Leadership Qualities for Successful Collaboration

Dave served as an important "bridge builder" between teacher education and science, mentoring Science Outreach participants in "thinking culture" (Kuh, 1994). Dave's command of the two cultures enabled him, as he described, to "work quietly and let others notice the results."

Kurt was less aware of the cultural differences between the teacher education department and the science department. Many of the problems he experienced, both with science faculty and students, could have been avoided with a greater awareness of and sensitivity to values, assumptions, and prejudices held by both departments. Through careful reflection on the early failures, Kurt began to "think culture" more effectively. "Each new thing we tried sort of shocked me with the depth of the gap between the two groups. I was clueless and it showed. Once I was aware of the issues, they weren't that hard to overcome."

The collaborative relationship between Dave and Kurt grew as an outgrowth of a common commitment to serving children through the Science Outreach program. The ability of Science Outreach leaders to establish common goals and vision for the program was a key to overcoming collaborative barriers, enabling participants to persevere in spite of difficulties. The finding of common ground is a key feature of successful cross-cultural communication and collaboration (DuPraw & Axner, 1996).

Science Is Hard and Teaching Is Easy: Conflicting Epistemologies

Distinct cultures often hold different beliefs about the nature of knowledge. Beliefs about the nature of knowledge can be viewed as a continuum between empiricist views and constructivist views. Empiricists regard knowledge as fixed, accurate, objective, and infallible as delivered by authority or through scientific method, while constructivists regard knowledge as constructed socially, tentative, and based on consensus-driven evidence and theory (Tsai, 1999).

The belief that education as a major, and by extension, teaching, is "easy" is indicative of epistemological differences between GFU academic cultures. Students in teacher education programs are enculturated to hold the constructivist view of knowledge (Roberts, Busk, & Comerford, 2001). Research shows that the epistemological beliefs of teacher education students, initially identical to their non-teacher education peers, change rapidly to a more constructivist view as students progress through the teacher education curriculum (Brownlee, Purdie, & Boulton-Lewis, 2001).

The epistemological views held by groups of science majors appear to be split between constructivist and empiricist (Tsai, 1999). Constructivist science students, like their teacher education counterparts, tend to learn through group discussion and other active strategies and are motivated by interest and curiosity. Empiricist science students, in contrast, tend to learn through strategies supporting rote memorization and are very often motivated by course grades and examination results (Hammer, 1995).

Different epistemological views of learning and knowing seem to underlie many of the obstacles to collaboration experienced by Science Outreach participants. In science culture, "learning" is delivered by experts, and occurs through hard, individual work and discipline. The belief that "science is hard and teaching is easy" was evident in the way the science students approached instruction, even with primary-age children. At the start of one initial class session taught by science majors, college-style syllabi were distributed to fifth graders, with the promise of a graded quiz over rules and procedures the following week. This was followed by a lengthy "note-taking" session, in which the science majors lectured.

The empiricist teaching strategies initially employed by the science majors, reminiscent of the "weeding out" process they experience in science departments, differed greatly from the constructivist pedagogy modeled in the teacher education program (see Duggan-Haas, 1998). When asked for her impressions about the first session in spring 2001, Angie, the graduate student coordinator of Science Outreach, observed, "The ed majors were more organized than the science majors usually are on the first day. They didn't do as much science, but the way they started out the classes was really good."

The teacher education students, although no longer of the belief that "teaching is easy," initially held to the belief that "science is hard," as reflected in the emphasis on absolute authority in content knowledge as a prerequisite to teaching. This belief may be a holdover from previous exposure to college science courses, in which the dominant culture of science was inadvertently taught.

Same Words, Different Meanings

Differences in epistemology also muddied communication between participants. When words such as *teaching*, *planning*, and *rigor* were used to convey ideas, miscommunication and misunderstanding often ensued. Sometimes these different meanings worked in complementary ways; at other times they created conflict and stress.

For example, Dave used *teaching* pragmatically, emphasizing "hands-on," getting kids excited about science, having a syllabus, and submitting grades. When Kurt used the word *teaching* he emphasized interaction with students and creation of an environment for learning. The science students emphasized the grading and lecturing aspects of teaching, while the education students emphasized the knowledge base and the need for relationships with students.

When the education students heard from Dave that the science students had *planned* the courses, the meaning taken was different than the meaning intended. In education culture instruction is subjective and negotiable, so *planning* instruction has a connotation of ongoing development and reflection. In science culture, a *planning* instruction means the development of a strict and rigid protocol and procedure for transmitting and assessing knowledge. A further example is seen in how the groups understood *rigor* in teaching and learning. The science majors describe the homeschool courses as *rigorous* because they assign homework, give tests, and submit grades. The education majors tended to speak of *rigor* more often in terms of "making students think" and "building excitement for science."

