Lessons From Assessment: Experiences of a Cross-Cultural Unit of Work in Science

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Abstract

This instrumental quasi-action-research multi-case study was conducted in Trinidad and Tobago to investigate students' responses to a summative assessment of a cross-cultural unit of work. The unit was designed to help my students to learn western science by building bridges between their traditional practices and beliefs on selected health-related matters and conventional science concepts. Students' responses to the summative test were analysed qualitatively by a process of coding and categorizing. The results indicated, firstly, that students did not necessarily show that they had learned conventional science when personalized tasks were associated with contextualized stimuli. Secondly, students' responses provided evidence of parallel collateral learning. These findings were deliberately explored during a second research cycle. The initial findings were corroborated. In addition, examples of dependent and secured collateral learning emerged. There are implications for assessment policy and for further research to develop a science of science within the Caribbean.

Key words: action research, collateral learning, science, context cues, assessment.

Introduction

According to Black (1998), there are three major fundamental purposes of assessment: to monitor student performance and so aid future learning (formative assessment), to certify students as having completed a predetermined phase of learning, and to act as a mechanism by which teachers are made accountable for their work (summative assessment).

Summative assessment has played a prominent role as a mechanism for the certification of students within the education systems of Trinidad and Tobago and the wider Caribbean region. It is generally intended to select students for higher levels of learning or for employment, based on their demonstrated acquisition of the concepts and or skills to which they have been exposed within the formal school environment.

The Caribbean Examinations Council (CXC) is the agency that is responsible for the summative examinations (Caribbean Certificate of Secondary Education –CSEC) that Caribbean students write at the end of the first five years of secondary schooling. The CSEC science examination questions are designed to determine whether students have learnt the science concepts to which they have been exposed and can apply them to everyday life situations - if they think scientifically. According to Leach and Scott (2000, p. 43) “learning science involves coming to understand, and being able to use, the conceptual tools of the scientific community.”

Many science teachers and science education researchers purport that in order to demonstrate that they have learnt science, most students must engage in the process of conceptual change (Posner et al., 1982). This is generally thought of as a process in which students’ prior knowledge, variously described as "misconceptions," "alternative conceptions," "untutored beliefs," "naive explanations" and "preconceptions" (Driver & Easley, 1978; Gilbert & Watts, 1983; Hills, 1989; Smith, 1994), is replaced by the science explanations and ideas presented by the teacher.

Many reports in the science education research literature reveal, however, that students' prior knowledge is resilient (Rampersad, 1996; Solomon, 1983, 1992), so based on their performance on examinations, it is often inferred that students have not acquired the science concepts that are taught in schools. Many teachers often informally support this conclusion as do the examiners' comments, which are quoted in some official reports. For example, the examiners' reports on students' performance in the Caribbean Examinations Council (CXC) science subjects (CXC, 1999a, 1999b, 1999c, 2000a, 2000 b) often include comments that students performed poorly, and examples of the misconceptions are identified.

One plausible explanation for the "misconceptions" often identified within students' responses to test items comes from research in science education in which the relationship between the design of test item and student responses was analysed. One example of this research was presented by Solomon (1992). She reported that students tend to revert to their prior knowledge when tasks contain stimuli that are embedded within their everyday life experiences, and that students tend to present classroom knowledge when the tasks are disembedded. There are obvious implications of these research findings for item construction. However, Black (2000, p. 328) laments "there is a gulf between the scholarly worlds of measurement and assessment and of science education research, with the latter for whatever reason, making very little impact on the former." He also suggests that there is very little if any research done on the sociocultural aspects of assessment.

This paper reports on students' responses to an end-of-unit test based on their experiences of a cross-cultural unit of work in science in which their traditional knowledge was used as the springboard for the development of science lessons. It attempts to advocate from empirical evidence, in accordance with the enlightenment model (Trowler, 2003) toward education policy, the need for further research to bridge the gap between policy on examination and certification of students and science education research within the sociocultural context of a developing country like Trinidad and Tobago. This paper, therefore, focuses on issues that can contribute to discussions about that aspect of summative assessment that addresses the certification of science learning. It attempts to serve as a catalyst for stakeholders to look at the sociohistorical context within which the examination and certification of students within the Caribbean emerged and to interrogate the underlying assumptions which guide assessment practices. Through this interrogation some deeper understanding of the assessment of science students within the Caribbean context may emerge.

