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Accessing Science Courses in Rural BC: A Cultural Border-Crossing Metaphor

Students in small rural schools in British Columbia face barriers to accessing senior science courses. A case study employing questionnaire and interview methods sought the perspectives of principals, teachers, and students in the affected schools on this issue. Interpretive data analysis revealed the following barriers as key factors that affect students' successful access to senior science courses: staffing at the school, availability of specialist teachers, trusting relationships between students and teachers, and the school and local cultures. The study considers these factors as constituting a border between students and school science, the crossing of which mediates students' access to the culture of school science.

Les élèves des petites écoles rurales de la Colombie britannique qui désirent suivre des cours avancés de sciences doivent faire face à certains obstacles. Une étude de cas reposant sur des questionnaires et des entrevues a recueilli les perspectives des directeurs, des enseignants et des élèves de ces écoles à ce sujet. Une analyse des données a révélé que les facteurs suivants constituent les obstacles principaux auxquels sont confrontés les élèves qui voudraient suivre des cours avancés de sciences : le personnel de l'école, la disponibilité des enseignants spécialisés, le rapport de confiance entre les élèves et les enseignants, la culture locale et la culture de l'école. Nous considérons que ces facteurs constituent une frontière que doivent franchir les élèves pour avoir accès aux cours de sciences à l'école.

Purposes

Access to senior science courses by students in British Columbia's small rural schools is not always assured. As students approach senior science courses such as biology, chemistry, physics, and geology, they encounter barriers to their access. The barriers exist on many levels and to differing degrees of permeability. Understanding these barriers can help us conceptualize how access to these courses is facilitated. Therefore, the study aimed to examine how students in small rural BC high schools experience accessing school

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science and how teachers and schools strive to facilitate access to senior science and mathematics courses.

Background to the Problem

A deficiency model has characterized education in small rural schools for many years. It has often been stated that small schools cannot be expected to deliver a wide range of program options for their students. School size is seen as the limiting factor, yet consolidating small rural schools into large comprehensive ones, the favored option, has created other sorts of problems. BC has experienced its rural areas losing population to out-migration, which is believed to be a result of global economic forces operating to downsize and mechanize labor-intensive industries such as logging, fishing, mining, and agriculture. Schools in these outlying areas are often faced with declining student enrollments. This has caused instability in staffing and course offerings in BC's small rural schools.

Economic arguments have been used to promote science and mathematics education in high schools and postsecondary institutions as a means to innovation and technological advancement (Conference Board of Canada, 2003; Deboer, 2000; Rutherford & Ahlgren, 1990). In addition, science education is seen as important from a social justice and citizenship point of view, so that all people in society have an underlying foundational literacy of how science can help us understand the world around us. Although not mutually exclusive, the economic and scientific literacy viewpoints support differing emphases in the schools.

School Science

Cultures have been defined as having their own norms, beliefs, expectations, and conventions (Geertz, 1973; Phelan, Davidson, & Yu, 1991). The notion of *culture* may be difficult to recognize, and even more so to characterize, yet "individuals embody and reproduce the commonalities and differences of a range of settings into which they have become enculturated" (Claxton, Pollard, & Sutherland, 2003, p. 9). The idea that becoming a part of a culture is a process is widely acknowledged. Erickson (2002) has argued that individuals over their personal life histories develop a multicultural repertoire that is based in the individual belonging to a number of communities of practice (Lave & Wenger, 1991). It is through belonging to these various communities that a person is socialized into the culture of a community. The school is one such community of practice where young people gain experience with the subject areas in the formal curriculum, including induction into the culture of science.

Science educators have noted the presence of a school culture (Aikenhead, 1996, 2001; Aikenhead & Jegede, 1999; Cobern, 1993, 1996; Costa, 1995). For the purposes of this article, Aikenhead's (1996) description seems apt: a culture has its own attributes, communication strategies, social structures, customs, attitudes, values, beliefs, world views, skills, behaviors, and technologies. A variety of subcultures that interact in complex ways can exist in a culture.

Evidence for the existence of a unique subculture of school science can be found at many levels of analysis: subject area classrooms, individual teachers' beliefs and attitudes, students' subcultures, and community cultures. As a part of the learning environment, each of these levels affects what goes on in the school, the type of experience each person in the school encounters, and how the community's values are transmitted and young people socialized.

Cobb (1994) has argued that learning involves both constructivist and sociocultural processes, and if learning science is indeed enculturation, as Hodson and Hodson (1998) suggest, the barriers inhibiting the development of personal relationships need to be overcome. According to what Roth, Boutonne, McRobbie, and Lucas (1999) have suggested, it may be what happens when people from varied life worlds enter into dialogue whereby differences are made clear and bridging the gap becomes possible. And according to Duit and Treagust (2003), a new theory of learning needs to encompass these situational and cultural factors while attending to individual cognitive development. Teachers' responsibilities and aptitudes for enacting this new theory of learning with all its complexity may ultimately enable students to negotiate access to the subculture of science.

