The Internet as a Site for Changing Practice: The Case of Ms. Owens

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Abstract

The Internet has been seen as a resource for reforming education. Researchers and reformers have had some success in developing reform-based innovations using the Internet. However, most teachers who use the Internet are not part of such projects and instead, are developing their own approaches to Internet use. This study explores the experiences of one teacher as she uses the Internet on her own as a tool for changing her practice. Ms. Owens is a high school chemistry teacher who used the Web as part of a unit on nuclear chemistry. Her experience suggests that reform by way of the Internet is complex and challenging; that it makes huge demands on teacher knowledge and time; and that, even with commitment and effort, the results can be distant from the kind of science reform at which the NRC Standards are aimed.

Key Words: chemistry education, educational reform, Internet, teacher knowledge

That mélange [of traditional and novel approaches to teaching] is part of the fascination of Mrs. O's story. Some observers would agree that she has made a revolution, but others would see only traditional instruction. It is easy to imagine long arguments about which is the real Mrs. O., but they would be the wrong arguments. Mrs. O. is both of these teachers. Her classroom deserves attention partly because such mixtures are quite common in instructional innovations—though they have been little noticed. (Cohen, 1990, p. 312)

Over ten years ago, as California worked to reform mathematics teaching and learning, researchers at Michigan State University conducted a series of case studies of teachers who were making their own way with new standards and materials for mathematics education.1 Mrs. O. was one such teacher, expected to teach in ways that met new standards, but with little support for doing so. The cases of Mrs. O. and others provided evidence that the business of changing practice places enormous demands on the subject matter knowledge of teachers and that it challenges deeply held beliefs about the nature of teaching and learning (Cohen & Ball, 1990; Darling-Hammond, 1990). New standards and materials did not turn those classrooms into models of reform. In fact, the California case studies suggest that although teachers may adopt the form, they may miss the substance of reform. Doing hands-on activities with students, using real-world problems, or letting students write and talk about mathematics or science sound like steps in the direction of changing practice. However, if those steps do not include significant attention to subject matter (Cohen, 1990) or if they result in students learning incorrect mathematics (Heaton, 1992; Putnam, 1992), or add more layers to an already suffocating curriculum (Peterson, 1990), they may be steps in the wrong direction.
The case presented here is about another Ms. O., Darcy Owens, a science teacher aiming to make her classroom more student-centered and to move her teaching toward the practices she learned about in her teacher-preparation program. Studying Owens is important for two reasons. First, many teachers are doing what Owens did. They are using the Internet as part of their science teaching and using it in ways that appear to be more student-centered or constructivist than traditional science classrooms (Becker & Riel, 2000; National Center for Education Statistics, 2001). Second, like Owens, many science teachers lack direction or support for their efforts from either internal or external sources (Becker & Anderson, 1999; Cuban, Kirkpatrick, & Peck, 2001; Ronnkvist, Dexter, & Anderson, 2000; Schofield & Davidson, 2000). The case of Owens is used to illustrate common issues that may arise for teachers who teach with the Internet and perceive it as a path toward changing their practice.

Background

Calls for reform in science education promote student-centered, inquiry-based teaching and learning based on the National Science Education Standards (National Research Council, 1996). With access to the Internet increasing rapidly in high school classrooms, advocates of the Internet argue that the wide-ranging, up-to-date content, the possibilities for communication, and other features of the Internet can be a valuable resource for standards-based teaching (Dede, 1998; Pea, Tinker, & Linn, 1999). Research suggests that given adequate support and tools—including curriculum materials, professional development, digital technologies, and technical support—standards-based uses of the Internet can be implemented in science classrooms (Edelson, Gordin, & Pea, 1999; Hoffman, 1999; Riel, 1998; Schofield & Davidson, 2000; Songer, Lee, & Kam, 2001).

However, most teachers are using the Internet independent of research projects that provide tools and support (Becker & Anderson, 1999; Fishman, Soloway, Krajcik, Marx, & Blumenfeld, 2001). Many teachers use the Internet to have students “do research.” This has become the third most common use of computers in classrooms across the United States, after word processing and spreadsheets (Becker & Anderson, 1999), although the category “do research” is ill-defined and can apply to a wide range of activities. Survey research indicates that teachers who use the Internet are, or perhaps become, more constructivist than those who do not use the Internet (Becker & Anderson, 1999; Becker & Ravitz, 1999). These teachers report beliefs and practices that are consistent with current reform standards for science teaching. What is not known, however, is how their constructivist beliefs and practices are actually manifest in their Internet teaching,2 and how they have developed uses of the Internet that are consistent with their beliefs. Outside of the major projects that have designed tools and curricula for standards-based teaching using the Internet, there is little evidence in research about how science teachers incorporate Internet-based activities into their teaching in ways consistent with reform standards.
The purpose of the current study is to explore how a science teacher interested in moving toward standards-based teaching used the Internet in her teaching and what such teaching entailed in practice. Although the survey research cited above provides interesting data about the characteristics and qualities of Internet-using teachers, it does not address the question of what teachers need to consider and do to teach with the Internet in ways consistent with current standards. The following case study illustrates some of the issues one high school science teacher faced in designing Internet activities, interacting with students as they worked on the Internet, and assessing the work students did using the Internet. This teacher's experience is analysed to propose common themes about teaching with the Internet in science classrooms, particularly in efforts to use the Internet in standards-based teaching.