Background to the study

From my experience as a science teacher in the secondary school system for 15 years, I became aware that many students had developed a negative view of science, and many informally expressed the view that science was not relevant to their everyday lives. In some cases, even science students who performed well on teacher-made tests tended to abandon the study of school science as soon as the opportunity arose, that is, as soon as the subject was no longer mandatory. In addition, the academic performance of some of my students was below my expectations.

Researchers who adopt a cultural lens to explain students' attitude to, and performance in, science in the formal setting suggest that there is interference between the cultural background of the learner and school learning (George, 1995; Ogunniyi, 1988). For example, Costa (1995) and Jegede and Okebukola (1991) have reported that the greater the degree of congruence between students' in-school and out-of-school experiences, the more positive were their attitudes towards school science. The cultural view of science education seemed plausible in the context in which I taught based on my own personal experiences and on the research that had been done within the Caribbean in the 1980s (George, 1986; George & Glasgow, 1988).

George (1986) engaged in pioneering work within Trinidad and Tobago, and she identified students' traditional customs and beliefs about matters that are often addressed in the formal science classroom as "street science." She noted, however, that street science is often premised upon principles that are quite different from those presented in the science classroom. In fact, her research indicated that 66% of the street science data collected were not supported by conventional scientific principles. For example, a traditional belief is that the common cold is caused by a sudden change in body temperature (temperature change theory) while conventional science argues that a virus causes the common cold (germ theory). Pursuing the line of research into the traditional customs and beliefs, George (1995) investigated the traditional practices and beliefs of persons who resided within the rural village that she named "Seablast." She discovered that many of the villagers' actions on health-related matters were underpinned by principles that were based upon the traditional way of knowing. One such principle was described by George (1995, p.93) as the principle relating to heat and cold, which states that "a ‘heated’ body should not be exposed suddenly to cold or cool environments."

In keeping with the Ausubelian principle that learning must begin where the learner is, and in light of current research findings that indicate that students who are knowledgeable about traditional practices and beliefs may be restricted in their access to the conventional science concepts unless the differences are made explicit (Aikenhead, 1996, 1997; Aikenhead & Jegede, 1999; Cobern 1991, 1993), George (1995) strongly advocated the use of students' prior traditional knowledge in assisting students to learn science that is presented in the classroom. It became evident then that my desire to improve learning in science in the classroom and to make the science curriculum relevant to my students’ daily experiences would naturally lead to an exploration into the development of a cross-cultural curriculum. I therefore embarked upon the investigation of my students’ prior knowledge of traditional practices and beliefs.

A questionnaire was distributed to all 36 students in a Form one class that I taught to determine their knowledge of traditional practices and beliefs. Follow-up interviews were conducted with 10 students who had demonstrated knowledge of traditional practices and beliefs on at least 70% of the items. The analysis of the data indicated that many of my students were knowledgeable about traditional practices and beliefs on some selected health-related matters. Most students, for example, described situations that were underpinned by the traditional principle relating to “heat” and cold (George, 1995). They believed that the common cold was caused by inappropriate interaction of the “heated” human body with the environment. Also, some of them had knowledge of "cooling" (a drink, which is prepared to remove excess “heat” from the body), such as "burnt bread water," and had been given "cooling" and purges as a matter of course. However, the principles underpinning the use of these practices and beliefs were not discussed in the formal science classroom.

Having determined that my students came to the science classroom with prior knowledge that often was not congruent with the substantive content of the western science that is presented in class, I designed a unit of work in which I attempted to have students build bridges between their everyday culture and the culture of science by explicitly comparing the two ways of knowing (traditional beliefs and conventional science concepts). The following research questions guided this phase of the research:

1. What explanations for selected health-related phenomena do students provide when a teacher-made test is administered after they have been exposed to a unit of work in which an explicit bridge building strategy of comparing traditional beliefs with conventional science concepts was used?
2. What types of items elicit conventional science concepts for selected health-related phenomena after exposure to a unit of work in which the explicit bridge building strategy was used?

Theoretical framework

Geertz (1973) defines culture as the ordered system of symbols and meanings, which facilitate social interaction. Phelan et al. (1991) operationalize Geertz's definition. They define culture as the norms, values, beliefs, and attitudes that are characteristic of a group, and they describe the students' daily experiences in the family, the school, and among their friends as experiences of multiple worlds. These worlds are defined by the attitudes, values, beliefs, expectations, and actions that are common to the family, the school, or the peer group. Phelan et al. posit that students may move among many worlds each day and, as a result, they are continually negotiating the boundaries between these worlds. Costa (1995) building on the work of Phelan et al. (1991) found that the greater the degree of congruence between students' in-school and out-of-school experiences, the more positive were their attitudes toward school science.