The negotiations between students and school science are mediated by the teacher and perhaps necessitate a well-prepared teacher who is a subject specialist consistent with what Giroux (1992) has suggested is the role for teachers as cultural workers. Lave and Wenger (1991) would agree that teacher preparation is key for this type of mediation, as enculturation involves interaction with more experienced others (Chaiklin, 2003; Karpov, 2003). Although teachers, particularly secondary school teachers, generally hail from and represent the dominant culture, the school is the place where various subcultures meet and mingle. Giroux goes on: "students must be encouraged to cross ideological and political borders as a way of furthering the limits of their own understanding in a setting that is pedagogically safe, and socially nurturing rather than authoritarian" (p. 33). Duschl (1988) claims that there exists a science teacher subculture that can distort the nature of science through many science teachers' beliefs in classical empiricist and logical positivist views of the world. A typical science teacher is a "positivist, authoritarian, non-humanist, objective, purely rational and empirical, universal, impersonal, socially sterile, impersonal teacher who is unencumbered by the vulgarity of human imagination, dogma, judgments, or cultural values" (Aikenhead, 1996, p. 39). In fairness, this assessment is a dark characterization and certainly does not represent all science teachers, nor should it imply that there is one way to teach science. As Bruner (1996) points out, "science is not something that exists out there in nature … Getting to know something is an adventure in how to account for a great many things … [and] there are lots of different ways of getting to that point" (p. 115). Bruner seems to be saying that science teaching is a mechanism for students to understand the condition of science, not knowing. Learning is then a voyage of discovery mediated by the teacher who also facilitates the students' entrance to the culture of science. However, Aikenhead has further argued that the positivist view is propagated in science classrooms, and for students to be successful in school science, a border crossing must be negotiated (Aikenhead & Jegede, 1999).

The border in a metaphorical sense is represented by a series of barriers, the crossing of which has implications for creating a more democratic society. A first step is to challenge existing borders according to Giroux: borders that recognize difference as part of a common struggle based in the language of history and power. Redefining the borders through a critical pedagogy involves understanding otherness and the fashioning of new ideas, arguably goals for schooling in our postmodern world as aspects of human development.

The border crossing can be successful as long as it is mediated through the school and its administration, the teachers and the students, and even the community where the school is located, because each of these layers may constitute factors that affect student access to school science. Nevertheless, even successful students may compartmentalize their own cultural belief systems in a form of cognitive apartheid, where varied knowledge systems are used for varying types of situations (Cobern, 1993). Jegede (1995) has called this "collateral learning," where despite conspicuous efforts on the part of the teachers to help students develop their understandings to include more scientific world views, individual knowledge can remain walled off and contextualized in various settings such as school or community. Campbell, Lubben, and Dlamini (2000) assert that for students, the out-of-school domains are more important contexts for their learning than were in-school settings. This poses problems for the efforts of the school and science teachers as they seek to help students construct more scientific personal world views and develop a degree of scientific literacy.

Students' commonsense views may conflict with their teachers' (Cobern, 1993). Costa (1995) has said that students negotiate the borders between home, family, peers and school, and school science depending on how the subcultures of the student and school align. Many of BC's small rural schools are predominantly populated by First Nations students (BC Ministry of Education, 2003). There is a societal assumption that cultural knowledge is shared, but according to Krugly-Smolska (1995), it is not. It may be that teachers hold an unexamined assumption that students have the responsibility to adapt their own understandings to the teachers' and the culture so represented. The persistence of this conflict is probably the result of subculture clashes.

The practice of culturally relevant teaching has been a notable direction for educational reform in mathematics over the last decade or so (Gerdes, 1997; Gutstein, Lipman, Hernandez, & de los Reyes, 1997; Lipka, 1999; Sleeter, 1997). In some cases, classroom philosophies based in the teachers' knowledge of their students' subcultures are empowering for the students. Gutstein et al., working with predominantly Latino schools and students, see this cultural awareness as having the potential to empower students for social change. This is in order for the students to be aware of and challenge the power structures in their own communities. Sleeter also bases teaching in cultural knowledge applied to the multicultural setting.

An alternative is a curriculum based specifically in the local culture. Lipka's (1999) group at the University of Alaska, Fairbanks, has built a series of ethnomathematical lessons and units that are culturally relevant and explore and use the mathematics inherent in various cultural practices. These are then used to frame conceptual development of the mathematics. As in mathematics education, culturally relevant or culturally based teaching approaches may serve an important mediating function as students and teachers negotiate access to school science.