Methods

Data were collected as part of a set of cases of Internet-using science teachers (Wallace, 2000). The purpose of the initial case studies was to develop a framework for analysing and understanding teaching with the Internet to explain why successful or exemplary uses of the Internet have been elusive in spite of the enormous investment in technology and infrastructure over the last decade (Dede, 1998).

This teacher was selected based on three criteria: she was not part of an external project; she had been using the Internet in her teaching for more than two years; and she expressed a desire to change her teaching toward a more student-centered and inquiry-based approach. The teacher, given the pseudonym Darcy Owens for this study, was interviewed before and after a unit of work that included Internet-based activities in her classroom. The pre-interview probed her educational background, experience with the Internet, her reasons for using the Internet, and how she prepared for teaching with the Internet. The post-interview asked for her assessment of the unit she had taught, what she would change or retain for future years, and in what ways she had met her goals. Classes during the unit were videotaped or audio taped with field notes. Video data included classroom video focused on the teacher during three class periods and video focused on the work of one pair of students as they used the Internet during two of those class periods. Audio data were collected from three other classes during the unit, along with field notes from all six classes. Initial coding of the data used tasks of teaching delineated over recent decades by scholars of teaching (Cohen, undated; Doyle & Carter, 1984; Green, 1971; Jackson, 1965; Lampert, 2001; Nardi, 1999). Starting from this initial coding using five different coding schemes, data were analysed using methods of grounded theory to identify themes and hypotheses about this teaching (Strauss & Corbin, 1997).

For example, in the initial coding, data from interviews, video, and audio records were organised in three main categories, preactive or planning, interactive, and postactive or assessing (Jackson, 1965). Within each category, subcategories were used to further specify the task of teaching observed or discussed. Interacting, for example, was divided into interactions with students working on the Internet or off the Internet.
Within the former category (on the Internet), subcategories included monitoring student work, brief content interactions, extended content interactions, and non-content related interactions. These subcategories were created through repeated analysis of the data, as it became apparent that the teachers in the initial study engaged in three relatively distinct types of interactions with students working on the Internet. In addition to subcodes within the initial categories, a sixth set of codes was developed to analyse the challenges teachers addressed explicitly and implicitly during their Internet teaching. From repeated analysis and coding of the data using all six initial categorisations, themes were identified to provide a framework for describing and understanding this teaching.

The Case of Darcy Owens

Owens taught in Middletown, an urban suburb in a large U.S. metropolitan area, categorised in census data as “urban fringe.” Middletown is a middle class community, primarily Caucasian, with one high school serving a population of twenty-two thousand. It is one of many small school districts surrounding a major metropolitan area. The total student population in the district is about three thousand students. The community is aging: in the seventies, the high school had a population of over 2000 students; in the 98–99 school year, it was 738. About 40% of the seniors go on to four-year colleges, and another 40% go on to 2-year technical or community colleges. Middletown High School offers one Advanced Placement course, in history.

At the time of this study, Owens was finishing her third year at Middletown High. She was teaching science, after completing college with a major in biology and a minor in chemistry. She received her teaching certificate after college, in a teacher certification program at a school near her home, and was taking additional courses in pursuit of a Master’s degree.

The science classrooms at Middletown High were renovated the summer before Owens started teaching, and she found herself teaching in a large, air-conditioned, well-equipped classroom. In addition to an on-line computer on her desk, the room included a lab space with sixteen on-line computers; a separate area with student desks, whiteboard, and overhead projector; and a permanently mounted television with VCR connected to the school’s network. Owens taught biology and chemistry, with an average class size of 25. The chemistry class observed for this study was unusually small, only seventeen students, all eleventh graders. Owens shared the chemistry classroom with another teacher.

Darcy Owens was in her third year of using the Internet in her science classes. With seventeen on-line computers in her classroom, she felt strongly that she should be using them in ways that would benefit her students. She said that she and her students were fortunate to have the computers and the Internet connection, especially since the science department was the only one in the school with so much technology. She was frustrated by her inadequate preparation to use computers in teaching. Neither
her undergraduate education nor her teacher certification program had offered classes that helped her learn to teach with technology. Although she graduated from college in the mid-nineties at a time when the Web was becoming commonplace on college campuses, she reported that she had almost no experience using the Web, and none specifically related to her work as a teacher. After she became a teacher she went back to school specifically to take classes about using the Web. In her three years as a teacher, she had entered a Master's degree program, taken a course on teaching with the Web, and attended a conference about integrating the Web into science classrooms. She had a book full of activities and Web addresses for science teaching and she was working to figure out how to use some of those ideas in her teaching.

Ms. Owens was on her own to figure out how to use technology in her teaching. The school and district provided no guidance for computer use. There were a limited number of application programs available, including some science laboratory software that used probes. But these were almost entirely for the physics class, not for the biology and chemistry classes that Owens taught. Owens indicated that she was one of the most frequent and skilled computer users in her school, although she was quick to point out her dissatisfaction with her own level of use, and with her technology skills. In past years, Owens let students use the Internet for research projects, but in the year of the study, 1998–99, she was planning to do something more structured. For her master’s class, she and another student prepared an interdisciplinary Internet unit as their final project. The unit integrated science and history around the subject of nuclear weapons and their effects on the Japanese in World War II. She hoped to actually teach the unit in her high school, coordinating with the history teacher.

