Students' Ease in Crossing Cultural Borders into School Science

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Abstract

The purpose of this article is to fine-tune a grounded-theory scheme originally proposed in this journal by Costa (1995). She categorized students according to the ease with which they succeed in school science; an ease related to the similarity between their life-world culture and

the culture of school science. In this article I propose an additional category, "I Want to Know" Students, to her five-category scheme. These are students who are just as interested in science as Costa's Potential Scientists but who find school science intimidating in some way, though not as intimidating as Costa's "I Don't Know" Students. By adding another category to Costa's scheme, researchers and teachers can better understand the range of differences between a student's life-world culture and the culture of school science. This understanding has direct implications for the ease with which students cross cultural borders into school science.

Based on a “science for all” ideology, cross-cultural science education is an emerging paradigm of research and practice that has guided investigations into curriculum, instruction, and assessment for students who experience school science as a foreign culture (Aikenhead, Allen and Jegede, 1999; Atwater and Riley, 1993; Jegede and Okebukola, 1991). Science seems foreign to the vast majority of students in school science, whether they live in Western or non-Western communities (Aikenhead, 1996). This foreignness arises from: differences between students' life-world cultures and the culture generally embraced by the scientific community (Costa, 1995; Jegede, 1995), differences between a student's worldview and the worldview commonly conveyed by Western science (Cobern, 1996), and differences between the social contexts of learning science knowledge and the contexts of using that knowledge (Hennessy, 1993; Layton, Jenkins, Macgill and Davey, 1993).

One approach to overcoming these differences was described by Aikenhead and Jegede (1999). They proposed that teachers (1) recognize Western science as being a cultural entity itself; (2) acknowledge the cultural border crossings that most students experience to varying degrees when moving from their life-worlds into the world of school science, and therefore, acknowledge that learning science is a cross-cultural event for most students; (3) consider the various ways students deal with cognitive conflicts arising from culture clashes, and use collateral learning theory to make sense out of these conflicts; and (4) help students negotiate their border crossings and help them resolve any cultural conflicts. This cross-cultural perspective was warranted by research undertaken in schools by cultural anthropologists. Phelan, Davidson and Cao (1991), for instance, found that students negotiated transitions between the subcultures of family, peers, and school, with various degrees of ease. Phelan et al. categorized these transitions as being smooth, manageable, hazardous, or impossible.

Inspired by this grounded theory, Costa (1995) focused her research on cultural differences between, on the one hand, students' worlds of family and friends, and on the other hand, the worlds of school and science. Costa gathered qualitative data (the words and actions of students) on 43 high school students enrolled in chemistry or earth science in two California schools with diverse student populations. She related students' consistent academic success with how easily students appeared to negotiate transitions into their science classes. Five categories of students emerged from her data:

1. Potential Scientists whose transitions are smooth because the culture of family and friends is congruent with the cultures of both school and science.
2. Other Smart Kids whose transitions are manageable because the culture of family and friends is congruent with the culture of school but inconsistent with the culture of science.
3. “I Don't Know” Students whose transitions tend to be hazardous because the cultures of family and friends are inconsistent with the cultures of both school and science.
4. Outsiders whose transitions are virtually impossible because the cultures of family and friends are discordant with the cultures of both school and science.
5. Inside Outsiders whose transitions are frustratingly difficult because the cultures of family and friends are irreconcilable with the culture of school, but is potentially compatible with the culture of science.

The first four categories represent degrees of ease at crossing cultural borders into school science. The fifth category arose from abject discrimination against some students by the school. “Although these categories do not fully capture the complexities and uniqueness of students' thinking and lives, they reveal important differences in student responses to school science that inform our understanding of what goes on in science classrooms” (Costa, 1995, p. 315).