There have been a number of recent reports in the educational literature in which a cultural dimension of science learning has been advanced (Aikenhead, 1996; Aikenhead & Jegede, 1999; George, 1995; Stanley & Brickhouse, 1998; Waldrip & Taylor, 1999). Culture is often discussed in science education literature through an exploration of "ways of knowing," multiple worlds and worldview theory -culturally validated presuppositions about the natural world (Cobern, 1991). Aikenhead (1996) posits that science taught within the formal school environment is a sub-culture of western culture that is characterized by specialized concepts/jargon and procedures that are specific to the particular sub-group of scientists within the society. Therefore, he argues that students must cross borders (Giroux, 1993) to the scientific way of knowing when they come to the science classroom from their everyday world of traditional practices and beliefs, because these two environments use different symbols and meanings to describe understandings about the world. It means, for example, that students who are knowledgeable about "heat" as an intrinsic property of the human body (George, 1995) will have to cross borders into the sub-culture of science in which heat is associated with the transfer of energy.

The idea that students cross borders from their everyday worlds to the world of science has its origins in the application of an anthropological approach to the thinking about curriculum, analogous to the way in which researchers may understand another culture (way of life of another people) but not necessarily personally accept that culture. Proponents of this recent strand of research into science teaching as border crossing into the culture of science have recognized the value/contribution of students' prior knowledge towards cultural identity and self-esteem (Cajete et al., cited by Aikenhead, 2001). Jegede (1995) and Aikenhead and Jegede (1999) believe that science is one way of knowing, and they have recognized and they aim to legitimize the idea that after exposure to science teaching students can hold on to different ways of knowing, which they may elicit in varied contexts.

Jegede (1995) described the type of science learning that occurs within a framework of pre-existing alternative knowledge as collateral learning. He defined collateral learning as "an accommodative mechanism for the conceptual resolution of potentially conflicting tenets within a person's cognitive structure" (1995, p. 117). He described four types of collateral learning- parallel, dependent, secured, and simultaneous-, and he conceptualized collateral learning as a continuum in which parallel collateral learning and secured collateral learning are at opposite poles.

Parallel collateral learning is said to occur when students hold in long-term memory concepts that conflict, but do not interact, and are elicited in different contexts. Secured collateral learning, on the other hand, is used to describe the result of the restructuring of original schemata or the situation where in resolution of the potential conflict the person is aware of both schemata and has an adequate reason for maintaining both sets of concepts. Dependent collateral learning and simultaneous collateral learning are located between the two poles on the continuum. Jegede (1995) describes the first as the mechanism in which there is some interaction between the conflicting world views that results in modification of the prior knowledge but there is no radical restructuring of previously held schemata. The result is a well-stirred mix of ideas. Simultaneous collateral learning is the process by which students learn concepts emanating from different world views at the same time at home and at school, and they reinforce each other.

Methodology

The study was designed as an instrumental multi-case study, which was informed by action research cycles. A Form Two class at Parkview Secondary constituted the first case and a Form Two class at Seablast Secondary comprised the second case. The first research cycle- plan, act and observe, reflect (Kemmis & McTaggart, 1988)- was undertaken at Parkview Secondary, and the lessons learnt from the students' responses to the experiences provided during the enactment of the unit and to the summative end-of-unit assessment informed the second cycle that was undertaken at Seablast.

Participants in the study

The students at Parkview Secondary (all female) were between the ages of 12 to 16 years when the unit of work was taught. These were students whom I had taught during their Form one year at Parkview. They were typical of the students who entered Parkview Secondary based on their performance on the Common Entrance Examination (the selection examination through which students are placed into secondary schools). They were generally considered to be academic students whose performance would have put them within the top 20% of the cohort of students who sat the examination for the year. They resided in various parts of the country, were of different socioeconomic backgrounds, and displayed varying levels of interest in science, although this interest was generally positive. The vast majority of students performed well on the teacher-made tests at the end of the term. They obtained scores that ranged from 50% to 90% of the total score. A small minority of students (one or two) obtained scores that ranged from 40% to 50% of the total. However, there was a noticeable overall decline in student performance as they advanced through the lower secondary level from Form one to Form three.