The Study

This study involved principals, teachers, and students in 12 small rural schools in BC that range in size from about 25 to 600 students. These schools were selected based on their size (Howley, 1994; Meier, 1996) and rurality (Montgomery, 1999) and expressed willingness to participate in the study. The participating schools are located in various rural areas around BC and are characterized by their location in a community that has limited access to the full range of civic services identified by Montgomery as available in a service center. The services include hospital, law enforcement, human services, and education. The group of schools constituted a case study (Merriam, 1998; Stake, 2000; Yin, 1984), which used mixed methods: quantitative and qualitative (Creswell, 2003; Denzin & Lincoln, 2003; Lincoln & Guba, 1985; Stake, 2000).

The quantitative phase involved a search of provincial and school district documents that included demographic information, provincial examination data, and other statistics. From Ministry of Education lists of all schools in the province, a subset of 55 schools were identified that had fewer than 600 students and were located beyond commuting distance to a service center. The data from these schools were then sorted and analyzed in a series of summary tables. An example is shown in Table 1, which presents five-year comparison averages (1997-2002) of students' provincial examination participation rates (PR) on senior science and mathematics exams along with the percentage of students achieving marks of A or B, both for the provincial averages and for the 55 schools identified as small and rural.

Not only did students in small rural schools participate in senior sciences and mathematics examinations, on average, at lower rates (with the exception of biology, where they were near the provincial average), they achieved lower marks in their coursework. Additional comparisons of failure rates, number of exams written per student, and Fraser Institute rankings demonstrated significant differences between schools identified as small and rural and provincial averages. All these data suggested that the issue of access for students ought to be investigated.

The qualitative phase of the study used the quantitative data as background information for the development of questionnaire surveys (Anderson, 1990) for principals, teachers, and students. This qualitative phase probed the organization and culture of the small rural schools. Selected questions from the questionnaire are reproduced in Table 2.

A total of 11 principals, 28 teachers, and 45 students completed the respective questionnaires. In-depth follow-up face-to-face interviews (Denzin & Lincoln, 1998; Fontana & Frey, 2000; Lincoln & Guba, 1985; Palys, 1997) sought clarification and elaboration of the responses offered on the questionnaires and lasted about one hour each. Interviews were conducted with 14 of those who had completed questionnaires whose responses required further probing because they were either enlightening or presented points that required clarification: three principals, six teachers, and five students. Their perspectives represented the diversity of school sizes and geographic distribution of the schools, as well as various science subjects and mathematics.

All the information from provincial and school district documents, questionnaires, and follow-up interviews constituted the data corpus for analysis,

Table 1
Five-Year Comparison of Averages for Participation Rates (PR) and %A or B Marks on Provincial Examinations (BC Ministry of Education, 2004b)

	Biology		*Chemistry*		*Physics*		*Mathematics*	
	%PR	*%A-B*	*%PR*	*%A-B*	*%PR*	*%A-B*	*%PR*	*%A-B*
Prov. Ave. (*n*=227)	29.1	38.4	22.9	49.5	18.1	51.0	33.2	43.8
Small Rural Ave. (*n*=55)	30.8	32.2	16.8	34.7	7.6	25.7	25.7	25.2

which was characterized by interpretive methods of qualitative research (Erickson, 1986; Gallagher & Tobin, 1991; Miles & Huberman, 1994). Each participant was assigned a unique identifier, which allowed sorting responses by question. Individual responses were then chunked into thematically constructed categories. Deeper analysis searched for underlying elements and messages conveyed in participants' comments. Key points were categorized, coded, and summarized (Erickson). This process was repeated several times as coding schemes were refined, revised, and retested in a search for emergent themes.

Results and Discussion

Emergent from the study were a number of factors that affect students' access to school science in small rural BC schools: staffing in general, qualified specialist teachers, teacher-student relationships, and the local culture of the schools. These factors appear to constitute a series of cultural barriers between students and school, new teachers and the community, and students and school science. In the reporting of results pseudonyms are used throughout.

Staffing

Each of the 11 principals reported staffing as a key factor that influences students' access to science and mathematics courses. Also, most of these principals expressly stated that teachers are important for student success and for school success. Yet they also reported high turnover rates for teachers and staff, which affected staffing stability and the ability of the school to offer a regular program of course offerings. The result, as the principals argued, is often the hiring of inexperienced teachers to fill teaching vacancies. These teachers are unlikely to stay in the school for more than one or two years.

