The authors describe a college course merging science and writing.

Interdisciplinary Teaching? It Only Takes Talent, Time, and Treasure

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SUSAN’S STORY—A HIGH SCHOOL, TEN YEARS AGO

It had been a long day. I walked out of my English classroom, down the hall, turned the corner, and entered another world—my colleague Joe Young’s room. I could see him through the cracked door of his workroom storing away a set of slides. I glanced around at his displays. Suspended from the ceiling were molecular configurations. In the corner were stuffed, mounted ducks. His rattlesnakes dozed in their glass cages. An aquarium filled with silvery and multi-striped fish bubbled lazily next to neatly placed rows of microscopes. A cougar head and skin splayed out on one wall. Racks of popular and more scholarly scientific periodicals now sat idly in his reading area. I soaked in the visual richness of his environment and called out to him.

Joe Young taught dynamite courses in biology and earth science to freshmen through seniors in a small town high school, located in a rural corner of southeastern Washington state. I was the junior and senior English teacher with a range of courses from AP English to speech and drama to journalism. I loved the natural world; Young happened to love literature and writing. In the ten years we taught together, we often chatted about our mutual interests that crossed over our distinct disciplines.

It really never entered our minds to teach a course together, despite our deep discussions about nature and writing and literature. Too many factors worked against such an idea at the high school level—rigid schedules, teaching classes during the same time blocks, multiple sponsorships of extracurricular activities, no rewards for the planning and curricular development necessary to teach interdisciplinary, etc. The list can go on, but the one regret I have as I left high school teaching after 13 years is that I never even tried to cross the barriers and teach a course with Joe Young, a gifted and much respected science teacher.

OUR STORY OF REVISION—A COLLEGE, THE PRESENT

It was a crisp autumn morning, and students chatted across the long lab tables as Sherry Southerland, the lead outside evaluator, set up recording equipment in the corners. Three instructors entered the crowded room and joined nearby conversations until the students were asked to get out their science autobiographies. As we began this second class of a newly developed, integrated science course for non-science majors, I, Susan, briefly described my love of nature as a child. My family had lived out in the country on ten acres of land, seven of them left as a forest. I did not become a biology major, however, despite my love of the natural world partly because of my experience with science education. I found science classes and long labs tedious and isolated from my world, requiring daunting amounts of memorization of seemingly arcane terms. I became a high school English teacher, instead—my love of literature and language having hooked me at an early age. As I described my personal and professional journey, I saw some students’ heads nodding agreement.

After this description I turned the teaching “stage” over to an environmental biologist who revealed his love of art and his college beginnings as an art major. Later, a course in botany captured this naturalist’s soul and creativity and turned him to the study of biological science. Again, student heads were nodding.

The third and fourth speakers brought similar revelations. One was an avid swimmer, musician, and photographer, who first became an aerospace engineer and then turned physicist, studying fluid dynamics in particular. The other was heavily influenced by the model of his scientist father who included him in field work, experiments,
and scientific investigations of all types. He became a chemist, physicist, and mathematician all rolled into one. Students listened intently, perhaps reflecting on their own biographies as lovers or haters of science.

Reading the students’ science autobiographies after class gave the four course instructors courage. We wanted to change these students’ orientations to science, using sound pedagogical practices to build on their interests in the natural world and washing away their past negative science experiences. On an instinctive level, we knew we were on to something with this interdisciplinary, team taught course. However, it would take the rest of the semester and the efforts of both course instructors and course evaluators to figure out exactly what was so profound about this innovative way of teaching science through writing.

DESCRIPTION OF THE NATURAL WORLD: EXPLORATIONS IN SCIENCE

Four teachers, twenty students, and three evaluators examining the entire process. Astronomy, biology, chemistry, geology, physics. Big ideas in science. Science as a process. Student-led investigation. Field work. Writing—reflections, summaries, descriptions.

