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9. ENHANCING SCIENCE EDUCATION THROUGH AN ONLINE REPOSITORY OF CONTROVERSIAL, SOCIOSCIENTIFIC NEWS STORIES

Scientific literacy involves the engagement of authentic science, technology, and environment issues by applying scientific knowledge and fundamental literacy (Yore, Chapter 2 this book). This project and its series of studies explored how students and teachers responded to an innovative instructional resource—*Science Times*—designed on contemporary and controversial issues. The importance of this effort is to establish relevance for science and environmental education by using contemporary, local news issues to challenge students and the related teaching approach to critically engage students. Case studies of the resource and teaching approaches are used to document student and teacher learning and reactions.

Science Times (ST; 2011), first and foremost, represents a proactive response by teachers to the call for current, authentic news stories in science. It was born out of our frustration with the rate at which science in textbooks becomes outdated, the limiting perspective of science that is often conveyed to students, and the apparent lack of relevance of a traditional science education to students' everyday lives. From its beginning, our project attempted to reflect the changing nature of science and the implications these changes have for society, especially in an age when socio-scientific issues (SSI) inundate the media (Reis & Galvão, 2004). It is our contention that students require certain skills to make sense of the world around them, specifically, the ability to recognize and understand the issues they face, identify key stakeholders, appreciate the multiple perspectives accompanying each issue, demonstrate open- and fair-mindedness when formulating an opinion, and make reasoned judgments based on ethical principles.

The structure of this chapter, like the ST Project, employs an autoethnographic reporting style in which "researchers constitute their own object of research so that the knowing subject and the research object become one" (Roth, 2005, p. 109). This has been achieved by juxtaposing a conversation that takes place between the researchers looking back on their experiences during the project with four detailed case descriptions that capture the essence of these experiences and the literature that supports it.

L. D. Yore et al (Eds.), Pacific CRYSTAL Centre for Science, Mathematics, and Technology Literacy: Lessons Learned, 149–163.

BACKGROUND

What are Socioscientific Issues?

SSI education is issue-based education where issues in scientific content are examined in their social, environmental, cultural, moral, legal, and personal context. SSI education differs from science, technology, society, and environment (STSE) education in a number of ways. Ratcliffe and Grace (2003) provided a comprehensive list of descriptors referring to the nature of SSI; a partial list includes:

- have a basis in science
- involve forming opinions
- deal with incomplete information due to nature of science (NOS) issues
- address local, national, and global dimensions of society and politics
- involve cost-benefit analyses in which risks interact with values
- involve values and ethical reasoning.

Abd-El-Khalick (2003) articulated the nature of SSI, describing the issues as ill-defined, multidisciplinary, heuristic, value-laden, and constrained by missing knowledge. He compared SSI to STSE issues, which are fully defined, driven by available and focused disciplinary knowledge, algorithmic, and objectively oriented and engaging the right procedures that often result in a single right/wrong answer. Zeidler, Sadler, Simmons, and Howes (2005) argued that SSI is not just a context for curriculum, like STSE, which can be ignored or used only marginally when introducing scientific content. SSI is a pedagogical strategy that stimulates and promotes moral and ethical development along with understanding the science–society interdependency. An important point to clarify is that SSI education recognizes the personal beliefs of the student when examining issues instead of the removed objectivity of STSE.

Conceptual Frameworks

The conceptual framework for SSI education suggested by Zeidler et al. (2005) addresses four socioscientific elements of pedagogical importance: discourse issues, cultural issues, case-based issues, and NOS issues. These issues can be thought of as entry points into the science curriculum that inform pedagogy in science education and as topics to guide implementation of SSI in the classroom. Furthermore, these issues contribute to personal cognitive and moral development that leads to functional scientific literacy. This proposed framework encourages further research in each area and addresses many of the issues raised with STSE education.