Principals acknowledged that teachers face a difficult workload in small rural schools, and this affects teacher retention. As Nora, a principal, admitted, "those good teachers, we're hard on them." Teachers in her school routinely teach courses in four or five subject areas, and many of these are outside the teaching specialty area (Nielsen & Nashon, 2004). The intensity of the workload, combined with a province-wide demand for specialist teachers who are often attracted to teach elsewhere, made it difficult to retain teachers on staff.

In addition, a teacher new to a community faces the task of adjusting to life in a place that is probably not his or her home. Lisa, a teacher in Nora's school,

Table 2
Selected Questions From the Survey Questionnaires

Participant	*Questions*
Principals	Is your school departmentalized? To what extent? Does your school have certificated subject specialists teaching senior science and mathematics courses? To what extent is consistency in staffing a factor for student success in senior science and mathematics courses? How important do you feel it is for the teacher in a senior level science or mathematics course to have a degree in the subject being taught? How many sections of each course are taught in a given school year at your school? Earth Science 11, Geology 12, Biology 11/12, Chemistry 11/12, Physics 11/12, Math 11/ 12, Calculus 12, Applications of Math 11/12
Teachers	List the senior science and mathematics courses you have taught in the last three years and indicate the courses that are outside of your subject specialty. How important do you think it is for students to take courses in a teacher-led environment, as opposed to distance learning, or other models of course delivery? How supportive is your parent group? How are labs or projects used in your senior courses?
Students	Does your school offer all of the courses you might like to take? Which ones are missing? How are students consulted when course offerings are changed? Have you considered taking courses through distance learning? Why or why not? What influence have your teachers of grade 8, 9, or 10 subjects had on your decisions to take senior-level science and mathematics courses? What do you consider to be some academic strengths and limitations of your small high school?

commented on the connection between becoming part of the local community and remaining to work at the school: "The people that don't want to stay are the ones that go home, stay in their apartment, come back, go to work. They never go to the beach or join in community events, kayaking or just enjoy the area." Lisa is suggesting that in order to teach effectively in a small rural community, one must become a part of the community.

People new to town are not anonymous. A stranger in town is immediately recognizable by people in the community, and this represents another barrier for a new teacher. Local habits, politics, and even recreational opportunities are new things to learn. Encounters with parents of students occur everywhere and at all times: in the grocery store, at the gas station, and in the liquor store. This lack of anonymity is often a new experience for the teacher, as most teachers take their training in urban centers where these types of encounters are rare. The ability of the teacher to negotiate this lack of privacy may well predict the future of the teacher continuing to work in the school: failure to adapt means yet another new teacher will restart this process in the fall. It may be a mutual acceptance of the differences between the teacher's and the community's sub-cultures, or it may be a recognition that by staying another year, the teacher is demonstrating willingness to adapt to the local community culture. This particular relationship has two interacting facets. However, the responsibility for adapting falls largely on the teacher.

Principals in the smallest schools of the study reported that teachers who have been on staff for a long time, and hence have successfully adapted to life in the community, are in part a necessary condition for students to be successful, as suggested by Steve, a principal: "Stability has a real impact on student success." Although acknowledging stability as an important factor, many principals wrestled with the reality of unstable staffing, which in turn made it difficult to offer particular courses on a regular basis.

Students also realized how important it was to have consistency among teaching staff. Donna, a grade 11 student, went into some detail about why staff stability is important.

> I think it has a very big impact if teachers stay stable. Just for that base knowledge. They know what you know, they know what you don't know, they know what you need to know. Whereas a new teacher comes in, totally out of the blue, she thinks you know this, but maybe you don't.

Apparently a temporary teacher had arrived at Donna's school while the long-term teacher was on a sabbatical leave. The new teacher's attitudes and practices conflicted with the established expectations the students held for teachers in the school, and so caused a large disruption to the routines in the school and to the perceptions of students about their own learning. Despite being an experienced teacher, accepting this temporary position represented a challenging situation for both the students and her. Several students in other schools of the study also commented on how important it was that the teaching staff remain stable over time.

Qualified Specialist Teachers

Principals, teachers, and students widely acknowledged the importance of having qualified and experienced teachers for senior science courses. Other principals agreed with this one: "The courses cover a lot of material and the teachers need to have a lot of knowledge." However, some principals found it difficult to meet this condition. Principals saw declining enrollments as the root problem in maintaining staffing levels that include a variety of subject specialist teachers. The result has been that teachers now teach a more diverse workload, including courses that are out of their areas of subject expertise. In fact about half of the senior science and mathematics courses taught in the small rural schools of this study were taught by nonspecialists in the particular discipline.

Several students observed that having nonspecialist teachers in science made their work more challenging and impeded their access to school science, with comments such as this: "Some of our teachers are not up to par for the courses they are teaching." In effect this creates a barrier for students in small rural schools as student access to specialized pedagogical and content knowledge may be limited.