In the fall of 1996, a team of physics, chemistry, and biology professors and a writing specialist began teaching The Natural World: Explorations in Science, an introductory, integrated liberal education science course for non-science majors at Westminster College in Salt Lake City. The course is laboratory-based, exploratory, and writing intensive. Students work in class in collaborative groups designated by tables and out of class in specified project groups. The course is funded in part by the National Science Foundation (NSF). Because of the NSF funding, a team of external evaluators from the nearby University of Utah are involved in all aspects of course development and implementation.

Following the 1993 guidelines for scientific literacy described by the American Association for the Advancement of Science (AAAS), the content of the course is organized around four major concepts in science—energy and matter, constancy and change, diversity and order, and interactions (feedback and equilibrium). The emphasis of the course is toward developing a depth of knowledge as opposed to breadth, emphasizing a small number of fundamentally important concepts instead of the minutia typically embraced in science courses. Gone are the teacher-dominated lectures typical of traditional science courses. Student-based activities punctuated by mini-lectures/explanations are the class norm. Gone also is the sanctity of separate courses for each distinct area of science. Each concept is approached through the lenses of multiple science disciplines. Intra- or inter-disciplinary, this course aims at demonstrating the interconnectedness of all science and knowledge.

David Porush, in A Short Guide to Writing About Science (1995), poses a salient question about science and, in actuality, all of education: “Is science more like reading from a book of facts or more like participating in an ongoing conversation?” (99). Using the latter model, the teachers, as a collaborative team themselves, discuss the biological, physical, chemical, geologic, etc., aspects of whatever activity is the focus for the day. Students, then, explore, question, read about, discuss among themselves, describe, record their data and observations, etc., as they are involved in an ongoing process of doing science in the classroom.

Science Notebooks

What helps to hold the discrete bits of science information together that students are uncovering? Their science notebooks, in particular, become the repository for their unfolding knowledge, their speculations, their changes. As the course instructors approach a topic from multiple scientific disciplines, writing serves an integrating role. Through writing, students are forced to pull together multiple interpretations of a physical event, thus learning the scientific concept in a more meaningful manner (Glynn and Muth 1994, 1057). The primary goal of the writing used in the course is writing to learn, but assignments include both informal, ten minutes at the end of class, and formal, more polished forms of writing.

Variety of Writing

Variety of writing is also a key feature of the course. Some assignments are personal narratives or expressive writing—science autobiographies, personal cosmologies, reflection on what students are learning about the nature of science, etc. Informal, expressive writing can take place at any time during any
class period. Some assignments involve creative writing—the geologic history of a rock picked up during a field experience or the possible life of a brine fly found at the Great Salt Lake. In addition, students are required to keep a detailed science notebook, as scientists do, of their observations, data, drawings, calculations, and notations of related readings that form the basis for their more reflective writing. A formal, collaborative project report and oral presentation cap off this writing-intensive science course.

Integration. Exploration. Collaboration. Process. Reflection. Innovation. Cooperation. These are some of the keys to an interdisciplinary science course. Writing to learn is an integral aspect of each of these, ensuring that the learning occurring in our class is meaningful, contextual, and relevant rather than rote memorization of isolated facts (Holliday, Yore, and Alvermann 1994, 881).

INTERDISCIPLINARY TEACHING AT THE COLLEGE LEVEL
—A RARE SPECIES

It is no surprise to high school teachers that few interdisciplinary courses are taught, but in reality interdisciplinary courses at the college level are also a rarity. It is not uncommon for college faculty within a department or program to remain isolated, sometimes rarely knowing or speaking to other teachers in the same general discipline. The larger the school, the more isolation is likely to occur. Small or large, college or university, however, teaching interdisciplinary courses is tricky business. When it is done, and done well, it is a combination of more than hard work, commitment, and cooperation.

Although Westminster is a relatively small college, with approximately 2,200 students and 100 full-time faculty, it is not a given that faculty will opt to work together to team teach courses or to cross discipline boundaries to develop an integrated approach to knowledge. Resources are stretched thin; faculty have heavy teaching loads of twelve hours per semester and frequently teach overloads so that critical courses are taught. The student/faculty ratio of 14:1 ensures students of their instructors’ time and attention, but the intense interaction leaves little time for curriculum development and innovative teaching. So, why would four faculty decide to create such an interdisciplinary, labor intensive team-taught course, and what are the elements that make such teaching possible?