Why the Internet?

Owens thought using the Internet was valuable for her students for many different reasons. She identified the following as the five most important benefits for her students:

1. Students can access up-to-date information.
2. It is important for students to learn to use the Web.
3. Using the Web provides variety in the classroom.
4. The Web provides access to information which lets students pursue their own interests.
5. Students learn to evaluate information.

She talked about the importance for her students of getting to use the Web, expressing the belief that the school was providing an opportunity many of them would not otherwise have:

I think it’s good practice if they get used to surfing the Web because my kids are middle class, low income and a lot of them don’t have computers at home so they don’t know how to surf the Web so I think it’s good to get practice. Just you know, just punching in words… I think that’s useful. (Owens, 4/14/99, Line 60)
Owens mentioned several times how important she thought it was for her students to learn to use the Web. She said she explicitly taught them how to get started – turning on the computer, starting the Web browser, and going to a search engine – since many students arrived in her classroom with no experience on the Internet. She felt students were motivated by being allowed to use the Internet, and she thought that an important reason for using it was to pick up on students’ motivation and use it to get them interested in science. These two reasons – that students need to know how to use the Internet, and that it motivates them – came up repeatedly in Owens responses to interview questions and in her interactions with students.

Underlying Owens interest in using the Web for motivating her students was a different kind of idea, though. She talked about her desire to make her classes more student-centered, to teach in ways closer to what she had been taught was exemplary. She envisioned using the Internet as a way of becoming less textbook-bound and teacher-centered. Owens wanted her students to have the freedom to explore new ideas and figure things out for themselves, and she talked about the Internet as providing the opportunity to make that happen. She saw science as something important and relevant to her own life, and she imagined that if students saw the connection of science to their lives, they would find it more interesting. The Internet was a place for students to make that connection.

For many of her students, Owens anticipated that her chemistry class would be the last science class they ever took. She expressed feeling a huge responsibility for having them leave her class knowing some chemistry. When she explained science to them – lecturing or “giving notes” to the whole class – she repeatedly checked with students to see if they understood what she said. She called on students singly and asked them to explain what she had told them in their own words. She asked them to solve problems, explain answers, and to use scientific words appropriately. She usually did not accept answers that were called out, and often called on students whose hands were not raised. She explained her reasons for calling on students regularly and randomly:

I guess you know the reason I do that is just so many of them, they could read a chapter and answer questions and they have no clue maybe even what the general topic is because they’re just copying it from the book, they’re not really understanding. So what I’m trying to check is if they really understand something or how much they really understand something. . . . So a lot of times I’ll explain things and it sounds really simple and elementary but I know that they understand what they’re talking about so I’m happy. And then sometimes I make them use the terminology to make sure that they understand what the words mean. (5/28/99 #141)

Owens style was patient and persistent, her explanations deliberate. She thought she talked too much, but wanted to at least offer a careful explanation of the material presented in the book. In general, her classes were based on the textbooks provided by the school. She reported that no one actually checked to see what she had covered, or even told her what topics she should teach, but that she probably covered about 75% of the chapters in the textbook.

For some topics, she depended on the textbook for her own knowledge. For nuclear chemistry – the unit observed for this study – she used the students’ textbook
(Kroschwitz, Winokur, & Lees, 1995) to prepare for presenting it to her classes. Her lectures on nuclear chemistry, which came after the Internet work described below, followed the textbook closely. Owens prepared overhead slides with which she led students through the chapter point by point. They balanced nuclear equations; practiced using the language associated with nuclear reactions (atomic weight, mass number, proton number, alpha and beta particles, gamma rays, and more); and used the periodic table to identify elements. Owens decided to do the chapter on nuclear chemistry, even though it was not usually included in the chemistry class by the teachers in her school, because she felt it was such an important part of science with so many connections to students’ lives. She knew she was pushing the limits of her own knowledge, but she thought it would present an opportunity to learn along with her students.

Owens described herself as “demanding. I would say that I’m kind of strict. I expect a lot out of the kids; I give a lot of homework. And I like to involve them as much as possible” (Owens, 4/14/99, line 44). She reported that her science classes frequently did labs that were about evenly split between highly structured procedures which students followed step-by-step, and more open-ended labs. In chemistry, students used the computers primarily for word processing and for accessing the Internet for research. Owens mentioned several times her desire to teach in a different, more student-centered way.

You have this model [of teaching] and that’s what you’re so accustomed to, but now in education courses they tell you that’s wrong, that’s wrong, that’s wrong, so you have to switch gears. So, it’s a little bit harder but I think it is better for the kids to have a facilitator. (4/14/99 Line 49)

Although she had in mind to teach differently, she felt she was still talking too much, not giving her students enough control, and not being the teacher she wanted to be.