Teacher-Student Relationships

Teachers and students articulated the importance of trust in their relations with each other. Gaining this trust is an important part of teachers' work in the first year of a new assignment. One participating teacher reported that little learning had occurred during her first year of tenure at the new school, because not enough time had passed to enable trust to be built. The cultural differences between the community and new teachers were cited as determining factors here. Nora, who was the principal at this school, agreed: "Our kids take a really long time to trust people, so I think we lose a lot of learning." Her school is located in a remote community, which traditionally has had high staff turnover rates, which had resulted in the hiring of five new teachers (of a staff of 14) in one recent school year. Gaining the trust of students becomes a particularly significant issue when this level of instability is present.

Teachers, particularly in the most remote communities, felt that in order to begin to be effective in their jobs, they must build relationships with the students, parents, and community. But quite often the new school year begins with many new people among the staff. Because of the common experience of having new teachers each year, and in some cases several in a year, students are wary of attaching themselves to a teacher who will probably be leaving soon. These drop-in teachers may be unwilling to invest energy in building relationships with people in a community where they will not be remaining. This represents a real barrier to students' access to science courses, particularly if the teachers for these courses change each year. If a teacher returns for a second (or subsequent) year, relationships can start to develop, and according to the participating teachers, effective teaching and meaningful learning can begin. In effect the teachers must mediate the cultural differences between themselves and the new community, and in so doing gain the trust of the students. As time passes, the differences between subcultures may become nominal, especially if a teacher makes the move permanent by settling in through buying a home or raising a family. Only then is it possible to address the border between the students and school science.

The School Culture

Although acknowledging that staff turnover was a big issue for students' access to senior science and mathematics courses, all the participating principals felt that having a stable teaching staff (most teachers being on staff for many years) was a significant factor for success. In schools that had such a situation, this enabled a culture of success to evolve and be maintained in their school's science and mathematics departments. Several principals commented on the positive role of stable staffing, as typified by this principal's comment: "Our math and science programs have had consistent staffing for many years. This has definitely had a role in the academic success of students in the past." Comments from some of the students in small schools reinforced the importance of teachers' personal knowledge of them. This is what promoted a culture of success in their schools as shown in these comments from students: "My teachers have gotten to know me over the last four years and know my learning styles and my weaknesses better" and "the teachers are really good about working one-on-one with students and helping them understand anything they need."

One student reported a culture of success at her school, which had been a part of the school community since she was very young: "When I was a little kid, I was still in elementary school, you know, going through the high school looking up at all the big kids … [thinking] I want to be just like you" (the elementary school was adjacent to the high school). Her message was that depending on the culture of the high school, the younger children look up to the high school students and wish to emulate them. In a school where success is celebrated, the younger students have models to which they can aspire. Donna further commented that in her graduating class of about 25, the top eight or so strongly academic students were striving to be the best. This resulted in a good-natured competition, which also set an example for the younger students.

Positive relationships between teachers and students serve to enable the building and maintenance of a stable school culture. According to teachers and students, this is facilitated by small class sizes. Students viewed the teachers' presentation styles, quirky personality characteristics, and subject expertise as responsible for increasing interest. The ability to generate and maintain students' interest was acknowledged as a source of academic strength.

Teachers set a tone in the school. One student offered, "I have pursued more sciences because the teachers I had helped me enjoy my studies and were full of knowledge." In many cases where the teaching staff has remained stable for a number of years, students commented that the teachers they had met as grade 8 or 9 students were most influential for later decision-making about course choices. Students acknowledged that through working with them over a number of years, the teachers had established meaningful relationships with students, behavioral expectations that students recognized and honored, and stimulated interest in the subject matter. One teacher commented that when she was new to the staff, it had taken "probably five years before the kids really accepted me and my teaching style." The issue of trust between students and teachers emerges repeatedly through this case of small rural schools.

Synthesis

The series of barriers discussed here represents varying challenges for the actors in the school setting and are patterns of human activity that can only be understood as a part of the surrounding systems in which they live (Cole, 1996). Barriers between students and science, teachers and the new community, teachers and students, and even the community and the school are important intersection points for student access and where learning is to take place. In a way, each intersection holds the potential for a culture clash.

One of the most significant intersections is the direct one between teachers and students on a personal level. Although an important prerequisite for student success, the building of trusting relationships with students takes time and is key to facilitating access to science. The effects are compounded when many new teachers start each year, as staffing instability means that students and teachers do not have the opportunity to build these relationships. This instability may impede the development and maintenance of a culture of success in many small rural schools.

A further intersection, at least for school science and mathematics, is the teachers' knowledge of their subject area. Skilled and experienced teachers who are current in subject-specific pedagogy are better equipped to assist their students in crossing the border into science (Darling-Hammond, 1997, 2000). This provides students with at least minimal access to the content of the discipline and thus represents an opportunity to make informed decisions about continuing in school science.