Interestingly, another conceptual framework has been proposed. Levinson's (2006) epistemological framework includes three categories: reasonable disagreements, communicative virtues, and narrative or logico-scientific modes of thought. He argues for the term *reasonable disagreements*, rather than controversial issues, and that they incorporate moral and social values. Communicative virtues include those that are necessary for having conversations addressing reasonable disagreements and across differences. The modes of thought are distinct ways of thinking that can be reflected in reasoning about reasonable disagreements. Narrative modes

of thought seek to interpret logico-scientific modes of thought. Levinson expressed this framework using different vocabulary; however, his three categories are quite similar to the four components of Zeidler et al. (2005). Reasonable disagreements are similar to case-based issues. Communicative virtues arguably are the same as discourse issues, and modes of thought are similar to cultural issues. Zeidler et al. go beyond Levinson by including a fourth issue, NOS, when approaching SSI education. Also, they do not attempt to categorize the possible facets of each issue; rather, they provide an umbrella term under which all voices, reasoning patterns, and cases fall.

Challenges and Limitations to SSI Education

It can be said that SSI education suffers from the same problems as environmental education. These problems, or challenges to the implementation of issue-based curricula, have been well articulated. Stevenson (2007) argued that there is a discourse–reality gap between the language and pedagogies surrounding environmental issues that was not being reconciled with the current standards of classroom practice. As well, the traditional role of schools, teacher pedagogy, teacher attitudes, and the need to maintain authority have hindered the inclusion of environmental issues. Therefore, it can be posited that challenges to environmental education are the same as those facing SSI education.

As research continues on SSI education, one area of interest is implementation. Will educators employ issue-based education in their classrooms? Bringing SSI into the classroom is challenging and requires an awareness of NOS issues and epistemological considerations; both involve reflective practice and potentially forfeit the teacher's authority role (Abd-El-Khalick, 2003). It remains to be seen how these issues are dealt with by educators and how successful SSI education can be in the long term. This then is the focus of our research as part of the Pacific CRYSTAL project—and particularly around the development of a purposeful SSI resource for teachers.

CONTEXT AND METHODS

When the Pacific CRYSTAL Project began in 2005, *Science Times* was conceptualized as a 1-page article featuring current events in science with an accompanying student activity sheet. The editor subscribed to over 50 online science news feeds and then selected stories according to the following criteria: an issue that students find relevant, involves multiple stakeholders, and no clear solution to the problem. Each story was edited to produce three versions accommodating basic, intermediate, and advanced reading levels. Since then and while maintaining its original mandate, ST has grown into a collaborative of partners from the science education community (e.g., science centres, teachers, schools, and school districts); and it has moved to an online delivery model (http://sciencetimes.ca/) in both of Canada's official languages (English, French), with plans for a Spanish version. Most importantly and as this chapter will illustrate, it has sparked the development of a unique pedagogical

approach that disrupts the traditional power structure in science classrooms by empowering students to engage in open-ended discussions about controversial SSI.

The research for the following four case studies and dialogue has been collected over the period 2007–2010. Three cases were conducted at an island community school in which one of the authors is a local researcher assisting with the execution of the school's environmental action plan. This is noteworthy because it afforded the project a special status that is not normally granted to outsiders. As a result, the staff welcomed and participated in the study. Two other elements included in the research pertain to each coauthors' interest in sharing the resource and teaching strategy with a broader spectrum of educators.

The data connected to the ST Project are presented in several ways. In the first two descriptive studies, ST is a resource that is used with several elementary school classes. In the third case, ST inspires an approach to controversy but does not actually act as the content source for it. The final case study considers the use and application of ST pedagogy with secondary school teachers.

The data for these studies were collected as video recordings, interviews, and personal accounts. These data are presented in chronological order to show the temporal developments from one case to the next. For each case description, they are introduced and summarized then given a more detailed commentary. Coauthors are identified by their first names.

Case 1: An Emerging Pedagogical Approach to the Resource Science Times

Two classes of Grades 6/7 students ($N \sim 60$) and their teachers file into the school library. To create an atmosphere of sharing, they are invited to sit in a circle. One teacher is proactive and uses the age-old classroom management technique of having the students sit boy-girl. Today, Susan tells the group that she is conducting some research into the feasibility of using biodegradable plastic in this island community. She adds that she has come from Simon Fraser University to spend an hour or so with them to learn their position on an environmental issue highlighted in the latest article of ST.