The students who attended Seablast Secondary participated in the second research cycle during the second term of the following year. They were somewhat older; their ages ranged between 13 to 17 years. They resided mainly in the rural area, and their performance on the Common Entrance Examination was below the level of the Parkview students. Their performance on teacher made tests was also different. A few students obtained scores of 70% and the vast majority obtained scores of 20% and below. The Seablast students were exposed to a modified unit and teacher-made summative test based on the lessons learnt during the first research cycle undertaken at Parkview and on their demonstrated levels of proficiency in language and science.

<u>Procedure</u>

Seven lessons were taught over an eight-week period during the first research cycle that was conducted at Parkview. The lessons were entitled:

- Why science, what science, whose science?
- The common cold: Catch me if you can
- Cold or not?
- Homeostasis: Constancy in the midst of change

- Cooling-off
- Cooling- A home remedy
- Pimples and the adolescent

The lessons were designed to have students engage in the explicit comparison of the “temperature change” theory of the common cold with the germ theory; heat as an intrinsic property of materials with heat as energy transfer; managing the “heated” body by taking deliberate actions with homeostasis; and the role of diet in the appearance of pimples with the role of hormones and bacteria.

During the act and observe stage of the first research cycle, a summative pencil/paper test was used to collect data on students’ understandings of the concepts discussed. Following is a brief description of some of these items. To assess students’ understandings of the concepts discussed during the lesson entitled *“The common cold: Catch me if you can,”* the item was designed unconsciously as comprising contextualized stimuli and two associated tasks. One task contained a personalized cue- “you”; the other task contained an implicit science cue by inclusion of the scientific jargon “operational definition.” Students’ understanding of concepts explored in the other lessons was assessed by single task items. Some of these tasks comprised implicit science cues that were not directed to contextualized stimuli, such as “what do you understand by the term homeostasis?” Others included phrases such as “the doctor,” which was intended to cue student towards the conventional science explanation.

Based on the findings of the qualitative analysis- a process of coding and categorizing the test data obtained – the unit of work and the end-of-unit test were adapted for the second research cycle that was conducted at Seablast. The new unit that was enacted at Seablast secondary comprised fewer lessons; a larger proportion of class time was spent on the explicit comparison of traditional practices and beliefs with conventional science concepts; and the teacher-made test was redesigned.

Five lessons were taught at Seablast. They were entitled: *"Cold or not?" "The common cold: Catch me if you can," "Cooling-off," "Cooling- A home remedy,"* and *"Pimples and the adolescent."* In constructing items for the end-of-unit test at Seablast, the language was simplified to cater to the students' abilities. Furthermore, the findings from the first research cycle at Parkview seemed to suggest that use of context cues impacted on the type of responses provided, whether traditional or conventional science. Consequently, context cues were deliberately used more frequently in the summative assessment of the unit of work enacted during the second research cycle.

The items comprising the end-of-unit assessment at Seablast were designed deliberately to present personalized tasks and overt science cues to contextualized stimuli for each of the lessons taught. In addition, the teacher-made test was also used as a pre-test for in-depth analysis of changes in Seablast students' responses to answer the additional research question:

> What changes in students' responses occur after they have been exposed to a unit of work in which there was explicit comparison of traditional practices and beliefs and conventional science concepts?

Findings from Parkview

The findings from the first research cycle that was conducted at Parkview revealed that students did not readily use conventional science concepts on the end-of-unit summative test when they were asked to respond to personalized tasks based on contextualized stimuli. The results are presented below.

Students' responses to context cues

The finding that students used different conceptual frameworks in response to the context cues provided emerged at Parkview. The students were asked to respond to the following item about the common cold:

> Many people have observed that they "catch the cold" if they (i) get wet in the rain (ii) go to the refrigerator after playing in the sun or after ironing, (iii) sleep with wet hair, (iv) have a cold shower immediately on waking.
>
> (a) Write an operational definition for the common cold and
>
> (b) How would you explain the observations stated above?

Fifty-seven and a half percent of the students used conventional science concepts in answering part (a). The phrase "operational definition" was an example of the implicit use of scientific jargon to cue students towards conventional science explanations. Only 32.5 % of the students used conventional science concepts in answering part (b), which contained the personalized cue. Given the experiences provided during this lesson, I had expected that in answering (b) students would have either of the following two responses. They could have provided a conventional science explanation by describing the conditions provided as triggering viral activity or they could have suggested that the persons who made these comments were drawing upon traditional ways of knowing when they described the conditions stated as the cause of the cold, and it is within this context that the students' responses are interpreted.