Attention to the need to interact and build relationships in the community should be identified as part of a new teacher's workload and time provided accordingly. Also, teachers whose personal experience or cultural background has provided the opportunity to understand the importance of relationships with those in the new community should be sought out for teaching jobs in small rural communities, because this aspect of successful small schools enables the border crossings for students and teachers. University teacher training programs similarly should offer specific training for preservice teachers for working in outlying areas. This could be done by placing more student teachers in rural communities for practicum experiences.

A further need exists for a reexamination of the models in use for implementing senior science and mathematics courses in small rural schools. As enrollments continue to decline, more schools will have difficulty in maintaining adequate staffing levels. This examination should start with case studies of the most successful small schools. Their success in implementing quality specialty courses needs further clarification and understanding. Questioning what constitutes success is also an important consideration. As Sher and Sher (1994) have said, local communities have varying goals and aspirations for their children. The school system must be responsive to these. What makes their programs successful? What can be learned from these schools and how they operate their programs? To what extent can these successes be exported to other schools?

Emphasizing cultural education and connecting communities through technology could be possible models for focusing local development efforts on facilitating students' access to the specialty courses. Researchers in Australia and Alaska have suggested that these types of efforts would be most fruitful for meeting the needs of students (Barnhardt & Barnhardt, 1983; Rural School and Community Trust, 2000a, 2000b, 2000c, 2000d; Sher, 1995; Sher & Sher, 1994). Alternative models for how courses are offered need to be considered. A word of caution, however, is appropriate. The one-size-fits-all approach to education is unacceptable. Small rural communities have unique challenges of geography, economics, and local culture. Each is unique, and so locally developed solutions to these challenges will be necessary.

Conclusion: Border Crossing

A border-crossing metaphor is used here to conceptualize how students' access to school science and mathematics could be facilitated in BC's small rural schools. The subcultural intersections between students and teachers and students and the content of science are particularly relevant here, while remaining mindful of the other important intersections: teachers new to the community and the place of the school in its community. According to Phelan et al. (1991) and Cobern (1996), students' congruent experiences in their various subcultures allow for success in crossing the borders into school science. However, crossing these borders presents students with various challenges, mostly related to how society and science teachers view science, a view that may be inconsistent with some students' understandings that have "scope and force" in the world (Cobern, 1993). This rift between science and students represents a border, the crossing of which means that students have access to the culture of school science.

The cultural border that students must cross or negotiate when entering the science classroom in a small rural school is probably similar to the cultural border that students face in large schools (Costa, 1995). However, the border between rural students and school science is wider: students have no choice of teachers and little choice of subjects to take (Nielsen & Nashon, 2004), so their access to the science subculture, which may be incongruous with the local community culture and individual student subcultures, may be an important factor rendering school science irrelevant for many students in small rural schools. This can be seen in the low participation and success rates for provincial examinations for small and rural schools in BC (BC Ministry of Education, 2004b). Thus the science subculture is walled off from most students. It may be this subcultural incongruity, where students' and teachers' differences prevent most students from taking senior science in small rural high schools. We argue that these cultural differences are responsible for the challenges that students face in approaching senior science and mathematics courses in small rural high schools, and that they represent a border for students to negotiate as they seek access to school science.

For students to negotiate this border successfully, we suggest that changes be considered in how teachers are prepared, how schools are organized, and how programs are delivered. Teachers need to be better sensitized to the importance of building relationships with students that honor the cultural heritage and prior knowledge that students bring to school. Similarly, teachers need to be aware of their own belief systems about the nature of science and the danger that a positivist view of science is being propagated unwittingly. The incongruence with students' own cultures remains problematic.

Small rural schools are organized similarly to large consolidated high schools. This model appears to be unsustainable as small schools continue to shrink, and part of the reason why access to senior science and mathematics courses is becoming increasingly irregular. A review of successful small school models needs to be conducted in order that the successes in other settings could inform reorganization of BC's small rural high schools. In particular, course delivery models where students are enabled to access the subject specialty content of their areas of interest while working in the local school should be considered. In some cases this will involve promoting teacher development to gain additional expertise, including both pedagogical and content knowledge. In others it may mean using the interactive potential of the Internet to connect students with teachers who offer the courses electronically. Several models are now under development or in pilot studies such as the BC Ministry of Education *E-learning Research Sites*, where five school districts are exploring how to connect two or more classrooms using interactive technologies in order to expand students' choices for course offerings, or the various programs operated by school districts to support *Learning at a Distance* (BC Ministry of Education, 2004a). Further research will be necessary to consider the efficacy of such models.