In preparation for the discussion, students were asked to read a 1-page news story presenting an issue involving biodegradable plastic that their teacher downloaded from the ST website. During this lesson, Susan will invite them to actively participate in a discussion so that they may develop their abilities "to express an opinion on important social and ethical issues with which they will increasingly be confronted" (Millar & Osborne, 1998, p. 9). If she is successful, students will engage in the conversation, despite the facts that they may not be familiar with the issue, she is a stranger, and they may not fully understand the science behind the making of biodegradable plastic.

The discussion begins with the question: What is considered newsworthy in the article? This is an excellent way to begin the conversation, especially in this case where Susan does not know the students. This approach is important because it allows a teacher to ascertain (a) the students' background knowledge of the topic and (b) what concepts may require further explanation before beginning the discussion.

In practice, this technique also can serve as an informal reading comprehension check regarding the language and terminology in the news story.

This experience is important because it is the first time in which teachers of this community school will be exposed to ST. They will observe and possibly engage in a demonstration lesson of an unusual, pedagogical approach to using this news resource in the classroom. According to Susan's experience, it is during firsthand experiences that teachers witness the powerful exchanges that can take place within a facilitated dialogue with students, which is the most effective way to share the resource. However, this is not an easy task for teachers; two common complaints by teachers that are often reported when considering the inclusion of SSI activities are lack of adequate training and lack of time (Hermann, 2008). It is our expectation that, once these teachers see how highly engaged their students become and the pedagogical practices used to stimulate debate (argumentation) and manage participation, they will become supporters of the resource and be more inclined to add this technique to their teaching repertoire.

Perhaps the most significant aspect of this question-led, facilitated process is the idea that it has the potential to invert the power dynamic from teacher as *knowledge bearer* to teacher as *information gatherer* or, in more popular terms, the "guide on the side, not the sage on the stage" (Christenson, Horn, & Johnson, 2008, p. 39). The task of the teacher is to conduct an inquiry into the students' positions on the issues found in the news story. However, there is a key element that is required to carry out this task successfully: The teacher must begin by adopting an unpopular, uncommon, or fringe position in the controversy.

In today's scenario, Susan is urging students to embrace the idea of biodegradable plastic because she has guessed that they will be more inclined to take the opposing position of avoiding plastics because they lead to pollution.

> SUSAN: Now might be a good time to explain why taking the unpopular position is critical to setting the stage for this teaching strategy. David, how did you first start using this approach?
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> DAVID: Well, I remember that it became important because often participants will not appear to have an opinion even about the most pressing scientific issues of the day. … The reasons for this are complex. A few years ago, I presented an issue about mad-cow [BSE] disease to a group of teachers at a local science conference using *Science Times*. To my concern, initially many seemed indifferent to the question as to how many or whether or not cattle should be culled in response to the outbreak … my sense was that many felt it was unsafe to voice an opinion and this frustrated and surprised me.
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> SUSAN: So what did you do to get participants more engaged with the topic?
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> DAVID: Well, in my customary style, I used a bit of dry humour and then adopted a 'Hindu' perspective on the issue—stating that not one cow should be harmed and that we had no business eating cows anyway—that it was unethical. … That really proved to be a fringe position—the conference was in Alberta—and that really opened up the conversation as people began to react

> strongly to my tongue-in-cheek position … I think it worked because it opened up the possibility to critique me as the speaker and to probe the issue a bit more.

In our experience, if a teacher does not have a strong sense of the students' positions in advance, the teacher can simply poll the students at the beginning of the discussion. It is not as important how strongly the teacher stands by a particular viewpoint as it is to convey a sense of indecision around the issue. In this case, as students question the impact and effects of biodegradable plastic on the environment and grow confident in their positions, Susan tells them that she is feeling rather confused by their very compelling arguments. She tries to expose them to different views as impartially as possible so that the students realize that arriving at and defending their opinion is the primary goal of this exercise, which Hand (2008) calls "teaching something as controversial" (p. 213).