Planning

Owens used the Web extensively to develop her Master’s class project, spending many hours finding Web pages about Hiroshima and Nagasaki, scientific uses of radioactivity, nuclear power, and nuclear waste. In preparation for her nuclear chemistry unit, she searched again to make sure good Web sites were available so students could be successful, and as a source for her own learning. She described her preparation as follows:

I don’t have much experience with [nuclear chemistry] because we never really learned it but I think it’s important for the kids to know. So, I looked in a lot of different chemistry textbooks that we have. Just like high school textbooks. And I also looked on the Internet a lot for information. And then when I gave them the Internet project, what I basically did was went in and I typed in some of the things, like keywords that I thought they would type in, and I saw what came up. And I looked at some of the Websites just to make sure they could find quality information [about radiation] which of course they can, there’s so many different Websites out there. But I just wanted to make sure that they were going to find what they needed to find. Like I kind of pretended like, this is my activity, how would I go about doing, what would I do. I just
looked at a bunch of different Websites and they seemed to give me the information I needed. . . . (Owens, 5/28/99, Lines 5–9)

Overall, Owens thought preparing for using the Internet was no more time-consuming than for other kinds of classes, just different. She expressed a lot of frustration with using the Internet though, occasioned by getting back too much information and by feeling that she did not know enough about search strategies and how to use search engines effectively. She thought her students were frustrated by the Web, too, and thought giving them more time to use it would help them learn to use it better.

Owens wanted to use the project she prepared for her Master’s class, but she could not coordinate it with the history teacher. Instead, she gave the students a single assignment based on one of the eight activities in her Master’s project. In a change that had important implications for what happened later, Owens switched her focus from nuclear reactions and radioactivity to radiation. Students were to accumulate evidence from the Web about radiation in preparation for a debate about whether radiation was good or bad. In the debate, each student would be assigned to a side—pro or con—and would be responsible for working with his team to present arguments and counter-arguments for their position. Students were required to make fifty notecards with facts about radiation, twenty-five pro or “good cards” and twenty-five con or “bad cards.” They were required to have a bibliography with at least five Web sites listed. Each card was to be indexed to the bibliography, indicating the source of the information. They would be graded on their participation in class while using the Web; on their participation in the debate; and on satisfactory completion of the “good and bad cards” and the bibliography.

It became apparent in the course of the work students did that radiation was a topic too broad to serve Owens’ purposes. However, Owens did not try to correct this error. It was evident in her post-interview and in many of the interactions with students that she did not fully understand how broad the topic of radiation was, and how far it strayed from what she hoped to focus on as the unit progressed.

Interaction: One day on the Internet

On the first day of the Web activity, Owens gave a short introduction to nuclear chemistry and described their assignment for the following four days. Although students had been asked to read the entire chapter on nuclear chemistry as homework the past weekend, Owens anticipated that most of them had not read it. The introductory lecture lasted about 15 minutes. She started this lecture by saying, “Okay, Radioactivity. If something is radioactive, what does that mean? You guys have all heard about it, but what is radioactivity?” She gave a short explanation of radioactivity, explaining that some elements are naturally radioactive, while others can be forced to be radioactive. Then she asked about radioactive elements,

Teacher: What would happen over a period of time? Since it is radioactive it would?
Student: Change.
Teacher: Okay, it would change. How? What would happen to the nucleus?
Student: It would get smaller, bigger?
Teacher: It would?
Student: It has isotopes.
Teacher: Okay, what is going to happen to the nucleus? Is it going to?
Student: There’s going to be a reaction inside of it.
Teacher: Okay, basically, a reaction. And it’s going to decay. So that’s all a radioactive element is. The nucleus decays and gives off radiation which is just energy. So, something is radioactive, whether naturally radioactive or we force it to be radioactive, the nucleus decays and gives off energy which is radiation. Now, when you guys hear radiation do you think good or do you think bad? (5/18/99, Lines 77–85)

Her lecture then moved into giving examples of good and bad things about radiation, touching on cancer treatment. X-rays, nuclear weapons, nuclear energy, and carbon-14 dating. She explained the assignment – searching the web for information about radiation, making good cards and bad cards, creating a bibliography, and holding a debate. She told them they would get participation points for their work on the Internet, and that the winning team would get a special treat, “like a food treat or like a free homework pass.”

She told them that she wanted them to learn to use the Web and to “search, search, search” and that she hoped they would “get a little bit curious about it so when we study the science next week it maybe won’t be quite as dull” (Owens, 5/18/99, line 91). She emphasised importance of learning to take a position and present evidence in support of that position, rather than just giving back information.

After Owens lecture and instructions, students moved to the other half of the room, where the computers were located at lab stations. Four students worked alone, while the others paired up and worked together at a computer. As they moved to the computers, students chatted casually, talking about school events, work, weekend plans and more. The computers had to be turned on, the Web browser started up, and this took a few minutes. Owens moved around the room, catching up with students in casual conversation as the computers started up.

Once all the computers were going, Owens moved around the room observing students work, commenting, and answering questions. Students talked quietly to their partners, and sometimes to nearby neighbors. They knew how to find a search engine and begin searching – Owens gave no instructions during this period about where or how to begin. Students searched using Yahoo, AskJeeves, or other search engines, taking notes as they went and discussing what they found. There was plenty of quiet talk, on and off task, but students seemed to know the limits within which they could combine work and socializing, and the class moved along smoothly.