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References

Aikenhead, G.S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education, 27*, 1-52.
Aikenhead, G.S. (2001). Students' ease in crossing cultural borders into school science. *Science Education, 85*, 180-188.
Aikenhead, G.S., & Jegede, O.J. (1999). Cross-cultural education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*, 269-287.
Anderson, G. (1990). *Fundamentals of educational research*. Basingstoke, UK: Falmer.
Barnhardt, R., & Barnhardt, C. (1983). Chipping away at rural school problems: The Alaskan experience with educational technology. *Phi Delta Kappan, 65*, 274-278.
BC Ministry of Education. (2003). *Enhancing rural learning: Report of the task force on rural education*. Available: http://www.bced.gov.bc.ca/mintask/rural.htm
BC Ministry of Education. (2004a). *Learning at a distance.* Available: http://www.bced.gov.bc.ca/dist_learning/
BC Ministry of Education. (2004b). *Success and participation rates for grade 12 provincial examinations by school*. Available: http://www.bced.gov.bc.ca/exams/trax/2004_trax5019b.txt
Bruner, J. (1996). *The culture of education*. Cambridge, MA: Harvard University Press.
Campbell, B., Lubben, F., & Dlamini, Z. (2000). Learning science through contexts: Helping pupils make sense of everyday situations. *International Journal of Science Education, 22*, 239-252.
Chaiklin, S. (2003). The zone of proximal development in Vygotsky's analysis of learning and instruction. In A. Kozulin, B. Gindis, V.S. Ageyev, & S.M. Miller (Eds.), *Vygotsky's educational theory in cultural context* (pp. 39-64). Cambridge, UK: Cambridge University Press.
Claxton, G., Pollard, A., & Sutherland, R. (2003). Fishing in the fog: Conceptualising learning at the confluence of cultures. In R. Sutherland, G. Claxton, & A. Pollard (Eds.), *Learning and teaching where worldviews meet* (pp. 1-13). Stoke on Trent, UK: Trentham Books.
Cobb, P. (1994). Constructivism in mathematics and science education. *Educational Researcher, 23*(7), 4-13.
Cobern, W.W. (1993). Contextual constructivism: The impact of culture on the learning and teaching of science. In K. Tobin (Ed.), *The practice of constructivism in science education* (pp. 51-69). Hillsdale, NJ: Erlbaum.
Cobern, W. (1996). Worldview theory and conceptual change in science education. *Science Education, 80*, 579-610.
Cole, M. (1996). *Cultural psychology: A once and future discipline*. Cambridge, MA: Harvard University Press.
Conference Board of Canada. (2003). *Solving Canada's innovation conundrum: How public education can help*. Available: http://www.conferenceboard.ca/
Costa, V.B. (1995). When science is another world: Relationships between worlds of family, friends, school and science. *Science Education, 79*, 313-333.
Creswell, J. (2003). *Research design: Qualitative, quantitative and mixed methods approaches*. Thousand Oaks, CA: Sage.
Darling-Hammond, L. (1997). *Doing what matters most: Investing in quality teaching.* New York: National Commission on Teaching and America's Future.
Darling-Hammond, L. (2000). Teacher quality and student achievement: A review of state policy evidence. *Educational Policy Analysis Archives, 8*(1). Available: http://epaa.asu.edu/epaa/v8n1/
Deboer, G.E. (2000). Scientific literacy: Another look at historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching, 37*, 582-601.
Denzin, N.K., & Lincoln, Y.S. (Eds.). (1998). *Strategies of qualitative research*. Thousand Oaks, CA: Sage.
Denzin, N.K., & Lincoln, Y.S. (Eds.). (2003). *Strategies of qualitative inquiry*. Thousand Oaks, CA: Sage.
Duit, R., & Treagust, D. (2003). Conceptual change: A powerful framework for improving science teaching and learning. *International Journal of Science Education, 25*, 671-688.
Duschl, R.A. (1988). Abandoning the scientistic legacy of science education. *Science Education, 72*, 51-62.