The relevant statistics from each part of the item were as follows:

(a) traditional responses: 20%; conventional science: 57.5%

(b) traditional responses: 55%; conventional science: 32.5%

Examples of students' responses, which were categorized as "traditional responses" and "conventional science" based on the ideas that had been discussed during the classroom sessions are presented below. They illustrate that students used concepts from traditional ways of knowing and from conventional science ways of knowing in response to the context cues provided:

Conventional science concepts

Students used the conventional science concept that an agent- the virus- causes the common cold in response to the item that comprised the science jargon "operational definition":

> The common cold is contracted by an airborne virus. The symptoms are running nose, coughing and sore throat.
>
> When a virus enters you body when it is at one temperature, if you do something to alter that temperature it triggers the virus to produce the cold.
>
> The common cold is not the virus but like a symptom like sneezing and coughing.

In addition to the above results to part (a) of the item about the common cold, the majority of Parkview students (90%) also used conventional science concepts in response to another item that contained implicit science cues as indicated by the science jargon, as "What do you understand by the term "homeostasis?" Some of these responses were:

> Homeostasis is the process by which the body temperature of a living organism remains stable or constant internally when the temperature outside has changed.

> Homeostasis is the process by which the body regulates its temperature.

Furthermore, half of the students used conventional science concepts with varying degrees of congruence with the universally accepted western science explanations when they were cued toward the conventional science response by use of the phrase “the doctor.” The following are two examples of students’ responses to the task: *“Write an account of how the doctor would explain the appearance of pimples,”* based on the lesson entitled: *“Pimples and the adolescent”*:

> Pimples are the result of hormones in your body producing excess oil, which clogs pores. The oil makes it easier for bacteria to get trapped in the pores, which leads to inflammation.

> During puberty androgens (male sex hormones) are produced and they cause the sebaceous glands to change in size and the amount of oil it produces. The oil clogs the pores and the bacteria trapped in the pores multiply and the skin becomes inflamed.

<u>Traditional concepts</u>

Some of the same students responded to the personalized cue presented in part (b) of the item on the common cold with the traditional concept that "temperature change" is the cause of the common cold. They did not refer to the virus, which is the conventional science concept that they had mentioned in part (a) of the item:

> When you awake on a morning your body is very warm...you are likely to catch the cold because of the change in temperature from warm to cold.

> If your body was at a temperature higher or lower than average, and you come into contact with something higher or lower than your present temperature, you might get a cold.

> First, it's true. I think if you get up in the morning, firstly hop into the shower or walk around barefoot, you could get the cold from the coldness

of the ground and that your body temperature is not normal.

Summary

As illustrated above, at least half of the students provided conventional science concepts in response to implicit or explicit science cues. However, the most significant finding from the analysis of the post-test data from the first case at Parkview was that the use of different context cues in tasks that were directed towards contextualized stimulus material seemed to trigger different types of student response—whether conventional science or traditional knowledge was used as the framework to explain the cause of the common cold. This finding seems to indicate that parallel collateral learning (Jegede, 1995) had occurred in some cases. Similar findings have been reported in the literature. Solomon (1992) reported on a study by Viennot in which the results indicated that the form of presentation of the task cued different responses. Consequently, this phenomenon was investigated further in a second research cycle that was conducted at Seablast Secondary. The findings from Seablast Secondary are presented below.

Parallel collateral learning at Seablast

Seablast students' responses to context cues on the post-test also gave evidence of parallel collateral learning. That is, the analysis of the Seablast data corroborated the finding from Parkview that parallel collateral learning was an outcome of the bridge-building approach to teaching a lesson about the common cold. As illustrated below, the responses to two items on the tests provided evidence that students had engaged in parallel collateral learning. In responding to the test item in which a personal explanation for the cause of the common cold was requested, some students used their traditional knowledge. They linked the occurrence of common cold with prolonged exposure to water and with exposure to water after activities that exposed the body to heat:

> Q: How would you explain how people "catch the cold?"
> A: Some people catch the cold by getting wet in the rain and doesn't dry their hair properly. After ironing going and bathe in cold water. After waking up and taking a cold shower right away.