During the thirty minutes students worked on the Internet, Owens interactions with them took four forms: monitoring, short content interactions, extended content interactions, and social exchanges, as shown in Table 1. The latter occurred mostly in the first part of the session, as the students moved to computers and turned them on. Monitoring interactions consisted of Owens asking questions like “Are you finding what you need?” or “Are you doing ok?” with an affirmative student response. Figure 1 diagrams Owens’ movement around the class, and shows the type of interaction at each point.
Table 1

Obens Interactions with Students, 5/18/99.

<table>
<thead>
<tr>
<th>Type of interaction</th>
<th>Number</th>
</tr>
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<tbody>
<tr>
<td>Monitoring</td>
<td>14</td>
</tr>
<tr>
<td>Quick Content</td>
<td>9</td>
</tr>
<tr>
<td>Extended Content</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
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</tbody>
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Figure 1: Obens movement on May 18, 1999.
During short content interactions, defined as interactions that included discussion of some aspect of radiation and lasted less than one minute, Owens answered questions or commented on something students were working on. For example, Owens noticed two students looking at a Web site about smoke detectors (#19, Figure 1).

Teacher: How are you guys doing? Oh, this is a good one. Smoke detector. That is a good one that I didn’t mention.
Student: Yea, but it doesn’t let out much radiation and then most of it’s absorbed by the plastic.
Teacher: Okay, so it’s a good use of it then. Used to make smoke detectors. (Moves on to next interaction) (5/18/99, lines 256–258)

In two instances, when she stopped to respond to students she took a much longer time, going into a detailed explanation, or pushing them to explain what they had found. These were extended content interactions, as long as five minutes. For example, one such interaction (#17, Figure 1) was prompted when a student asked, “Hey, do you want to explain radiation again please? I don’t understand it.” In response, Owens got out a piece of paper and pencil and gave the two students a short lecture on nuclear chemistry, drawing a picture of an atom and showing how a nuclear reaction differs from other kinds of chemical reactions. An excerpt from the middle of this five and a half minute interaction gives the flavor of the work she was doing with these two students. During this interaction, Owens was pointing to the diagram she had drawn.

Teacher: Okay, see for this right here. Nothing happens to the protons here. Nothing happens to the protons and neutrons here. So the only thing that is changing is the electrons.
Student: So then that’s like the same thing as radiation or . . . ?
Teacher: No. This is something totally different because now with radiation, the nucleus is actually changing. Before here, with regular bonding.
Student: The change was in the electrons?
Teacher: Exactly.
Student: In radiation, protons change?
Teacher: With radiation now we have a nucleus with protons and neutrons. This is getting broken down. Not necessarily in half but it’s losing some protons, it’s losing some neutrons. When that happens, energy is given off. Right? Because these two are being held close together. When they break apart, energy is going to be given off. So that energy is in the form of radiation. (5/18/99, lines 211–217)

An interesting aspect of this interaction is that it was unrelated to what the students were doing on the Internet. Their question was more general and basic. They were not sure what they were supposed to look for and asked for more information about radiation. What Owens explained was not radiation in any general way that corresponded to the assignment, but rather a nuclear reaction.

In another extended interaction (#26, Figure 1), Owens stopped to ask two students what they were finding. One student responded, “Yea, I found a Web site that’s got like the pros and cons of everything.” Owens pushed him on what he meant by that, asking for examples from the Web site. He pointed to content about the value of nuclear weapons, and she pressed him to explain why he believed those arguments, and particularly, who provided the information he was relying on. In this five-minute
interaction, Owens and the students moved back through Web links to identify the author or source of the Web site, eventually finding that it came from a nuclear weapons manufacturer:

And then read that and make sure you understand what perspective they’re coming from because some people put out some crazy stuff on the Internet. Nuclear weapons assembly and disassembly, facility. The only one in the United States. So remember that when you’re reading this stuff. And try to, if you see something on here, especially if it sounds a little outrageous, make sure you can find it somewhere else. A spot where maybe it’s a little more credible. (5/18/99, line 335)

As shown in Table 1, during this period, when students spent about thirty minutes on the computers, Owens had thirty four distinct interactions with students, of which the largest number (14) were monitoring interactions. With the exception of the two extended interactions described above, all of the other content interactions were instances when Owens responded to something on the screen by joining into the students’ conversation. The example of the smoke detectors given above is typical: science was in the background at most, while social, political, or even commercial issues were discussed. Often, Owens simply indicated her interest in the topic students were looking at, offering her opinion about information the Web site presented. These were short interactions, based on mutual interest, but not closely related to “the science” of nuclear chemistry.

Two subsequent days on the Internet were similar to the first: Owens’ primary mode of interaction was monitoring student work, with few extended interactions about content.