Teaching to the controversy opens up the complexity of the issue and the variety of other perspectives, which might be important in considering societal implications. Once this dynamic has been created, it is important to model an inquiry disposition. Susan does this through a constant flow of questions that she poses to the students in an attempt to help them uncover what is fact and fiction in the news story, who the stakeholders are, and what questions they need to have answered in order to make sense of the issues. She encourages them to identify with others' viewpoints regarding ethical positions so they might attain a more pluralistic perspective (Bainer, 1985). Due to the complex nature of the issue, students soon see that there are many factors to be considered when examining a controversial topic. Based on her exchanges with the group today, Susan challenges with the assertion that cleaner beaches in a community that benefits from tourism would make biodegradable plastics a valid technology and perhaps one worth exploring.

By presenting the news story in such an open-ended manner, students who usually feel compelled to adopt the teacher's position experience a sense of disequilibrium. On one hand, they have come to accept what the teacher says at face value or fact, but now they are confronted with information that makes them wonder what they should believe. It is at this moment that they must re-evaluate the question at hand and decide for themselves which position to take. One way to explain students' disengagement with science would be to consider the lack of cognitive dissonance they experience in the classroom. Festinger (1957) stated, if they are not undergoing psychological discomfort, "there would be no motivation ... to seek out new or additional information" (p. 127). Our assertion is that SSI approaches might provide this type of cognitive dissonance for students.

Susan took steps to make the classroom environment safe for everyone to voice their perspective by taking the unpopular or fringe position. It became evident that students were comfortable expressing their thoughts and reactions to the issue. Interestingly, without realizing that this is part of an unconventional teaching strategy, one teacher observing the demonstration lesson soon joined the students in challenging the notion of embracing biodegradable plastic.

> SUSAN: I think this example really shows how students and even teachers can become motivated to address a topic when it is meaningful and relevant to

them. I truly believe more teachers would bring controversial issues into their classrooms if they could see how engaging it can be for students.

DAVID: Okay Susan, what do you think makes controversy such a powerful teaching tool? And why did you get so excited about getting involved with *Science Times* when I first asked you?

SUSAN: Well, I could not answer your first question without telling you about my early days of teaching science methodology courses at the University. I was working with a group of preservice teachers who had just come from a system where transmission of knowledge through lectures was the principal teaching strategy. No matter how hard I tried, I could not seem to generate any worthwhile discussions about how effectively or ineffectively we educate kids in science. Most of the group seemed quite satisfied with their education and were surprised to learn that fewer than 15% of secondary school students ever go on to study science. So I had to resort to drastic measures. It occurred to me that the only way I might be able to shake up these students with their tunnel vision would be to show them a video (Schneps, 1989) in which an 'A' student who answers all of the standard test questions about the cause of the seasons with complete success soon reveals some very fascinating, nonscientific interpretations (misconceptions) of the Earth's orbit when asked some probing questions. As the video concluded, on the board I wrote, "Can we really teach anyone anything?" It was during the discussion that followed when I realized the true power of controversy.

Case 2: An Elementary Teacher Volunteers to Teach Using Science Times

Shortly after the first ST presentation at the research school, STEVE (a pseudonym), a teacher who witnessed the first lesson (Case 1), expresses interest in trying out the pedagogy. He says that he is intrigued with the approach and would like to try it with Grades 4 and 5 students. He inquires about the articles: where to find them, what support materials are available, and whether or not there is anything he should know before he sets out to lead 60 students on this adventure.

Despite offers to help him prepare, the only thing STEVE says he requires is the address of the ST website with the stories. Independently, he selects a story, maps out a 40-min lesson, and weaves together innovations and ideas that reflect his personal teaching style. For example, he organizes the students into cooperative groups of four and instructs them to divide the following tasks: captain, writer, reader, and speaker. He also introduces a hand-gauge signal in which the students indicate their response to a comment or question by moving their thumb in the appropriate direction. The students have 24 hrs to read the story. By providing resources in advance, teachers can ensure students who are not able to participate in more spontaneous discussions have time to process and reflect on the information, thereby leading to a richer dialogue. For introverts especially, this and small group discussions can come as a great relief (Burruss & Kaenzig, 1999).

STEVE opens with the question: *What is* new *to you in this article?* He then invites students to talk amongst themselves in their cooperative group and report back a few minutes later. As each speaker shares their group's responses, the other 59 students listen respectfully, indicating 'that's new to me' with a thumbs-up or 'I knew that already' with a thumb horizontal to the ground. Speakers take turns calling on each other, and STEVE ensures that all groups contribute.