INGREDIENT #1 FOR INTERDISCIPLINARY TEACHING—TALENT

Good teaching starts with teachers who are knowledgeable and passionate about their discipline. They get excited about sharing their subject with students, and the students recognize their teachers’ competence and enthusiasm for their discipline. Still, why and how would such teachers come together when the model for teaching at the high school and college levels is individualistic?

Sharing a vision of good teaching is what brought two of the teachers involved in the Westminster course together. Gothard Grey, a physics and chemistry professor, and myself, the writing coordinator for the faculty, were both former high school teachers, teachers of and consultants to elementary and secondary districts. Also, we had served on inter-level teams to write new curricula for the elementary and secondary teaching of science or English/language arts. We knew the world of the elementary and secondary schools, and we recognized the possibilities of interdisciplinary, integrated teaching. We both believed college teaching did not need to be so isolated, fact-filled, and deadly dull.

Building, then, on the middle school models of cooperative learning, discovery-based activities, and integrated curricula (Gaskins et al. 1994), Grey and I wrote a grant to give the interdisciplinary team other necessary resources for creating and implementing an innovative way to teach science. But more critical to the course than the traditional resource issues were the actual individuals who would teach it. For this, Gothard Grey recruited Ty Harrison, an environmental biologist, and Chris Cline, a physicist.

Except in very general terms, few journal articles address the critical issue of personnel when they describe a successful curriculum design, a newly implemented program, or a course that fulfills a need in a new way. From our experience, our interdisciplinary team has found that in the case of interdisciplinary teaching, the foremost hurdle is the participants. Their personalities, their teaching styles, their philosophy about teaching and students must mesh in significant ways for successful teaming. The four involved in the integrated science course shared some im-
important features, even though we represented different perspectives on the world. We all:

- shared a curiosity and respect for each other’s disciplines;
- were willing to take some risks in teaching;
- were willing to share the teaching stage with three colleagues;
- were passionate about teaching our subjects;
- enjoyed working with students and watching them grow;
- were willing to commit significant amounts of time to curriculum development, planning sessions, and reflection about our teaching;
- liked and respected the other team members;
- believed from the outset that such intense work would be challenging and satisfying and would provide insight into being better teachers.

At the college and university level, where teaching is an undervalued professional activity, these shared characteristics represent no small accomplishment. No wonder more interdisciplinary teaching takes place in the elementary level where discipline boundaries are routinely crossed in the span of a school day. Those contemplating such teaching in a high school, where discipline boundaries are often perceived as hallmarks of academic rigor, will need to find the right combination of individuals for the work to be done well.

INGREDIENT #2 FOR INTERDISCIPLINARY TEACHING—TIME

In high schools, as well as small college settings, teacher resources are often stretched thin. Teachers teach nearly every period in a day with perhaps one prep block, and they carry a maximum number of students in each class. Even when teachers share a vision for teaching across disciplines with one another, the factor of time often makes the vision fade. Who has more time to devote to designing a new course? When more than one teacher is involved, what is the increase in time necessary for planning and implementation?

In addition to the lack of hours in a day to do the work, teachers are often scheduled in back-to-back classes and rarely share even a planning period with colleagues interested in team teaching. High school schedules are particularly rigid; in some colleges and universities that run programs from early in the morning till late at night, the same schedule problem exists. Unless teachers are extremely committed to making cross-disciplinary teaching happen, the logistics of scheduling can make the idea prohibitive.

If teachers are able to coordinate their other teaching responsibilities to make an interdisciplinary class possible, then they will also need to make time to create the course curriculum. Our teaching team met in three-hour blocks twice a week most of the summer to establish mutual goals and purposes for the course, decide content and lab activities, and get to know each other as much as possible before being up front together. Our interdisciplinary team wanted to be in sync with each other so that we could truly “team” teach.