Reflection

Owens assessed student work on the radiation project in three ways: participation during the on-line work, completion of the fifty note cards, and participation in the final debate. During the on-line work, Owens noted what students were doing and recorded points later. As she described her process,

I just keep track of participation points in general. Like if somebody – I can kind of remember who’s working and who’s not. And if somebody is really doing something blatant, then I usually remember it but if I think I won’t remember it then I write it down. (Owens, 5/28/99, line 73)

In the end, most students got full points for participation while on-line. The note cards were graded with letter grades A–F based on content and completion. Owens had specified what was to be included (the fact or data from the Web and the bibliographic reference), the number of cards (25 “good” and 25 “bad”), and the number of different sources (at least five). Students were graded on whether they met these criteria. In addition, Owens said that she considered the substance of the data on their cards as part of their grade. Her process was subjective – no specific rubric was applied to come up with a grade. Students received grades ranging from A to F on the cards.
Finally, she gave each student points for participation in the debate, a subjective evaluation of how they did. The debate occurred five days after the session described above, after students had spent a total of three days using the Internet to find their facts. In the debate, students offered ideas about subjects ranging from X-rays to nuclear waste in a wide ranging and sometimes heated discussion. Owens reported that she liked the fact that they got involved and interested during the debate, but she was disappointed that there was little evidence of the science of nuclear chemistry in their arguments. She repeatedly expressed her concern and disappointment that students had not made the connection between what they found on the Internet and “the science.” She gave herself and the unit a “C,” expressing disappointment that she had not been able to tie their work on the Web closer to the science in the chapter.

After the debate, Owens continued the nuclear chemistry unit in the class with several days of lectures and homework, covering the topics in the textbook. In the end, the only documentation Owens had for student work on the Internet was the set of note cards. Students were not expected to use what they had found on the Web either for further assignments, or for the test on the nuclear chemistry chapter.

Discussion

The brief description of the case of Ms. Owens above is intended to represent the days she and her class spent on the Internet. Throughout the unit, interactions were short and lacked a focus on science. The topic of radiation took students far afield, from sites selling radar detectors to sites with information about solar energy. Owens spent most of her time monitoring student work, and students spent most of their time browsing the Web.

From another perspective, though, the unit was a success. Owens achieved two of her main goals: getting her students interested in what they found on the Internet, and giving them some practice and experience using the Internet. It is possible that achieving those goals was more important for these students than what they might have learned if Owens had designed an activity more squarely focused on radioactivity, and more closely connected to nuclear chemistry. However, this study did not attempt to assess either whether those goals were actually achieved or their impact on students. In spite of feeling that she accomplished those goals, Owens was not satisfied with what students did during the unit. She felt they never made a connection between their work on the Internet and the science they learned later from the textbook and her lectures. She reported that, although they were motivated by using the Internet, they were mainly motivated to find interesting information, not to consider how that information related to chemistry.

In Owens’ classes, information from the Web was used to initiate conversation. Owens moved around the room talking about what she saw students doing, contributing her ideas to theirs in a creative discourse, but almost always in a non-scientific way. She wanted students to participate in this discourse to get them involved with
ideas she thought would bring them closer to science. Information was the vehicle for student participation. They talked to each other, they talked to Owens, and they finally debated in a whole-class forum, talking to everyone. The content of their discourse was the information from the Web, and the ideas that information led them to think about. What was missing from this discourse was chemistry: connections to science that might have engaged students in understanding radioactivity and nuclear reactions.

Challenges

Owens was not satisfied with what happened in this Internet unit. Her dissatisfaction was based on the distance she perceived between what students did on the Internet and in the debate that followed, and the science of nuclear chemistry that she intended for them to learn. The following section discusses the challenges that Owens faced in planning and teaching this unit: managing multiple student trajectories, assessing student work, managing unfamiliar content, and planning for the unknown. Each is discussed below.

Managing multiple student trajectories

In her movements around the room while students worked on the Web, Owens had few resources available to help her keep track of what each student was doing, or of the threads of conversation she was involved in. As a result, most interactions started anew, without building on what had happened before. Unlike some other kinds of seatwork during which the teacher monitors progress and interacts selectively with students, the artifacts of student work on the Web are inherently sparse. There is no trace of what the student has worked on, what he has thought or understood, or where he is heading. In Owens’ class, there was little for her to work with except her memory of past conversations. She had no artifacts and no common knowledge to build on.

Assessing student work

At the end of the unit, Owens had very little to go on in assessing what students had learned. There were some indicators: each student turned in fifty note cards with evidence and citations. Owens reported that she graded these loosely, for completion but not substance. The debate itself was free-form enough that not every student had the same opportunity to demonstrate what he had learned, and, for the most part, it was impossible to tell whether students were using evidence they found on the Web, opinions they held prior to this work, or ad hoc constructions of ideas as they debated the wide-ranging issues that came up. Content from the Web activity was not assessed formally on a quiz or exam. In the end, Owens had little evidence about what students learned from the Internet activities.
Managing unfamiliar content

The assignment opened the doors to content with which Owens herself was not familiar and put her in the position of "teaching more than you understand" (Floden, 1997). As a student of biology and chemistry in college, Owens had extensive content knowledge, but seemed to have compartmentalized that knowledge so that things that she knew as science were not readily available to her in non-scientific interactions. In this case, Owens had not developed an understanding of various forms of radiation, how they are related to each other, and how they relate to nuclear chemistry. This lack of knowledge let her change the topic from "radioactivity" to "radiation" without realizing the impact that would have on the assignment. By her own report, much of the content was new to her, and she was learning with the students. She expected to be able to work in this general domain without needing a detailed, readily accessible map of the sort she used to prepare her lecture notes. However, in practice, her interactions with students became non-scientific, mostly staying in the realm of ideas and opinions about science. In part, this was a deliberate strategy: her goals were to get the students interested and give them some experience with the Web. But in part, it was a result of a mistaken belief that interest in Internet information would naturally or automatically translate into interest in science. Detailed analysis of Owens interactions with students reveals that she rarely pressed them to explore the science behind the claims they were finding on the Internet, either by pushing on the science that could explain what they were finding (e.g., how is the amount of radiation a person receives measured and quantified?) or by pressing them to understand evidence for the claims (e.g., what are the actual assertions this Web site is making and how are they substantiated?)