As Costa predicted, her scheme has proven to be very useful to cross-cultural science studies (e.g. Aikenhead, 1996; Aikenhead and Huntley, 1997; Cobern and Aikenhead, 1998). In addition to Costa's work, cultural differences have been studied in terms of students' worldviews (Cobern, 1996), students' orientations (Snively, 1990), students' interpretive frameworks or repertoires (O'Loughlin, 1992), and minority students' culturally discordant experiences in North American science classrooms (Atwater, 1996; Lee, 1997). A cultural perspective on school science such as Costa’s seems more intuitively practical to teachers than other perspectives found in the literature because we all constantly negotiate cultural differences in our daily lives whenever we move from one social setting to another.

As a result of using Costa’s scheme to understand classroom events, I discovered a group of students who did not seem to fit into any of her five categories. Consequently I wish to propose a sixth category to Costa's scheme to enhance its usefulness for researchers and teachers. The purpose of this article is to document the evidence that supports the additional category "I Want to Know" Students. Costa's categories provide a fresh perspective on familiar problems in both formal and informal venues of instruction. They have implications for teaching, mentioned later in this article.

Evidence for a New Category

Three sources of evidence from different research studies are considered here. The first two are about individuals and come from studies in which I was involved. The third source describes a group of students identified by other researchers.

Tom

While engaged in an action research project in a grade 10 classroom (located in a conventional high school in Saskatoon, Canada), I became intrigued with a student's unique way of explaining phenomena. The student, Tom, was a reasonably conscientious student in an STS science course. His teacher and I were collaborating on research into ways to enhance personal constructivism (the teacher's agenda). Tom was one of five students to volunteer to interact with me via a journal, and to be interviewed before and after a unit on heat was taught by the classroom teacher.

Tom, a Euro-Canadian monolingual English speaker, described himself as an "average" student who loved to learn. "There was this science award I won in grade 6, but usually only grade 8's won it. ...I always liked science" (Tom, April, lines 2-5). Throughout my contact with Tom, he was always keen on science. Interestingly however, he could not accept some key scientific values endemic to the culture of science. For instance, he could not deal with idealized conditions, a central value to scientific thinking. This became apparent in his disbelief of temperature equilibrium. According to Tom, every object had a different temperature, and the temperature within an object changed throughout the object. Consequently, there was always a temperature gradient, either between objects or within an object. For example, a bundle of nails sitting in boiling water would never uniformly reach the temperature of the boiling water, according to Tom. Slight differences in temperature readings within the boiling water supported his view (e.g. the temperature at the water surface was cooler because it was further away from the heat source), while identical temperature readings at two different places within the boiling water were dismissed by his explanation that the thermometer was not sensitive enough to detect the temperature differences. In Tom's world, everything had a unique temperature. This view prevented Tom from controlling and manipulating variables, in spite of the fact that he enthusiastically did experiments in class. Rather than control variables, he would minimize their influence in an experiment, a characteristic of an engineering type of reasoning (Layton, 1991; Schauble, Klopfer and Raghaven, 1991). I originally described Tom's reasoning as technological rather than scientific.

Tom's commonsense conceptions formed a self-consistent system that in his mind explained all the events in the unit on heat. This alternative framework seemed to be embedded in his worldview and was consistent with his self-identity as a science person who reveled in reciting encyclopedic details and who respected an uncle who "knew lots of science." Tom's alternative framework was very useful to him and seemed impervious to any contradiction his teacher or I suggested (e.g. Is the top cover of the textbook at the same temperature as the bottom cover? — No, the top cover will have a slightly higher temperature because heat rises). Because Tom did not conceive of ideal cases, he could not see events through the eyes of a scientist, in spite of his desire to do so. Because he conceived of events in terms of concrete idiosyncratic instances, he could not participate in the culture of science in any conventional way.

Tom believed that scientific knowledge was any knowledge of nature; a generic definition of science that Lewis and Aikenhead (in press) referred to as a "nature-knowledge system." Tom's definition of scientific knowledge contrasted with the conventional definition subscribed to by most school science curricula and reform movements — Western science.