Once the semester started, the course instructors met weekly for two hours to continue coordinating our teaching, revise our expectations, discuss grading, and reflect on what we did that worked or didn’t work. As an evaluator, Sherry also attended these meetings to provide insight gleaned from the ongoing research of the class. We all found that these committed hours together were essential for a fairly smooth running course with three and sometimes four high-energy teachers. We discovered early on that more than one teacher complicates the process exponentially. Attempting to meld visions and standardize approaches takes a considerable investment of time.

INGREDIENT #3 FOR INTERDISCIPLINARY TEACHING—TREASURE

Even if teachers share a vision and can work out the timing to make an interdisciplinary course possible, the effort won’t be successful without substantial administrative and financial support. As mentioned previously, the course is funded in part through a grant from the National Science Foundation (NSF). Westminster was reviewing its liberal education curriculum, and this course examined a possible model for restructuring other liberal education courses.

Despite the go-ahead from administration, our teaching team realized this course is not only labor intensive but also costly. Putting a team of four into one course for twenty students does not appear very cost effective. Additionally, the outside evaluation was totally dependent on NSF support. Thus, the outside funding from NSF made
summer curriculum work and development during the year and systematic research into this process more feasible for our small school.

If interdisciplinary teaching is desirable at the high school level, then, principals and district administrators will need to provide funding for such an experiment. The costs include:

- scheduled revision time to allow participating teachers to teach and to plan together;
- sufficient summer funds to pay teachers to create the course;
- support from boards for collaborative but labor-intensive teaching;
- funding to pay for both internal and external evaluation and assessment of the course.

**BENEFITS OF INTERDISCIPLINARY TEACHING**

Creating and sustaining interdisciplinary courses is a complex task, so why would teachers choose to be involved? The first reason is obvious—the chance to learn some new things about areas of interest, but in which the teacher has limited expertise. Teachers in an interdisciplinary team grow in the process, sensing the richness that different perspectives bring to a subject.

Probably one of the greatest benefits to team teaching is the opportunity and necessity of becoming a reflective teacher. What was done in isolation before is up for scrutiny as well as admiration in front of teaching peers. For example, when our teaching team sat down for debriefing sessions, we often talked about pedagogy, and those who had been immersed only in their content before had to think about how that content was being delivered to students. Unconscious or automatic responses were made conscious as we discussed with Sherry what outside evaluation was saying to us—her research showed course successes and areas requiring revision. As described by Irene W. Gaskins et al. (1994), this metacognitive awareness of our own unique teaching styles has sparked each of our continual development as teachers.

**Student Gains**

The other benefits, of course, had to do with what our students said they were getting from this innovative course with multiple teachers. Throughout the semester, Sherry video and audio taped class sessions, and she and the other two evaluators were present taking notes of class interactions, content, and activities. Sherry gathered information on students’ science knowledge at the beginning of the course with a series of informal writing prompts plus a standard, true/false test of science concepts. She repeated these exercises at the end of the course to assess students’ conceptual growth. In addition, she conducted an exit interview with each of the students. Thus, we (Susan and Sherry) are able to report some general reactions of students after just the first semester and use this information to inform later offerings of the course.

The evaluation determined that the goal of wanting students to participate in the “ongoing conversation” of science became a reality for the vast majority. Repeatedly they commented on the lack of pure memorization of language, formulae, and facts and the emphasis on “looking critically, to make sense of what you see.” Students also clearly saw the importance of “doing science,” not memorizing isolated bits of scientific knowledge. One student noted that the teachers provided “the tools and the confidence to figure things out on your own.” They found peer groups, discussions at the table, a small community solving problems extremely helpful, and, as one student commented, “You found yourself thinking in class, trying to make sense, which is not true in other classes.” In the terms of Shawn Glynn and K. Denise Muth (1994), students were being asked to *meaningfully* learn science material, requiring them to think, make connections, and see relations.

As Anne Gere noted over ten years ago in *Roots in the Sawdust* (1985), “The measure of success in education should be how well students can think rather than how much of the teacher’s knowledge they take with them as they leave the class” (4). Gere’s comment echoes the call of AAAS in 1993 for students to understand the nature of *how science progresses*, and Richard Duschl’s “knowledge about science” instead of the traditionally stressed “scientific knowledge” (1990, 26). Students’ perceptions in this preliminary assessment suggest that this major goal of the course has been realized.

