BEYOND SCHOOL WALLS

INFORMAL EDUCATION AND THE CULTURE OF SCIENCE

KAREN SULLENGER

THE CULTURE OF SCIENCE IS MORE THAN SCIENCE-AS-KNOWLEDGE. IT IS even more than science-as-method. It includes public awareness of the impact of science-technology and mathematics on the economic and social well-being of citizens and their opportunity and readiness to enter into civic discussions of scientific issues. The culture of science in this larger sense is poorly represented in the experience of most people, partly because the formal school curriculum stresses science-as-knowledge and typically presents science-related issues as divorced from social, political, and ethical considerations and debate. If we want Canadians to be aware of, informed about, and willing to discuss the culture of science-technology and mathematics, informal learning may be the best approach.

Although a science, technology and mathematics infrastructure exists in every province, it is generally embedded in schools, universities, and government organizations. Outside these formal structures, opportunities for science education in its broadest sense are limited. The culture of science is likely to be especially impoverished in relatively rural, economically-undeveloped areas such as Atlantic Canada. There, the lack of technical and scientific infrastructure outside the schools gives students little exposure to science, mathematics, and technological culture through avenues other than the standard school curriculum. We know that attitudes and opinions about science and mathematics for both students and parents are shaped as much by popular culture as by formal learning,[1] and we believe this is likely to be even more true in regions where students are unlikely to encounter scientists as role models or observe scientific activities first-hand as an integral part of the economic or social/community infrastructure.

One consequence of our inability to deal with the culture of science – well documented and by no means limited to the Atlantic region – is that student interest in science and mathematics typically fades after the early grades. Another is that ever fewer students opt for post-secondary science and mathematics concentrations. Neglect of science-as-culture can lead, sometimes tragically, to a clash of culturally-based, local knowledge with scientific knowledge and the culture it represents. The well-documented failure of communication between fishers and federal fisheries scientists that contributed to the collapse of the Newfoundland cod stocks in the early 1990s is a vivid example of this problem. Finlayson documents how, in that episode, federal scientists charged with managing fish stocks often ignored the information and insights of local resource users, while resource users in turn mistrusted scientists and lacked sufficient understanding of their methods and aims to enter into a dialogue.[2] The result was an environmental and human tragedy rooted in a clash of cultures of a kind all-too-frequently encountered in the constant episodes of resource management and regulatory decision-making facing our technological society.

BUILDING INTEREST IN SCIENCE

Given the inevitable limitations of formal learning in schools and the lack of exposure to a vibrant culture of science, opportunities for "informal learning" about science, technology, mathematics, and their culture become particularly crucial. Some preliminary research has suggested that informal learning can offer more effective learning experiences about science-technology and mathematics than formal school programs. The research team involved in CRYSTAL Atlantique (Centre for Research in Youth Science Teaching and Learning) wanted to know whether and under what circumstances this might be true. We chose at the outset to avoid questions like what counts as understanding science, or what constitutes scientific literacy, and instead chose to ask what elementary, middle, and high school students can learn about science and what kinds of experiences influence their attitudes towards and interest in science. We also wanted to know what adults understand about science-technology or mathematics and how their understandings contribute to their reluctance or willingness to interact with science-technological and mathematical issues and concerns in their communities.

CRYSTAL Atlantique is a collaboration of English, Francophone, and First Nations educators, scientists, experts in related disciplines, and community organizations from New Brunswick and Nova Scotia. We are one of five CRYSTALs created across Canada to address the Natural Science and Engineering Research Council's (NSERC) concern that too few students are choosing science-technology and mathematics as a career. Each of the centres has a theme; ours is to study and enhance the culture of science-technology and mathematics in Atlantic Canada. We chose informal learning as our initial research focus because we feel that it offers more opportunities to influence science-technology and mathematics understandings than other parts of the educational infrastructure.

We define informal learning as learning that takes place outside the formal structure of the classroom or university, including a range of learning opportunities from clubs and organizations to museums and science centres, as well as individual learning through everyday experience. In the first year of our five-year project, we established eighteen research activities studying aspects of informal learning grouped into six sets of research questions.