Tom's enthusiasm for the subject of science would suggest that he is a Potential Scientist, according to Costa's category system. But the cultural difference between the values that guide Tom's epistemology (e.g. knowledge is an accumulation of concrete contextualized facts) and the values that guide scientists' epistemology (e.g. knowledge is an accumulation of decontextualized abstractions) is so great that these two cultures are not at all congruent. Tom could not be considered a Potential Scientist. Moreover, the high relevancy of science in his life discounts him as an Other Smart Kid. His enthusiasm for science keeps him from being an "I

Don't Know” Student or an Outsider. Because he did not fight institutional discrimination, he is not an Inside Outsider. Tom does not seem to fit any of Costa's categories.

Betty

In a study of science teachers who taught Aboriginal[1] (Native American) students, Aikenhead and Huntley (1997) explored teachers' views on the connection between science and culture. Semi-structured interviews probed this science-culture nexus as it related to the participants' teaching. Betty was an Aboriginal teacher who taught grades 7-9 science in an urban school. The school had a high percentage of Aboriginal students. Betty described herself as “a sciencing teacher” who viewed student learning as making connections between school content and the students' world (Aikenhead and Huntley, 1997, Table P5). She believed that hands-on activities resulted in student comprehension, which she contrasted with the ineffectual textbook-bound teaching of her colleagues. To her, science was knowledge that all cultures have in their own way (that is, a nature-knowledge system; Lewis and Aikenhead, in press). According to Betty, Western science was the knowledge of nature found in Western culture.

During her interview, Betty described students in terms of how naturally they appeared to learn science. She talked about people who seemed to understand what was taught: “Just bang, they had it, and that was the way it was” (lines 228-229). She also described a second group:

> Then there were other people like me who always wanted to know why, and I had a terrible time understanding it. So therefore, even when I got the formulas and understood the basic idea behind the way they were teaching me, it couldn’t dominate my thinking because I never really fully understood it. (lines 229-233)

Betty did not offer a detailed explanation for her two categories, and consequently we cannot compare Betty’s reasons for finding school science difficult with Tom’s reasons.

Betty's two categories describe students’ relative success at navigating the cultural border between home and school science. She used this idea when reflecting on her own teaching. Perhaps Betty could have been much more effective in her reflections had she known Costa’s (1995) categories and had incorporated them into her thinking. Costa’s categories could likely increase Betty’s sensitivity and appreciation of individual differences among her students (as indicated in the section “Implications for Teaching”).

Betty's situation supports the need to fine-tune the category system that emerged from Costa's research. Betty's personal struggles in school science (quoted just above) suggest that she negotiated rather hazardous transitions into school science because she ran the psychological risk of doing poorly. However, Betty acquired a degree of understanding motivated by her curiosity about the world. She negotiated a hazardously adventurous border crossing into the culture of school science. Her understanding of science was different from Costa's Potential Scientists whose worldviews coincide with a typical Western science worldview, whose transitions into school science are smooth, and who achieve a deep understanding of the subject. Betty's desire to understand science, motivated by her interest in knowledge about nature, sets her apart from Costa's Other Smart Kids who do not see science as relevant to their lives, but who are motivated to acquire high grades and course credits needed for higher education, and who are able to manage the transition into academic school science. Furthermore, Betty certainly does not belong to Costa's "I Don't Know" Students whose transitions into school science are hazardous because of a discrepancy between school culture and their own home culture, and who invariably memorize ideas and procedures to save face and do well enough at school (i.e. play Fatima's rules; Aikenhead and Jegede, 1999). Certainly Betty does not fit the description of Costa's Outsiders or of her Inside Outsiders. Another category for Costa's scheme seems warranted.