The second step Steve includes, consistent with the ST approach, is taking the unpopular position. In this instance, he opposes wind energy because of its danger to birds, bats, and other flying creatures. To further provoke the conversation, he proposes that oil and gas are a much safer alternative. Students quickly voice concerns about global warming, pollution, oil spills, and the additional threats to humans and the environment. Clearly, wind power is the better choice in these students' minds, and the obvious next step is to make it safer for animals.

However, if STEVE is to be fully convinced, he must first see some designs of safe wind turbines that would eliminate any chance of birds being killed. He asks the writers to assist their group members to brainstorm and invent an effective wind turbine. The lesson concludes with a student volunteer who draws her group's design on the board and explains how it will protect birds and bats while providing environmentally friendly energy. STEVE offers some parting words: *I'd really like to thank you because I think I have a much better idea about using wind turbines in a safe manner*.

> SUSAN: There are a few reasons why I think STEVE was really successful using this approach. In order to take this leap with several Grade 4/5 classes, he showed that he is not afraid to take risks. He must have felt engaged and intrigued during his own experience as a participant to make the offer in the first place. But perhaps the more important quality STEVE possesses that a teacher must have in order to use this method with confidence is a willingness to let go of control and empower the students to take the lead. So, in answer to your earlier question, these are also the reasons why I got excited about *Science Times*. I could see the potential that this resource has to stimulate these kinds of experiences for kids and possibly even change the way that teachers approach science education. I thought that if we could get these controversial news stories into classrooms there would be a greater chance of engaging students in science and making it more relevant and meaningful for them.
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> DAVID: Wait! I'm having an epiphany. I'm thinking about the elements that would have to be in place for this teaching strategy to work. You would need open-endedness about curriculum and would need to allow students a critical voice and shared control of their classroom routines. These are constructivist ideas about pedagogy that you would have to subscribe to. Further, the radical notion that knowledge is conjecturable—you would have to believe that too. Well, in this research school we have been working to develop a place-based and constructivist pedagogy in teachers … and the SSI approach seems to foster this effectively. In our discussions with teachers, using environmental

> issues like these allow us to have an open-ended aspect to the curriculum … opening up some of the content to local interpretation [by students and teachers]. Allowing students to adopt a critical voice in the classroom is key as well; students must feel comfortable in questioning … even challenging the teacher. Finally, some notion of sharing [curricular] control with the students about where a topic might go—these are all key ideas or principles in our evolving pedagogy using SSI.

Case 3: Taking the Pedagogy One Step Further

One benefit of the Pacific CRYSTAL Project was the opportunity to learn about other innovative science, mathematics, and technology activities as well as engineering and environmental education (Chapters 4, 5, 6, 7, & 13 this book). Of particular interest was Seaquaria in Schools (Zandvliet, Holmes, & Starzner, Chapter 5 this book), a project by a Pacific CRYSTAL partner/researcher to get marine aquaria full of native sea creatures into local schools. It seemed only logical that the community school in which Carlos and David conducted their research should have one; the school's staff and administrators agreed. Before long, classes were circling the seaquarium in the front hallway, studying its ocean creatures, and observing with fascination what lay below the waters surrounding their island—until one fateful day during the winter school break when the seaquarium's circulation pump malfunctioned.

David, being an island resident, was able to go to the school and deal with the situation. It was clear that the only thing that could be done was to release the organisms back into the ocean, at least while someone sorted out the technical challenges. In the meantime, Carlos and David began to hear from teachers that some students had generated a petition to release the animals and get rid of the seaquarium.

One teacher in support of the seaquarium went to David and Carlos to discuss the issue. Together they decided to view the emerging controversy as if it were a ST story and apply the same teaching strategy. They recognized the powerful potential of this cognitive conflict that had spurred the students to action and wanted to help them process it. In Piagetian terms, the new situation did not fit with their current cognitive schema creating a sense of disequilibrium. "In trying to overcome disequilibrium—here perturbations, errors, mistakes, confusions—the student reorganizes with more insight and on a higher level than previously attained" (Doll, 1993, pp. 82–83). What follows is a brief summary of what transpired in this impromptu lesson that capitalized on the opportunity afforded by the seaquarium malfunction when the students returned to school in January.