Conclusion

"We all have an internal list of those we still don't understand, let alone appreciate. We all have biases, even prejudices, toward specific groups" (Lantieri & Patti, 1996)

The illustrations described in this article indicate that the task of interdepartmental collaboration should be reframed in terms of "building bridges and crossing borders" between the cultures of science and teacher education (Giroux, 1993). The *cultural borders* between science and teaching, if ignored, may confound efforts both to reform the science preparation of elementary educators and to enhance recruitment of science majors into teaching. It was discovered at George Fox University that simply setting up projects between teacher education and science felt to participants like being "airlifted" and "dropped behind the lines," without so much as a phrasebook to aid communication with the locals. The importance of "thinking culture" (Kuh, 1993) was made clear through the Science Outreach experience.

Cultural barriers rooted in epistemological beliefs about teaching are subtle and tenacious. As is true in changing any misconception, whether scientific or cultural, coming to realize a different viewpoint can be a difficult process. Natalie, one of the participants in Science Outreach, made during an interview the following recommendations for students and faculty members attempting interdepartmental collaboration. Note that many of her recommendations are "countercultural," asking participants to think and act more like members of the "other" culture.

For science students:

1. Be open-minded.
2. Be responsible, but delegate and let go of control.
3. Realize that elementary education people are more oriented toward the big picture of learning, but are afraid they don't know enough science.
4. The way you structure class is more effective if you understand learning. Realize that knowledge isn't enough.

For education students:

1. Ask questions.
2. Be assertive and be clear about what your ideas are.
3. Realize that science people are more oriented toward the knowledge but are afraid that the children will be out of control.
4. The way you structure class is just as important as the knowledge you have. Realize that knowledge isn't enough.

At GFU, Science Outreach has played an important role in providing difficult, yet positive cross-cultural experiences, creating friendlier border crossings between teacher education and science. Such projects provide common ground, where the hard work of understanding and learning to work together effectively can take place.

References

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy: Project 2061*. New York: Oxford University Press.

Arhar, J., Holly, M., & Kasten, W. (2001). *Action research for teachers: Traveling the yellow brick road*. Upper Saddle River, NJ: Merrill Prentice Hall

Bondy, E., & Brownell, M.T. (1997). Overcoming barriers to collaboration among partners-in-teaching. *Intervention in School and Clinic, 33*, 112-118.

Brownlee, J., Purdie, N., & Boulton-Lewis, G. (2001). Changing epistemological beliefs in pre-service teacher education students. *Teaching in higher education, 6*, 247-269.

Carlson-Dakes, C., & Sanders, K. (1998, November). *A movement approach to organizational change. Understanding the influences of a collaborative faculty development program*. Paper presented at the Annual Meeting of the Association for the Study of Higher Education, Miami, FL.

Cole, D.J., Ryan, C.W., Serve, P., & Tomlin, J.A. (2001, June). *Collaborative structures between the colleges of education and human services and science and mathematics*. Paper presented at the combined Standards-Based Teacher Education Programs Conference of the American Association of Colleges for Teacher Education and the Council for Basic Education, Washington, DC.

Duggan-Haas, D. (1998, April). *Two programs, two cultures: The dichotomy of science teacher preparation*. Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

Duggan-Haas, D., Smith, E., & Miller, J. (1999). *A brief history of the collaborative vision for science and mathematics education at Michigan State University*. East Lansing, MI: ERIC Clearinghouse on Science, Mathematics and Environmental Education. (ERIC Document Reproduction Service No. 443 655)

Duggan-Haas, D., Roetigger, E., Foster, G., Truedson, J., Yeotis, C., Schwartz, R., & Lederman, N. (2000, January). *How we got there, and where we are going*. Paper presented at the Annual Meeting of the Association for the Education of Teachers in Science, Akron, OH.

DuPraw, M.E., & Axner, M. (1997). *Working on common cross-cultural communication challenges* [Online]. Available: http://www.wwcd.org/action/ampu/crosscult.html

Ely, M. (1991). *Doing qualitative research: Circles within circles*. New York: The Falmer Press.

Giroux, H. (1993). *Border crossings: Cultural workers and the politics of education*. New York: Routledge.

Gordon, R.K. (2001, April). *Collaboration for educational change*. Paper presented at the Annual Meeting of the American Educational Research Association, Seattle, WA.

Hammer, D. (1995). Epistemological beliefs in introductory physics. *Cognition and Instruction, 12*, 151-183.

Hitchcock, G., & Hughes, D. (1989). *Research and the teacher: A qualitative introduction to school-based research*. London: Routledge.

Kuh, G.D. (1993). Some implications of cultural perspectives for student affairs. In G.D. Kuh (Ed.), *Cultural perspectives in student affairs work* (pp. 111-124). Latham, MD: University Press of America.