The argument has been made that teachers can, and perhaps should, teach more than they know, functioning as a facilitator and guide rather than a source of knowledge (Collins, 1996; Floden, 1997). Owens jumped in headfirst and gave it a try. In Owens' interactions, it often seemed that she was not aware that she herself did not know the connection between nuclear chemistry and the content students encountered. Not knowing that she did not know, she missed opportunities to model her own learning process. She felt a connection between the political and social issues and the science, but had not articulated how they were connected scientifically. For Owens, the fact the social issues had to do with science was enough. What was missing was an understanding of how science is entailed in each of the issues. In this instance, she did not have a detailed conceptual map of the scientific terrain of radioactivity, of the social issues and controversies entailed in uses of radioactivity, of the kinds of evidence and warrants which could be used to support claims about radioactivity (which include claims about biology, chemistry, medicine, physics, and more). To the extent that she lacked any of that knowledge, she needed to know where her expertise stopped, and when and how to model her own learning processes for the benefit of students.
Planning for the unknown

Owens spent a lot of time preparing for the radiation activity, but she did not spend that time thinking about and planning for how she would help students translate between Internet information and nuclear chemistry. She assumed, as many do, that the Internet is “just another tool” that delivers information. Owens did not anticipate the challenges of teaching with a virtual medium, nor did she anticipate what content students would encounter and how she would use that content to mediate students’ understanding of nuclear chemistry. She believed that it was adequate to verify that reliable content was available on the Internet about radiation, and easy to find. What she did not plan was what her learning goals were for students as they used the Internet, and how she would interact with them to pursue those learning goals. Her planning strategy assumed that mere encounter with content about radiation would offer opportunities for students to learn.

Themes

What can we learn from the case of Ms. Owens? Several themes emerged from analysis of data in the case presented above. They are: 1) the importance of learning goals; 2) the significance of the question(s) students are asked to pursue; 3) the possibility of a disconnect between interest (motivation) and learning science; 4) the importance of the teacher anticipating and attending to students’ engagement with content; 5) the importance of the teacher’s subject matter knowledge.

The importance of learning goals

With respect to science, Owens did not establish clear learning goals for her students. Although she accomplished two of her stated goals – giving students more time to use the Internet and getting them interested in the content they found on the Internet – that success did not translate into increased interest in nuclear chemistry or into enhanced learning of nuclear chemistry. Owens assumed that there would be a crossover or connection between what students did on the Internet and the science of nuclear chemistry. She thought this would happen because of their interest what they found on the Internet. But she did not think through what she wanted them to learn from the Internet or how it might connect to what she planned to teach in the nuclear chemistry unit. Her learning goals, at least with respect to nuclear chemistry, were entirely unspecified in the Internet unit. Developing learning goals challenges intuitive notions about “student-centered learning,” which imply that students should be in charge, even setting their own learning goals. Yet research in science teaching has demonstrated repeatedly that meaningful learning through inquiry requires establishing learning goals (Crawford, 2000; Edelson, Gordin, & Pea, 1999; Songer, Lee, & Kam, 2001).
The significance of the question(s) students are asked to pursue

Even without well-specified learning goals, the students might have made connections between their Internet work and the nuclear chemistry unit if the question they investigated had led them to do so. But the question—"What are good and bad things about radiation?"—was so broad and unrelated to what she hoped they would learn later, that their Internet work was mostly unrelated to the science of nuclear chemistry. A question that was clear, that gave direction to their investigation, and that specifically asked them to connect issues from the Internet with science might have produced entirely different outcomes. This is consistent with prior research that has suggested the key significance of the "driving question" for project- or inquiry-based science (Blumenfeld et al., 1991).

The possibility of a disconnect between interest (or what Owens called motivation) and science learning

Owens assumed that if students found interesting information about science on the Internet, their interest in learning about the science would increase. In practice, the students were interested in content on the Internet, but Owens felt that their interest did not translate into an interest in the detailed nuclear chemistry she later presented. For Owens herself, the information she found on the Internet piqued her interest in science, and she assumed the same would happen for her students. She did not consider techniques for converting their interest in specific Internet information into an interest in nuclear chemistry. This is an interesting pedagogical problem that arises across subjects: how do you turn an interesting real world problem or issue into an opportunity to learn content? This problem has emerged repeatedly in efforts to reform both mathematics and science education, as problems that have a real world component are inserted into the curriculum as if they could cause student engagement with the mathematics or science (Cohen & Ball, 1990; Edelson, 1998). Yet, research suggests, and this study confirms, that a task or problem is neither motivating nor engaging except through its enactment by teachers and students in the classroom (Blumenfeld, 1992; Doyle & Carter, 1984; Edelson, 2001).