Taking advantage of opportunity as a need to know. The seaquarium malfunction was a potential controversy that provided real local context in which to apply the ST pedagogy. Using the essential components of the pedagogy (e.g., problematic issue, controversy, multiple perspectives, and fringe opinion), Carlos and David enacted the following lesson.

Carlos is about to say something. The students become quiet to listen. He looks upset. He turns to look at David and says in an angry voice, *I'm really mad about*

the fact that you made the decision to put the animals back in the ocean without talking to me first. David replies, *I came to the conclusion while you were away that I find it ethically wrong to have animals taken out of their habitat and placed in an aquarium. Besides, I had no idea it would upset you so much and I figured you didn't want to be disturbed over the holidays*. The students look on, some in disbelief. They must be asking themselves: Who is right? Carlos or David?

Carlos answers back, *How did you suddenly change your mind? We should have discussed this. I am upset that you did this without consulting me and the rest of the students*. David turns to the students and asks, *Well, let's ask them now. Did I do the right thing? Is it okay to have the seaquarium in the school, or should we leave the animals in their natural habitat?* Hands fly up. Most of the students have something to say. There is a flurry of comments and questions: Were all of the animals still alive? Maybe we shouldn't keep creatures in the seaquarium. Where did you let them go? Let's just get a new one and find some more animals. Why does the seaquarium need a pump in the first place?

The entire conversation lasts about an hour. It seems as though half of the students want to reconsider having the seaquarium. They express concerns about a repeat incident: What if it happens again over the summer when no one is around to fix the pump? On the other side are those students in favour of keeping the seaquarium. They begin suggesting ways to avoid such a mishap; maybe there are some creatures that would make better aquarium dwellers and others that should be left in the ocean. The conversation concludes, and everyone agrees that the next step should be to conduct an inquiry into the most appropriate creatures for the seaquarium.

> SUSAN: It was pretty amazing what happened during this discussion. Instead of starting with a *Science Times* article, you started with a real scenario but applied the same strategy. It shows how powerful controversy can be to inspire critical and creative thinking in students. The fact that 9- and 10-year-olds are debating the merits of keeping animals in captivity—and by the way this continued for days afterward—speaks to the magic that can be sparked with a little planning and an authentic situation.
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> DAVID: I think the epiphany I had here was that by personalizing the seaquarium situation to Carlos and me we made it a personal conflict rather than an abstract one, which is why I believe it was so powerful for the students of this grade level. I believe this was also developmentally appropriate—situating the controversy as one between two people—rather than as a societal one—I thought that the issue might be too difficult or abstract for Grade 4's to understand … but this approach seemed to work.

Case 4: Using Humour to Approach Sensitive, Controversial Issues

Science conferences provide an excellent opportunity to share ST with others. So far, these public forums have been the most effective way to expose a large group

of educators to both the resource and teaching strategy. The following is a typical description of the workshop we have presented at conferences:

> *Science Times* is a news source that provides students with up-to-date information about breaking, controversial stories related to science, technology, and environmental issues. Join us as we demonstrate how we use these news articles (written for three reading levels) to challenge students' attitudes about science while promoting scientific literacy. (Zandvliet & Teed, 2010)

As the 30 attendees arrive to the workshop described above, they are presented with a 1-page printout of the story entitled *Robotic Surgery*, which tells the benefits of using a robot to repair a valve during heart surgery. If they turn the sheet over, they will find the same story written for a different reading level. Later, we advise them to prepare the handouts in this way so that their students can select the side that is most comfortable for them.

David and Susan have prepared for this workshop in two ways: They have determined what they believe the unpopular position will be, and they have taken opposing sides on the matter. Once the audience (in this example, mainly secondary school science teachers) has had time to read the story, David explains that instead of going over the resource upfront we will demonstrate how it might be used first and then debrief later. Next, he poses the question: What is considered newsworthy in the article? A sprinkling of answers comes from the audience: *It was interesting that surgeons will have to develop a whole new set of skills. I've never heard of the technique called the 'American Correction'. My husband just had heart surgery and will have to have it again in 20 years—it made me wonder what kind of processes will be around then*.