In another item, the science context was overtly established by use of the cues "science class" and "science textbook." The item was presented as follows: "During science class, Kevon read an explanation from his science textbook about how people catch the common cold. Describe what might have been written in the science textbook." Students demonstrated that they had accessed the conventional science concept that germs cause the common cold. The response below, which was given by the same student was cited above, shows that she drew upon conventional science concepts by suggesting that an external agent caused the common cold:

> It might have said by transferring or giving someone the cold. Like when someone sneeze and doesn't cover their mouth the germs from them is spred to other individuals.

In addition to corroborating the occurrence of parallel collateral learning, the analysis of the Seablast data gave examples of other types of collateral learning. In the examples that follow the responses from one student, who was given the pseudonym Lystra, will be used to highlight the different types of students' responses. In addition, a comparison of Lystra's pre-test and post-test responses will be presented.

<u>Dependent collateral learning</u>

Lystra's responses to the test item that requested her explanations for the properties of materials revealed dependent collateral learning. The students were presented with the following scenario:

> Q: A class meeting was in progress when Wendy and Jane entered the air-conditioned room. There were only two chairs left. Both girls sat down, but Jane immediately jumped up with a screech: "Ahh! This chair is cold. You sat on the warm chair!" Do you agree with Jane's statement that one chair is cold and the other is warm?
>
> Pre: Yes. I agree that Jane's statement that the chair is cold because when sitting on metal or iron it's a very exposed piece of metal so it becomes cold.
>
> Post: Because when a metal chair is exposed it feels very cold when you sit down on it and the cloth covering material will be very warm.

A comparison of the pre/post-test results revealed that Lystra had changed her response from "it is cold" to "it feels very cold." One possible explanation for the difference is that she intended to demonstrate a change from an explanation based on the intrinsic property of material to one that conveys the idea that there is interaction between the person and the metal. Another is that the language was used loosely, and was not intended to indicate a change in conceptual understanding. However, given the experiences of the lesson entitled "*Cold or not?"* it appears that Lystra had accessed some aspects of the conventional science concept that some materials (conductors) can transfer energy across a temperature differential and others (insulators) cannot. It can be also be inferred that she maintained the notion that heat was an intrinsic property of materials. She said: "it will be very warm," and, in so doing, she used the future tense of the verb "to be."

Secured Collateral learning: Restructuring schema

A comparison of the pre-test responses with those on the post-test indicated that Lystra had accessed many of the conventional science concepts presented in the lessons. Lystra had learnt science, and, in so doing, some of her prior ideas were restructured. The comparison of the pre/ post-test responses based on the lessons *"Cooling*-Off" and

"Pimples and the adolescent," revealed that Lystra built on her prior conventional science notions to construct a fuller scientific explanation for the phenomena discussed. There was a change from the use of a mixture of traditional and conventional science concepts to explain the phenomena addressed in the lessons "*Cooling-Off"* and *"Pimples and the Adolescent"* to the use of conventional science concepts only- an indication of secured collateral learning. The new explanations reflected a convergence of those aspects of her original explanation that were similar to the conventional science explanation. The details of the analysis in which Lystra demonstrated that she had constructed a new conception in her long-term memory are presented below.

In response to the question "What is the purpose of sweating?" that was based on the lesson *"Cooling-Off,"* Lystra revealed some restructuring of schemata. Her explanation changed from a statement that comprised commonsense ideas about the removal of excess water and dirt to one in which she focused on water (now called perspiration) and included the conventional science concept that perspiration leads to a cooling effect on the body:

> Pre: So it can bring out the excess water, dirt, you burn energy while sweating.
> Post: Is when your body heat rises so it causes perspiration so your body could (feel cool) warm.

Similarly, on the item based on the lesson entitled *"Pimples and the adolescent,"* Lystra showed that she had restructured her original mixed explanation that puberty and dirt were both factors that contributed to the appearance of pimples:

> Q: Your young brother says: "I don't understand why you have pimples on your skin." Write what you would say to explain to him why you have pimples**.**

> Pre: Because when someone grows old they come into the stage of puberty. From dirt left on your skin. And everyone goes through a stage of puberty. And puberty is harsh on some people.
> Post: I have pimples because it's a part of growing up when you reaches the stage of puberty there are changes in your body. The hormones and bacteria reacts to your body.