Erickson, F. (1986). Qualitative methods in research on teaching. In M. Wittrock (Ed.), *Handbook of research on teaching* (pp. 119-161). New York: Macmillan.
Erickson, F. (2002). Culture and human development. *Human Development*, *42*, 299-306.
Fontana, A., & Frey, J. (2000). The interview: From structured questions to negotiated text. In N.K. Denzin & Y.S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 645-672). Thousand Oaks, CA: Sage.
Gallagher, J.J., & Tobin, K.G. (1991). Reporting interpretive research. In J. Gallagher (Ed.), *Interpretive research in science education* (pp. 85-95). National Association of Research in Science Teaching Monograph No. 4. Manhattan, KS: NARST.
Gerdes, P. (1997). Survey of current work on ethnomathematics. In A.B. Powell & M. Frankenstein (Eds.), *Ethnomathematics: Challenging Eurocentrism in mathematics education* (pp. 331-371). Albany, NY: SUNY Press.
Geertz, C. (1973). *The interpretation of culture*. New York: Basic Books.
Giroux, H. (1992). *Border crossings*. New York: Routledge.
Gutstein, E., Lipman, P., Hernandez, P., & de los Reyes, R. (1997). Culturally relevant mathematics teaching in a Mexican American context. *Journal of Research in Mathematics Education*, *28*(6), 709-737.
Hodson, D., & Hodson, J. (1998). Science education as enculturation: Some implications for practice. *School Science Review*, *80*(290), 17-24.
Howley, C. (1994). *The academic effectiveness of small-scale schooling (an update)*. (Report No. EDO-RC-94-1). Charleston, WV: ERIC Clearinghouse on Rural Education and Small Schools. (ERIC Document Reproduction Service No. ED 372897)
Jegede, O.J. (1995). Collateral learning and the eco-cultural paradigm in science and mathematics. *Studies in Science Education*, *25*, 97-137.
Karpov, Y.V. (2003). Vygotsky's doctrine of scientific concepts. In A. Kozulin, B. Gindis, V.S. Ageyev, & S.M. Miller (Eds.), *Vygotsky's educational theory in cultural context* (pp. 65-82). Cambridge, UK: Cambridge University Press.
Krugly-Smolska, E. (1995). Cultural influence in science education. *International Journal of Science Education*, *17*, 45-58.
Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York: Cambridge University Press.
Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.
Lipka, J. (1999). Yup'ik culture and everyday experience as a base for school mathematics. In J.E. Hankes & G.R. Fast (Eds.), *Changing the face of mathematics: Perspectives on Indigenous people of North America* (pp. 263-276). Reston, VA: National Council of Teachers of Mathematics.
Meier, D. (1996, September). Big benefits of smallness. *Educational Leadership*, *54*(1), 12-15.
Merriam, S.B. (1998). *Qualitative research and case study applications in education*. San Francisco, CA: Jossey-Bass.
Miles, M., & Huberman, A. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, CA: Sage.
Montgomery, J. (1999). *An investigation into the issues shared by professionals living and working in rural communities in British Columbia*. Unpublished doctoral dissertation, James Cook University, Townsville, Queensland, Australia.
Nielsen, W.S., & Nashon, S.M. (2004, April). Factors impacting teaching of senior science and mathematics in small rural British Columbia schools: Perspectives from principals, teachers and students. *Proceedings of the National Association for Research in Science Teaching* (CD Rom). Vancouver: Annual Meetings.
Palys, T. (1997). *Research decisions*. Scarborough, ON: Thomson Canada.
Phelan, P., Davidson, A., & Yu, C.H. (1991). Students' multiple worlds: Negotiating the boundaries of family, peer and school cultures. *Anthropology and Education Quarterly*, *22*, 224-250.
Roth, W.M., Boutonne, S., McRobbie, C.J., & Lucas, K.B. (1999). One class, many worlds. *International Journal of Science Education*, *21*, 59-75.
Rural School and Community Trust. (2000a). *A first person account of the Rural Trust's Education Renewal Zone Initiative in Missouri*. Available: http://www.ruraledu.org/roots/rr301g.htm
Rural School and Community Trust. (2000b). *Alaska standards for culturally responsive schools*. Available:www.ruraledu.org/rpm/rpm201c.htm
Rural School and Community Trust. (2000c). *Declining enrollments: Silent killer for rural communities*. Available: http://www.ruraledu.org/rpm/rpm205a.htm
Rural School and Community Trust. (2000d). *Standards in public schools: A policy statement of the rural school and community trust*. Available: www.ruraledu.org/docs/standards.pdf

Rutherford, F., & Ahlgren, A. (1990). *Science for all Americans*. New York: Oxford University Press.
Sher, J. (1995). The battle for the soul of rural school reform. *Phi Delta Kappan, 77*, 143-148.
Sher, J., & Sher, K. (1994). Beyond the conventional wisdom: Rural development as if Australia's rural people and communities really mattered. *Journal of Research in Rural Education, 10*, 2-43.
Sleeter, C.E. (1997). Mathematics, multicultural education, and professional development. *Journal of Research in Mathematics Education, 28*(6), 680-696.
Stake, R. (2000). Case studies. In N.K. Denzin & Y.S. Guba (Eds.), *Handbook of qualitative research* (pp. 435-454). Thousand Oaks, CA: Sage.
Yin, R. (1984). *Case study research: Design and methods*. Thousand Oaks, CA: Sage.