Respectfully, David acknowledges the group's contributions and declares, *When I read this article, I just wanted to jump for joy because I love technology. I like video games. I was thinking that maybe they would even let me try this out because I have really good hand-eye coordination*. As you have probably guessed, David and Susan anticipate that the audience may not be so quick to jump on the technology bandwagon and that this is likely an unpopular fringe position. David says, *Wouldn't you like to try to do an open-heart surgery using this technique? I would really love to hear what you think about this*. Someone in the group questions the cost of the surgery: *If it's expensive, who would actually have access to the technology?* Another person challenges the reliability of the software program, citing personal experiences of frustration using the Internet and various word processing programs. Susan wonders what would happen if something failed; who would be at fault, the doctor or the robot? A moment later, a woman points out that decreased hospital care and costs and shorter recoveries would result from robotic surgery compared to the lengthy recuperation that follows repairing a breastbone. Another gentleman sitting in the back says he would go with the robot, and he would hope that the doctor grew up playing video games because his skills would be that much better. He adds that we could train a whole bunch of doctors quicker if they have grown up playing hand-eye coordination style games. Then someone chimes in, *Doctors won't have to have any social skills to be able to interact with their patients* and the crowd bursts into laughter. The woman who had mentioned

her husband's open-heart surgery says that she thinks he probably would have opted for the robotic surgery because of the invasive nature of cutting through his sternum in the current method.

Yet, despite all this support for the technology, David suddenly announces that he feels totally confused and now finds himself leaning away from technology. Susan responds by stating that she feels compelled to reconsider her position due to the strong arguments in favour of technology. She remarks that computer simulations might be a great way to engage students in science, especially since one of the struggles facing science teachers is being able to provide equipment and authentic experiences.

At this point, David announces that we will now end the discussion portion of our presentation and commence the debriefing process. He begins by summarizing the types of arguments people used to defend their various positions throughout the discourse: people expressed personal values, scientific and technological advancements, economics as well as social and ethical issues. He points out that these all emerged spontaneously from the discussion, adding that when we do this with students, an important part of the debrief is to actually analyze the controversy—not with the intention of resolving it but to summarize why it is a controversy, what makes it authentic, and what are all the perspectives brought to bear in a controversy that deepens the discussion. *The first time I did this with a Grade 8 science class, I didn't do the debrief; and there was almost a fistfight in the hallway between two people with opposing viewpoints. That's how engaging this experience can be for kids*, recalls David.

At the core of this technique is a pedagogy that involves carefully constructing activities that address SSI, which encourage the development of scientific literacy by reflecting authentic, open-ended problems that occur in life (Zeidler & Sadler, 2008). These are up-to-date news stories that need to be resolved, not canned issues where we already know the answer. As a result, it is safe to have a range of viewpoints on the issue. And, unlike what is often conveyed in traditional science lessons, there is not one right answer.

One way that David demonstrates a sense of open-mindedness is by playfully interacting with the ideas from the audience as well as challenging his own statements. For example, midway through the conversation he proclaims, *I thought I knew how I felt about this issue but now I'm beginning to have serious doubts*. In this way, he models that as we are confronted with new advances in science and technology, it is only natural to have doubts and questions.

Another aspect that emerges from this approach is the need for further research. In other words, students may discover that they need to know more about a certain topic before they can really take a position on an issue. In our case, questions requiring more investigation included: How robust is the software used in robotic surgery? Is the doctor in the same room or performing the surgery across a network? How does robotic surgery work? These questions act as an authentic springboard into inquiry, especially since they have been student generated. When students see that their questions become the basis of follow-up assignments, they have more connection and conviction to pursue the answers.