The post-test response revealed that she had constructed a fuller understanding of the conventional science explanation about the relationship between puberty and the appearance of pimples by including the conventional science concept that hormones and bacteria play a role in the appearance of pimples. From a comparison of Lystra’s pre-test and post-test responses to the item that requested a personal explanation about the cause of pimples, it can be inferred that she had retained the scientific notion of puberty. However, it also indicates that she changed her explanation from a commonsense one that dirt is the cause of pimples to one that included the conventional science concept that hormones and bacteria play a role in the appearance of pimples.

The pre-test and post-test also contained an item based on the lesson entitled "*Pimples and the adolescent"* in which students were explicitly cued for the science explanation. The task presented was: “*Let's tell you the reason that our science teacher gives for the appearance of pimples*.” Lystra's pre-test response to this item is interesting because she did not use the conventional science term "puberty" that she had included in her personal explanation. In the pre-test response to this task, her explanation was based on the commonsense notion that the dirt left on the skin was the causative factor. At the end of the unit, however, the science explanation that she presented was similar to her personal explanation, and Lystra used conventional science concepts in response to both the personalized cue and the explicit conventional science cue:

> Pre: Pimples is left on the skin by excess dirt on the skin stage of pimple.
> Post: The hormones in your body and the bacteria reacts to the germs in your body and when you're growing up and you reach the stage of puberty you get acne.

In sum, based on Lystra's responses to both items, it was evident that on the pre-test she used different explanatory constructs in conveying her personal explanation and the science explanation. However, on the post- test, there was evidence that there was a convergence of her personal explanation and the science explanations towards the conventional science concept of puberty and the associated concepts of bacteria and hormones.

Overall summary

At the end of the unit, the students from both sites responded to items on the common cold in a manner that provided evidence of parallel collateral learning.   From Lystra's responses (as an illustration of the findings at Seablast), the request for personalized explanations triggered traditional responses about the common cold. On the other hand, explicit cues for the science explanation allowed her to demonstrate that she had accessed conventional science concepts about the common cold even though she had used the traditional mode as her personal explanation. In dealing with items about the properties of materials, there was evidence of the adjustment of her schemata to include concepts presented in the class alongside her traditional knowledge. She constructed schema that embraced both world views, that is, she readjusted her "memory to accommodate the different view presented in the science classroom" (Jegede, 1995, p. 119)-evidence of dependent collateral learning.

The analysis also revealed that requests for personal explanations sometimes elicited the conventional science concepts. For example, in response to the items on the lesson entitled: *"Pimples and the adolescent,"* Lystra restructured her original mixed explanations about the cause of pimples by focussing on the aspects of her explanation that were similar to the conventional science concepts that were presented in class, and she developed these conventional science explanations about puberty. A similar restructuring was observed in the task that requested the purpose of sweating in which the personalized term "you" was not used. These restructured responses suggest that secured collateral learning had occurred.

In sum, the findings of this instrumental case study support those of Viennot as reported by Solomon (1992) that students may revert to their prior knowledge when presented with contextualized or embedded stimuli. Additionally, this study revealed that some students who gave conventional science responses when cued toward the science explanation used their prior knowledge in response to contextualized stimuli when the task was personalized. These results were indicative of parallel collateral learning. Furthermore, there was evidence of collateral learning as conceptualized by Jegede (1995) revealed as dependent, and secured collateral learning.

Secured collateral learning led to the construction of more developed conventional science concepts. This is the generally expected/desired outcome of normal science teaching as reported in the educational literature. Leach and Scott (2000, p.42) express this view explicitly when they say that "learning science involves being introduced to, and coming to accept and understand, some of the norms, the ways of thinking, and the ways of explaining used in the scientific community." But, in addition to secured collateral learning, parallel and dependent collateral learning have also surfaced as results of this study, and there are obvious implications for the measurement of student performance on pencil/paper tests. However, as mentioned earlier, Black (2000) laments that science education research is rarely used to inform the measurement of student learning. This latter view will be addressed in the following discussion in light of current practice of the Caribbean Examinations Council (CXC) and in terms of the implications of parallel and dependent collateral learning for the assessment of science learning and the subsequent certification of science students.

Discussion

The results of this particular study show that the majority of students used conventional science concepts in response to items that are designed to include the personalized cue "you" in conjunction with scientific jargon. A perusal of the some of the CXC's Caribbean Secondary Examinations Certificate (CSEC) science examinations 1997-2000 (CXC, 2002 a, b, c, d) reveals that there is general use of the personalized cue "you" in this form, and, hence, the results of this study are in line with this measurement practice.