**Interconnectedness of Knowledge**

The importance of the interconnectedness of the knowledge generated from often isolated scientific disciplines as well as the
interconnectedness of nature came through clearly to students. They appreciated the use of examples from everyday life, the importance of personal learning, and the “new view on the world that shows how everything [student’s emphasis] is related.”

One of the most significant means for helping students to see this interconnectedness, they reported, came from their writing experiences, particularly their project work and their science notebooks. The use of writing to learn was completely intertwined with the hands-on lab experiences in small groups. Labs, discussions, and mini-lectures generated “science entries,” and students followed these in-class recording sessions with longer, more descriptive reflections.

As one student told Sherry, the writing was the way “to make sense, to make connections.” Another student described the power of the writing in the notebooks: “Science notebooks made [student’s emphasis] you make connections to other content areas, made you see interrelationships.” One student observed that she found herself “thinking in class, trying to make sense. [This is] not true in other classes.” Another student made a similar confession: “The reflective writing [in the science notebook] forced me to think, to figure out what I didn’t know, then to go look it up.” Another student said, “Writing helped concretize what I knew.”

Although one student viewed some of the writing as hard, she also admitted, “The daily observations made in the [notebook] made it easy to reflect, to see what you knew, what you need to know. They made you think. You’re always turning things in your head.” Thus, despite the difficulty and perceived tediousness of constantly writing in their science notebooks, students noted over and over “when I wrote in them, it helped me learn a lot. It helped me review, put things together, collect ideas from a lot of outside sources.”

In the terms of the AAAS and its publication Project 2061: Science for All Americans (1989), the course made great gains in allowing students to become scientifically literate. The AAAS defines the scientifically literate person as:

One who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and who uses scientific knowledge and scientific ways of thinking for individual and social purposes. (4)

As demonstrated through the students’ post-course comments, the use of writing to learn was very instrumental in achieving this goal. We came to realize that Stephen Becker’s (1995) thoughts for physics were true for all scientific disciplines:

Writing about physics is learning physics just as is reading the text, hearing lectures, or doing problems.
Writing about physics forces students to come to grips with the material, with what they do and do not understand. (587)

**OUR HOPES—A HIGH SCHOOL, THE FUTURE**

Two teachers—perhaps a Joe Young and Susan Gardner of the future—exchange glances as they watch students gather their things and leave the classroom. They heave parallel sighs and sit together to talk about the just-finished class in environmental science and writing. The work is taxing but exhilarating at the same time. They laugh at the memory of the debate they held before their puzzled students. Each had argued from positions of expertise on the topic but from very different perspectives. They enjoy reading students’ responses to the dialogue. These responses then inform their thinking about how to open the next day’s class.

This class is rich in science and literature and writing. The teachers recognize the demands of the 21st century—demands for citizens who think broadly, who see connections, and who understand that “our lives are built on the natural world and supported by technology” (student quotation from exit interview). These citizens have experience applying what they know to real-life settings. Thus, the teachers collaborate and model the nature of process, using examples from their disciplines, and then invite the students to collaborate and work through the science and writing processes to discover what they think and know. Collaborations, projects, computer simulations, reading primary texts, lively discussions, and hands-on experimentation pervade the class. As Lawrence B. Flick (1995) has described, the intensity that occurs in an atmosphere in which teachers and students form a commu-

The goal of wanting students to participate in the “ongoing conversation” of science became a reality.
Funding and support from administration and colleagues, the working out of teaching schedules and the provision for planning time make an interdisciplinary science and writing class a reality at the high school level. True professional development occurs because the teachers are immersed in each other's teaching, and they have time to reflect on how they help students learn content and processes more meaningfully.

Works Cited


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To Ms. Springer’s dismay, what began as a festive Thanksgiving grammar lesson quickly degenerated into a discussion of turkey rights.

Bob Gassen and Ms. Springer will be celebrating Thanksgiving in Hutchinson, Kansas.