First, we asked about the role and impact of community-based science organizations, such as science centres, and outreach activities. Even within our research team, some

believe the long-term impact of outreach programs is so limited there is little use in studying them and others believe it is so self evident there is little use in studying them! Whatever debate may exist about their longer-term impact, the power of outreach activities to spark curiosity and engage interest in the sciences and mathematics during school years and afterwards is well documented.[3] One researcher argues, "Free choice science education facilitators such as science centres, zoos, aquariums, youth

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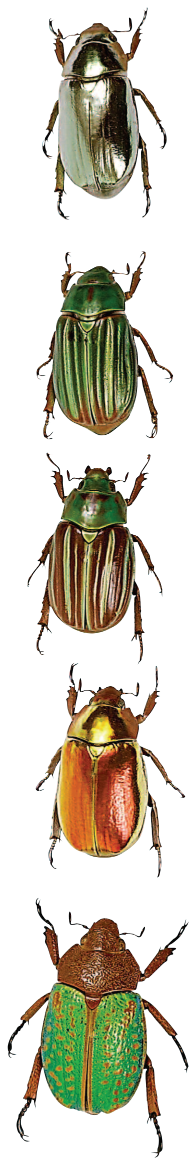

groups, health and environmental organizations, the Internet, public television, and libraries can thus be viewed as part of the nation's infrastructure for science education".[4] For these researchers, informal, free-choice learning experiences are an integral part of the educational process with significant influence; others suggests that these experiences often have little long-term impact or connection to the school science curriculum.[5]

Outreach activities are the primary way government and university scientists in Atlantic Canada interact with students, providing resources and activities as well as university- or school-based programs. In addition, numerous community-based organizations in each province conduct outreach programs in schools or provide on-site programs for school visits. However, the rural nature of most provinces makes delivering informal learning experiences a challenge; schools in more urban communities enjoy an abundance of opportunities while those in rural communities have few. Falk and Dierking identified several factors as key determinants of successful informal learning experiences, including motivation and expectations; prior knowledge, interests, and beliefs; choice and control, within-group sociocultural mediation; facilitated mediation; familiarity with the experience; design; and follow-up experiences.[6] In addition, we believe other important determinants include who delivers/plans the experience, location of the experience, coherence of sessions, materials provided, age, and first language of the learner.

The second set of research questions addressed the significant decrease in science attitudes and interests when elementary level students move to middle school. We wondered whether after-school science programs could reverse this trend. While lunchtime science enrichment programs for girls and other initiatives with volunteer science and engineering students from the university do exist, they tend to be sporadic in delivery and content. We believe much of the problem is that such short term or stand-alone initiatives are not as effective as coordinated, sustained activities which involve students, teachers and researchers collaboratively.[7] If ongoing, informal science/mathematics activities and research projects, embedded in students' own communities, were available, would they become involved and would they stay involved throughout their schooling? Would they develop more complex understandings of science and mathematics than with school-based studies alone, and would more of them pursue science careers? To explore these questions, we created a series of school-based activity and research programs for elementary and middle schools that take place outside the classroom.

A third set of questions asks about what happens when students – from elementary school through university – partner with scientists to conduct research. Does the act of participating as researchers influence students' understandings of and attitudes towards science? Do they develop a stronger sense of responsibility towards their environment and community? In what ways do these experiences with researchers result in understanding "science as a culture" rather than "science as information"?

Fourth, we are interested in the role of online learning. If students had access to online science or mathematics activities, would they use it? What kinds of activities would they undertake outside the classroom? If they could record, share, and comment on research online, would it influence their own research – would they participate? If they received feedback from "experts" on their online submissions, what kinds of things would happen? If prospective teachers respond to these online learners, what influence would the experience have on their understanding of teaching and learning?

Our fifth line of inquiry explores what is loosely called the "public understanding of science" (and in our case mathematics as well). These research activities probe what teachers and members of regional communities (in one case members of Aboriginal communities) believe about science, about the role of science in society, and about the kind of mathematics they perceive in their everyday lives.

And finally, our questions shift from students' informal learning contexts to informal learning contexts for teachers. Growing evidence suggests that 'grassroots' or teacher-initiated/directed change is longer lasting than mandated or 'top down' initiatives, even if slower to be implemented. We are establishing a context in which to examine these claims by creating new professional development opportunities for elementary, middle, and secondary teachers to network with experts from science, mathematics, forestry, and engineering and to form their own action teams to implement new ideas and/or practices into their classroom. We want to know if opportunities like these influence teachers' comfort with and confidence in teaching science. Do they influence teaching practices or curriculum decisions?

PRELIMINARY RESULTS

Although we are only beginning to analyse data and post findings, we have learned some interesting things this first year that are already affecting our research.