Future Technicians

Seventeen-year old science students in the UK are often given a choice between studying an advanced level, academic science course (A-level, which emphasizes symbolic knowledge) or an advanced level, technology-design science course (General National Vocational Qualification, GNVQ, which emphasizes the more concrete knowledge of design technology). By conducting interviews with 60 GNVQ students, Solomon and Thomas (1999) studied the factors that played a role in their decisions to opt for a GNVQ science course (factors such as students' anticipated type of employment and their interest in the subject area). Solomon and Thomas concluded, "Other studies [conducted in the European Community] of GNVQ advanced level science students also found a more durable connection between success in vocational science courses and interest in science, than with the grades obtained previously in school science examinations" (pp. 75-76). In other words, students' success with GNVQ was associated more with interest in science than with achievement in academic science. These students found the area of science highly interesting (enough to take advanced science courses) but were less successful in academic science courses than in technology-design science courses. Similar to Tom and Betty, these students are not Potential Scientists, nor do not fit any of Costa's other categories.

"I Want to Know" Students

For Tom, Betty, and others who enjoy science for various reasons but who experience a degree of difficulty in school science for many different reasons, I propose the category "I Want to Know" Students. These people display the following characteristics: (1) they tend to experience hazardously adventurous border crossings into school science; (2) their personal worldview or home culture may not exactly mimic the worldview conventionally conveyed by Western science or by the culture of school science; but (3) they are predisposed to learning Western science because of a pervasive desire to learn more about the world (Tom), a personal curiosity about nature (Betty), or a high interest in a technology-related field (GNVQ graduates), and hence, (4) they do not achieve a deep understanding of science, but instead, they acquire a modest yet effective understanding of science. A modest yet effective understanding of science is a world above the memorization and superficial learning that Other Smart Kids and "I Don't Know" Students usually achieve (Aikenhead and Jegede, 1999).

The new category, "I Want to Know" Students, recognizes students who want to understand Western science but whose success is made difficult by the diversity between their cultural identity and the culture of school science. Their border crossing into Western science seems to be hazardously adventurous mainly for cognitive reasons, for example, difficulty with idealistic situations, difficulty speaking mathematics fluently, or difficulty with symbolic representations. The self-esteem of "I Want to Know" Students tends to be at risk if they receive a low mark in science after all the work they put into studying their favorite subject.

Costa's Revised Scheme

This article's cultural perspective on student learning encompasses, rather than negates, psychological and sociological constructivist perspectives on learning. For instance, Costa's anthropological categories are reinforced by Alsop and Watts's (1997) psychological model for informal learning in science museums. Their model of conceptual change has four components. The first is cognitive and draws upon the intelligible, plausible, fruitful, and dissatisfaction aspects of Strike and Posner's (1985) early view of conceptual change. The second component is conative and relates to "the degree to which knowledge and understanding can be practically useful and made applicable" (Alsop and Watts, 1997, p. 639). This component addresses the problem arising from cultural differences between the context of learning and the context of use mentioned earlier (Hennessy, 1993; Layton et al., 1993). The third component is affective and is highlighted by the degree to which learning is germane (personally relevant), salient, and palatable. The fourth component is called self-esteem and deals with a person's confidence in learning science, a person's capacity and motivation to pursue scientific topics, and a person's image of themselves and how this image fits the person's perception of science. Alsop and Watts (1997) concluded:

> A person's engagement with scientific knowledge must fit with his or her self-image and lifestyle, to enable them to act with confidence and self-direction. Where these features of learning are weak then engagement with ideas and concepts is likely to be insecure — conceptual change learning is then very precarious. (p. 648)

In the context of schools, precarious learning causes adventurous and hazardous border crossings into science.

Costa's Potential Scientists and Other Smart Kids likely share the cognitive attributes of the Alsop and Watts model, as well as the self-esteem attribute in terms of academic success. However, Other Smart Kids have self-images and lifestyles at odds with science, making science personally irrelevant to them. Similarly, each category of Costa's scheme can be delineated by Alsop and Watts' model of conceptual change.

Costa's scheme can be summarized as follows (fine-tuned by the addition of "I Want to Know" Students):

1. Potential Scientists: smooth border crossings that lead to an in-depth understanding of science. Their self-image and lifestyle resonate with the world of Western science.