The importance of the teacher anticipating and attending to students' engagement with content

Owens prepared for teaching the Internet unit by doing searches which verified that students could easily find interesting content about radiation. What she did not do was prepare for how students would interact with and react to that content. Given the nature of the activity she designed, it would have been a difficult to undertake such preparation. Nonetheless, without anticipating what students already knew and what help they would need in order to make a connection between Internet content and nuclear science, Owens was unprepared to help students make those connections. Other researchers provide vivid descriptions of both the need to anticipate
and respond to students, and the difficulty of doing so in inquiry-based environments (Lampert, 1995, 2001; Scott, 1995). In the current study, Owens’ experiences illustrate that the difficulties entailed in changing practice through the use of technological tools are not a function of the complexity of the tool, but rather reflect the complexity of the teaching and learning per se.

**The importance of the teacher’s subject matter knowledge**

If Owens’ understanding of nuclear chemistry had been extensive, many aspects of this unit would have been different. Most significantly, it is unlikely that she would have included all of radiation in a unit in which she intended to end up focusing on radioactive materials and nuclear chemistry. She was not sure what she needed to know or what she wanted students to learn. She was willing to try this approach because she thought it would help her to become a more student-centered teacher. One can imagine that if she had taught an Internet unit in a topic she knew well, it would have looked quite different from this radiation unit. Although there has been a push for teachers to be less concerned about having authoritative subject matter knowledge, it is clear from this study and from other research in both mathematics and science education that teaching in inquiry- or problem-based modes places enormous demands on teachers’ subject matter knowledge (Crawford, 2000; Edelson, Gordin, & Pea, 1999; Heaton, 1992; Lampert, 1992; Schneider, Krajcik, & Marx, 2000). While the teacher may not need to act as a subject-matter authority, evidence suggests that she must have a depth and breadth of knowledge that arguably exceeds what is required to deliver a good lecture.

**Conclusions**

The five themes that emerged in the case of Ms. Owens point to three important lessons about teaching with the Internet. These are lessons that have been learned in other contexts, but the enthusiasm for teaching with the Internet has resulted in a glossing over of the substantial curricular and pedagogical challenges such teaching entails.

1) The Internet is not a magic bullet. It does not teach but requires careful planning and mediation to produce opportunities for students to learn. This lesson has been learned and relearned as new technologies take center stage in the public eye, each arriving with optimistic, nearly utopian predictions for changing schools and ending up with disappointment and blame as the predictions are not met (Cuban, 1986, 2001).

2) Creating curriculum is complex and challenging work that requires extensive subject matter knowledge, careful planning, and considerable time. Making new Internet activities is a form of creating curriculum, and it should not be treated as merely using a new tool. Researchers in major technology projects have learned this lesson, as they turned from merely creating tools and making them available to
developing curriculum and providing extensive professional development for teachers participating in their projects (Cognition and Technology Group at Vanderbilt (CTGV), 1997; Edelson, Gordin, & Pea, 1999; Reiser et al., 2000; Schneider, Krajcik, & Marx, 2000). Some of these projects have begun to directly address the issues of scaling up to include teachers who cannot directly interact with the project personnel who created the tools, curriculum, and initial implementations in classrooms (Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2000; Edelson, Gordin, & Pea, 1999; Fishman et al., 2001).

3) Getting students engaged in classroom activities that include science is not synonymous with providing them opportunities to learn science. Teaching and learning science in classroom contexts are intentional acts that require planning, complex interactions, and meaningful assessments, not merely doing something interesting or fun. Although there has been considerable research investigating the complex link between doing and learning (e.g., Bereiter & Scardamalia, 1989), research in technology has often been wooed by the glamour of the tools into ignoring how complex this translation from doing to learning can be.

In some ways, Owens created a successful Internet activity: the students were engaged and motivated as they used the Web, she moved right into nuclear chemistry without a hitch; she came away with some ideas about how to do it differently next time. She realized that the unit did not have the impact she had expected on students’ motivation to learn nuclear chemistry, or on their understanding of social and political issues related to nuclear chemistry, and that disappointed her. But, in many ways, her experiment was a success. She talked less, the students controlled their own work, and they explored information about radiation. The students seemed to enjoy their time on the Web. Owens conducted what she called a “student-centered” Web-based unit in a high school chemistry class. These results provide a cautionary note to the optimistic results of the CRITO surveys, which suggest that teachers who teach with computers are more constructivist and student-centered (Becker & Riel, 2000). Owens would surely appear on that survey as becoming more constructivist or student-centered, and yet, like the Mrs. O. from the California case studies, she has changed the form, but not the substance of her teaching. The results also suggest that the category of “doing research” – now the third most common use of computers in schools (Becker & Anderson, 1999) – can include a range of learning experiences, from banal to profound. The category alone is not enlightening.

The big lessons to learn from Ms. Owens return to the lessons from Mrs. O. (Cohen, 1990). Changing practice is a complex endeavor that requires more than new materials or new technologies. What appears on the face of it like student-centered (or reform-based, or standards-based) teaching can in fact be only a small, first step in that direction. Teachers using the Internet to change their practice will not find any shortcuts to attaining their goals.
Notes

1. These case studies appeared in Educational Evaluation and Policy Analysis, 12(3) and The Elementary School Journal, 93(2).

2. “Internet teaching” is used here to mean using the Internet with students in a classroom, lab, or library, with the classroom teacher present. This excludes using the Internet to prepare for teaching, as a source of lesson plans that are then used independent of the Internet, or as a source of materials that are printed out and used in classes.

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