Kuh, G.D., & Hall, J.E. (1993). Using cultural perspectives in student affairs. In G.D. Kuh (Ed.), *Cultural perspectives in student affairs work* (pp. 1-20). Latham, MD: University Press of America.

Lantieri, L. & Patti, J. (1996). *Waging peace in our schools*. Boston, MA: Beacon Press.

National Research Council. (2000). *Educating teachers of science, mathematics, and technology: New practices for a new millennium*. Washington, DC: National Academy Press.

NASA Project NOVA (2002). *NASA opportunities for visionary academics* [Online]. Available: http://nova.ed.uidaho.edu/

Osguthorpe, R.T., & Patterson, R.S. (1998). *Balancing the tensions of change. Eight keys to collaborative educational renewal*. Thousand Oaks, CA: Corwin Press

Roberts, W.L., Busk, P., & Comerford, P.L. (2001, February). *Epistemological beliefs of teacher credential students*. Paper presented at the Annual Meeting of the Southwest Educational Research Association, New Orleans, LA.

Seymour, E., & Hewitt, N. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

Tobias, S. (1994). *They're not dumb, they're different: Stalking the second tier*. Long Branch, NJ: Science News Books.

Tsai, C. (1999). The incongruence between science teachers' (or scientists') views and students' perspectives: A summary of educational research. *Science Educator*, *8*(1), 36-42.

Wolcott, H. (1994). *Transforming qualitative data*. Thousand Oaks, CA: Sage.

Editors' Note: Correspondence concerning this article should be addressed to Kevin Carr, George Fox University, 414 N. Meridian St., Newberg, OR, 97132.

Electronic mail may be sent via Internet to kcarr@georgefox.edu

Appendix A

Characteristics of Teacher Education in Science and Mathematics (National Research Council, 2000, p. 68)

Teacher education in math and science should...

...involve collaborative endeavors developed and conducted by scientists, mathematicians, education faculty, and K-12 teachers.

...help prospective teachers to know well, understand deeply, and use effectively and creatively the fundamental content and concepts of the disciplines they will teach.

...unify, coordinate and connect content courses in science and mathematics with methods courses and field experiences.

...integrate science education theory with actual teaching practice, and knowledge from science and mathematics teaching experience with research on how people learn science and mathematics.

...welcome students into the professional community of educators and promote a professional vision of teaching by providing opportunities for experience and future teachers to assume new roles.

Appendix B

Six Patterns of Cross-Cultural Difference (Dupraw & Axner, 1997)

Pattern of Cultural Difference	Key Illustrative Features Distinguishing Cultural Groups
Communication style	Are similar words used that intend different meaning?
Attitude toward conflict	Is conflict viewed positively or negatively?
Approaches to completing tasks	What is more valued, completing tasks as efficiently as possible, or the development for relationships?
Attitudes toward disclosure	Is frankness and disclosure valued, or considered intrusive?
Decision-making style	Are decisions most often made by delegation, consensus, or majority rule?
Epistemology: Learning, knowing, and teaching	Is information mostly acquired individually through cognitive effort, or through social interaction with others? Are learning outcomes objective or subjective?

Appendix C

Online Survey Administered to Student Participant

1. Describe your involvement with the Science Outreach Program this semester, including the amount of time you spent participating, type of class, and the nature of your involvement collaborator, spectator, teacher, helper, etc. Come up with your own descriptors. Give examples of things you did.

2. How would you describe your experience with science or education culture based on your experiences with Science Outreach? What difficulties did you encounter? How did your experience change as the semester went on (if applicable)? Give specific examples to illustrate your opinions.

3. How would you evaluate the teaching and learning that took place in the Science Outreach courses? Characterize your partners as teachers. Please give examples. How did your views of teaching and learning change as a result of this experience?

4. Give suggestions for improving the collaboration between science and education departments in the future.

Appendix D

Summary of Interdepartment Cultural Differences

Pattern of Difference	Teacher Education Department	Science Department
Communication style	Direct and clear communication is valued but sometimes must be sacrificed to preserve relationships.	Direct and clear communication is highly valued and rarely compromised.
Attitude toward conflict	Direct conflict is avoided, especially in public between colleagues.	Conflict is an integral part of the process of creating knowledge and is often carried out publicly.
Approaches to completing tasks	Tasks are seen ongoing and the process malleable; the building of relationships sometimes interferes with task completion.	Tasks meticulously planned and carried out with efficiency.
Attitudes toward disclosure	Disclosure of weakness, lack of knowledge, or apprehension is expected, and sometimes used to avoid tasks.	Disclosure of weakness, lack of knowledge, or apprehension is avoided.
Decision-making style	Group consensus.	Delegation by authority.
Learning and knowing	Everybody is seen as a co-learner, and knowledge is gained through not only individual effort, but as a result of relationships and dialogue.	Learning is the assimilation of knowledge delivered by experts.