Finally, there are two techniques in this method that teachers employ. First, they engage students in a process that is empowering. Second, if that occurs, they facilitate a conversation that has the potential to gain momentum as students begin expressing ideas. Teachers generally choose not to subject themselves to the risks of introducing controversies when it is far safer to maintain the status quo (Sanjakdar, 2005). When it looks like an eruption might take place, one effective strategy is to ask the students to step back and answer this question: What is it about us humans that make us feel so strongly about these issues? By doing this, students must become observers of those behaviours demonstrated when people are highly engaged with a topic. This brings awareness to the emotionality that often accompanies controversial SSI. It also allows students to see that personal values play a key role in the way people respond to emotionally charged topics.

> SUSAN: I got a good feeling from most of the people in the audience about our presentation although a few were hard to read. I think for some people what we are proposing is really radical. They may be thinking that this would be a nice activity to try in some spare time but I'm not sure if they can see applying it to their regular teaching—perhaps because they don't see the connection to the curriculum.
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> DAVID: It's true. We really are asking people to move away from the traditional teaching model. And not only do they have to talk about the science but they need to address the social, economic, and environmental elements as well. In order to use this approach, you have to be open to different positions. And you have to be culturally sensitive because some students may have opposing moral and ethical viewpoints.
>
> SUSAN: But that's the beauty of switching sides. You can't cling too tightly to any one position. Not only does it prevent you from showing your own biases, but it also makes the students wonder what you're up to. That's how you create the cognitive dissonance!

Cross-case Analysis

Each case description illuminates one or more aspects of the learning that took place for the coauthors during the Pacific CRYSTAL Project. In Case 1, the emerging pedagogical approach, it seems evident that the model works very well with Grades 6/7 students. In fact, it was so effective that it inspired one teacher to volunteer to lead a ST lesson with Grades 4/5 students. By observing his presentation of a controversial issue (Case 2), one could begin to imagine how teachers might personalize and innovate the approach to make it work best for them. However, he did preserve and reinforce the importance of our three basic elements: opening question (What is new for you?), adopting the unpopular or fringe position at the onset, and changing (modelling) different viewpoints partway through the lesson. These cases illustrate the essential elements and how robust the approach is to

modification and personalization made by teachers as they enact the approach in different contexts.

Case 3 illustrates the opportunistic aspect of capitalizing on the need to know and just-in-time delivery of the teaching approach that, when authentic situations replace ST news stories, the technique still works. In fact, it seems appropriate to use this approach to facilitate science-related as well as other conflicts that may occur at school or in the community. It also highlights the importance of personalizing the controversy, particularly for young people, so that the conversation is rich and meaningful for them. Secondary school students can benefit by a sense of immediacy as well, but they will likely be more able to handle abstract concepts with a higher level of complexity than younger students.

When presenting this pedagogical approach to secondary school teachers, who can be critical of innovative techniques as in Case 4, several observations can be made. First, like their students they enjoy humour and its ability to bring levity to a serious conversation. Second, they can see the merit of using controversial SSI in their classrooms and acknowledge the power it has to engage participants. However, they express reticence about their own ability to carry off such a presentation and wonder what would happen if the discussion gets too intense. This should come as no surprise because, as Doll (1993) might say, it signifies the perturbations that are necessary to reorganize and advance their own thinking. If this is their first experience addressing potentially sensitive issues, they may decide that they require further training.

CONCLUSIONS

There is no doubt that now more than ever students require the skills to face the ever-changing world in which they live. It is the intent of the Science Times Project to enable students to gain valuable insights into the potential social and ethical implications of current science and technological advancements. The use of ST news stories allows teachers to challenge students' attitudes toward and beliefs about science while promoting scientific literacy through discussion. Choosing stories that are open-ended in nature empowers students to think critically and creatively about socioscientific issues. Furthermore, members of the so-called *net generation* are ready to be presented with options; they do not want to be taken for granted, and they enjoy challenges.

As part of the Pacific CRYSTAL initiative, we were able to follow the development of ST as a teaching tool and accompanying pedagogy. We learned that teachers are more comfortable using the teaching strategy once they experience it firsthand, and we discovered that its impacts can be memorable and long lasting. What we have not ascertained is to what degree teachers will incorporate Science Times into their toolkit. This prompts the question: What further resources, professional development, or support do teachers require so that they see the inclusion of socioscientific events as mandatory in the preparation of scientifically literate students instead of a fun activity that might only be done in some spare time?

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