First, we have learned that many students are anxious for science experiences. For example, the science programs we set up for elementary schools have been so successful that we are being forced to consider limiting enrolment. Two of the four schools involved have so many participants the teachers have had to recruit colleagues to help. In one rural school in an economically depressed community, we contemplated paying for a late bus because in the past elementary level after school programs have had limited attendance. But almost forty students joined the new science program for Grades 3 to 5. In a small-town school, over 80 students joined. And in all of the elementary and middle schools, we have been amazed at the range of participants, including students with autism, ADHD, English as a second language, and limited writing/language capabilities. We are working in multi-age teams, using the model of scientists working in teams and sharing their skills, so we have developed writing buddies and are using scribes until all students develop the skills they need to keep up on their own.

This enthusiastic turnout is both good news and bad. Will we have to restrict the numbers of students? Can a program that attracts such large numbers be run exclusively by teachers who have already worked a full day? This could be a good opportunity to offer prospective teachers an internship experience, but the rural nature of the region can mean up to three hours travel time. And even though edu-cators from the community-based science organizations work up to half time with these projects, commitments with their own organizations often conflict.

Which leads to our second finding: Informal education is labour intensive. More than twenty-five teachers volunteer their time to implement these programs. What if we paid educators to deliver them? Would the costs be worthwhile? Could informal learning be a new career path for educators? If our projects show considerable positive influence over students' attitudes, interests, and understandings, will we be able to extend the programs based on volunteers alone?

This approach is not only labour-intensive; it is 'understanding-intensive'. It requires people who have an informed understanding of the natures of science-technology and mathematics. For us, that means an

EN BREF **CRYSTAL Atlantique, le Centre de recherche sur l'enseignement et l'apprentissage des sciences des provinces atlantiques, vient d'entreprendre un projet de cinq ans pour déterminer le rôle que peuvent jouer les milieux d'apprentissage extrascolaires pour susciter une culture scientifique dans laquelle la science est autre chose qu'une « simple source d'information ». Vu les limites inévitables de l'apprentissage scolaire et du manque d'exposition des élèves à une culture scientifique dynamique, il est d'autant plus crucial que ceux-ci puissent faire des apprentissages extrascolaires en science, en technologie et en mathématiques, et aussi se familiariser avec la culture de ces disciplines. Les chercheurs espèrent en apprendre plus sur l'impact à long terme d'une variété d'occasions extrascolaires d'apprentissage, telles que les programmes d'extension communautaire, les partenariats avec des scientifiques et les programmes de sciences parascolaires. Les résultats préliminaires indiquent que les élèves sont enthousiastes et prêts à participer. Malheureusement, ces programmes extrascolaires ont tendance à surcharger les ressources limitées des personnes et des organismes bénévoles qui peuvent les offrir.**

understanding that science is not everywhere or everything. It is not something we do all the time, but something done by a particular group of people who follow certain conventions. We want learners to ask not "What do scientists know?" but rather, "How scientists do research and what kinds of things influence their work? Why do they believe things differently than others? How does what scientists and mathematicians learn from their work contribute to solving problems in our community?" Developing this kind of understanding will take time.

Finally, we are realizing that everything takes longer than expected. Informal learning and research activities are more vulnerable to the factors exacerbated in rural locations – like weather, travel, and family – than formal learning activities where more formal structures and back-up plans are in place. Delivering a continuous program of informal learning opportunities will require a well developed network of educators that reaches all communities. Even with our pilot schools we are stretching resources.

We are only beginning our five-year study and look forward to sharing what we learn with those interested through our website – www.crystalatlantique.ca. The positive response to the informal learning activities we have introduced suggests there is a place in the educational infrastructure for such activities. However, it is already clear to us that if informal learning is to play a central role in developing the public's understanding of science-technology and mathematics, we will need to strengthen our informal learning infrastructure and provide it with sufficient financial support.

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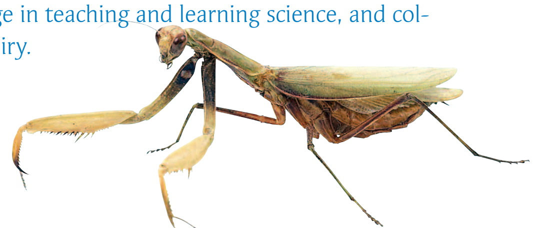

Notes

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