2. “I Want to Know” Students: adventurous border crossings that lead to a modest yet effective understanding of science (there are hazards but students want to know). Their self-image and lifestyle resonate with the world of science, but the intelligibility, plausibility, or fruitfulness of Western science concepts is often a challenge to them.
3. Other Smart Kids: easily managed border crossings but with no personal interest in pursuing science. These students do not fit the self-image and lifestyle they associate with Western science, but they do have strong self-esteems and self-perceptions related to academic success.
4. “I Don't Know” Students: hazardous border crossings into a superficial understanding of science (there are hazards but students do not want “to look stupid” in the eyes of their peers or teacher). Science does not fit their self-esteem or their lifestyle, but they have enough self-esteem and self-perception to persevere.
5. Outsiders: impossible border crossings that lead to dropping out, physically or intellectually. Science fits neither their self-images nor their lifestyles.
6. Inside Outsiders: impossible border crossings due to institutional discrimination in spite of personal interest in understanding science.

Implications for Teaching

The six categories in Costa’s revised scheme have direct implications for science curriculum, instruction, and assessment. Imagine if teachers were able to reflect on the different ways their students’ experience cultural border crossing into their class (smooth, adventurous, managed, hazardous, or impossible border crossings). When we perceive our students differently, our instruction can change accordingly. This is briefly indicated here for the first three categories of students. (More examples are found in Aikenhead, 1996, 1997).

For Potential Scientists, borders do not seem to exist at all. Much has been written about enculturing such students into the practice of Western science in ways like apprentices are initiated (Costa, 1993; Hawkins and Pea, 1987; Ryan, 1981). The teacher's role is one of coaching apprentices. These students comprise a very small proportion of any student body.

“I Want to Know” Students are usually challenged by adventurous border crossings into school science. A sensitive teacher provides guidance for these students to support their self-esteem and to nurture their interest in a scientific apprenticeship. This explicit support is captured by the notion of tour guide. A teacher would modify the apprenticeship approach by giving “I Want to Know” Students the guidance and support that one would expect from a tour guide in a foreign culture. This approach tends to bridge the differences between the social context of learning and the social context of use, identified earlier as a problem for science teaching (Layton,1991; Layton et al., 1993).

Other Smart Kids often manage their border crossings into school science either by relying on their capacity to handle academic abstractions easily, or by playing Fatima's rules that help them pass courses without understanding the course content meaningfully (Aikenhead and Jegede, 1999). Manageable border crossings could become smooth if students perceived the content of the course as relevant to their personal world. Thus, a sensitive teacher would connect the course content to students' academic interests by constructing a bridge to the culture of Western science out of technical and social issues, and out of the history, epistemology, and sociology of science (i.e. STS content; Solomon and Aikenhead, 1994). Because Other Smart Kids are travellers in an unfamiliar culture, they require a degree of guidance from a travel-agent type of teacher who provides incentives for them to travel into the culture of science, incentives such as topics (water quality), issues (genetically altered food), or events (scientific controversies such as cold fusion) that create the need to know more about the culture of science. The teacher’s travel-agent role is often one of co-learner.

Summary

For people in Western or non-Western countries, Western science can seem foreign for many types of reasons — psychological, sociological, and cultural. Whether in classrooms or museums, learning science seems to be determined by:

1. the difference between a student's cultural identity and the culture of science or school science,
2. the effectiveness with which students are able to cross the cultural border between their life-world and the world of science or school science, and the assistance students receive as they negotiate those cultural borders.

By adding another category ("I Want to Know" Students) to Costa's (1995) scheme, researchers and teachers can better understand the range of differences between a student's cultural identity and the culture of school science. By being cognizant of these differences, teachers can better assist students negotiate the cultural borders into school science.

Footnotes

1. The term "Aboriginal" is a Canadian constitutional term that encompasses all peoples of First Nations ancestry, whether or not they are of pure blood lines. Most importantly, the term "Aboriginal" was chosen by the people to whom it refers. Nevertheless, I acknowledge the problems of labeling people by such categories (Calliou, 1998).

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