Further, the use of explicit science cues especially when tasks are based on contextualized stimuli that are embedded within the students' prior knowledge is supported by this research. Some students demonstrated that they had accessed the conventional science concepts when cued explicitly, although they may not have personally accepted these constructs because they reverted to their traditional knowledge when the personalized cue "you" was used.

What is particularly noteworthy is that some of the items that are designed for the CXC integrated science examinations include the explicit term "the science explanation."

For example, the May/June 1999 Basic Proficiency examination Paper 2, question 2c, asks: “Give your brother, Joe, a scientific explanation for the death of the fish” (CXC, 2002c). In the May/June 2000 examination, the following item was presented: “Your grandparents live close to the seaside. Your parents live far from the seaside. Your grandparents' wrought iron gate rusts faster than the one at your parents' home. Give a scientific explanation for this occurrence” (CXC, 2002c). Similarly, on the general proficiency examination in chemistry, the students were asked for the scientific explanation in some items, or for a chemical reason for phenomena in others. However, there is no evidence that CXC has enunciated a policy statement that items should be constructed to include explicit cues that would facilitate those students who may have to cross borders between the traditional ways of knowing and the sub-culture of western science.

The probable absence of such a policy is borne out by evidence from the CSEC science examinations. The use of explicit cues that guide students toward the culture of science is not a common feature of all the science items which include contextualized stimuli. Some biology and chemistry items did contain references to the science student and the research scientist. However, for example, there was an item on the May/June 2000 Biology examination paper as follows: “Some scientists consider the liver to be the most important organ in the body. To what extent do you think this is true? Support your answer with reasons” (CXC, 2002a). It is possible that students may use traditional concepts as they provide reasons to this personalized task because the explicit cues toward a science explanation have not been provided.

This research seems to indicate that without the appropriate test item-format some students who may actually have learnt science may remain uncertified. It seems that with this sensitization, the research section of the measurement and evaluation department of the CXC may want to investigate reports on the prevalence of traditional ways of knowing throughout the Caribbean region and on collateral learning. Other stakeholders from international examination agencies may find it prudent to review similar research findings in science education within their environment (Solomon, 1983, 1992). Such data may assist in the development of a general policy on item writing for science examinations and for dealing with responses, which indicate that two different conceptual frameworks were used.

As evidenced in this study, dependent collateral learning is a possible outcome for students who have entered the classroom with traditional/alternative knowledge but who have accessed the conventional science concepts discussed in the classroom. From my personal experience of correcting CSEC science examination scripts, however, students are normally penalized when they provide answers that are seemingly contradictory, as is often the case when they draw upon different ways of knowing. However, as demonstrated by this research, dependent collateral learning is evidence that students have accessed conventional science. Again, it is evident that further research and discussion is needed to formulate policy on the certification of students who have accessed, but who have not necessarily accepted, the western science concepts that are presented in the classroom.

As related specifically to the Caribbean region, CXC has been given the mandate to provide examinations that are appropriate to the region. "The Council shall (a) conduct such examinations as it may think appropriate and award certificates and diplomas on the results of examinations so conducted" (CXC, 1972). The people of the Caribbean have inherited a system of examination and certification in which little attention has been given to students' traditional knowledge either in terms of the format of items that remind students to cross the borders between the traditional world and the sub-culture of science or in terms of dealing positively with students' responses when traditional concepts are included. But new research in science education by Jegede (1995) and others puts a different light on the status of prior knowledge, and of learning within the framework of pre-existing knowledge. Perhaps, stakeholders may wish to discuss ways of certifying students who have demonstrated that they have accessed conventional science although they may not personally have accepted it.

As more students within the Caribbean region are exposed to science education, we may find that there are many who possess, and are deeply committed to, traditional knowledge, which for them provides reasonable solutions to the problems that they face, particularly as they relate to health. However, if the students are penalized for revealing their prior traditional knowledge, even as they demonstrate that they have accessed the conventional science concepts, there will continue to be many students and teachers whose self-esteem is eroded as students under-perform on the summative examinations. It follows that any approach to science teaching and testing within the Caribbean should take cognizance of the situated cultural knowledge and should extend to consideration of non-western views of science and of medicine. The latter is particularly important in dealing with matters that address health issues. It seems evident then, that further ethnographic research is required to develop a science of science within the cultural traditions that we within the Caribbean have inherited. This knowledge can be made more widely available to science teachers, teacher educators, and examiners who have the responsibility for teaching and testing.

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