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SECONDARY SCIENCE TEACHERS' METAPHORS: A Case Study, Part 1

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This case study sought to gain insights into a group of secondary science teachers' conceptions of teaching through an analysis of their metaphors. In addition, lesson plans, classroom observations, and artifacts produced during the year-long Diploma in Education (Dip.Ed.) programme were analysed. The data were analysed by reading the metaphor in context and against its obvious meaning to allow multiple meanings to emerge, and by coding to determine patterns, themes, and significant events. The findings revealed the multiple interpretations of teachers' metaphors and also that teachers' metaphors were similar to and different from those reported in the literature. In addition, teachers' actions did not always match the behaviours implied by the initial interpretation of the metaphor. The mismatch was either positive or negative in relation to contemporary learning theories. The implications for teacher educators' actions are discussed.

Background

Research into the use of metaphors to provide insights into teachers' understandings of the process of teaching is fairly common practice among the educational research community in developed countries (see Bullough, 1991; Collins & Green, 1990; Dooley, 1998). For example, teachers have been asked explicitly to describe their metaphors of teaching/learning, or they have revealed their metaphors during conversations/interviews with researchers (Dooley). Some researchers have observed classrooms and the interactions therein to develop metaphors of teaching (see Collins & Green), and others have framed research based on common metaphors of teaching (Marshall, 1990).

The Oxford dictionary (1995) defines the word *metaphor* as "an application of a name or description to something to which it is not literally applicable." Further, it states that "a metaphor is a figure of speech that goes further than a simile, either by saying something is something else that it could not normally be called or by suggesting that something appears, sounds, or behaves like something else." Postman and Weingartner (1969, pp. 86–87) hone in explicitly to the role of

representation associated with metaphor. They use the word *metaphor* "to denote any representation of reality, especially linguistic representations." The above conceptualizations are all very general, but Collins and Green (1990, p. 77) apply the term *metaphor* specifically to the classroom context. They propose that "metaphors build a 'web of meaning' and make visible the dynamic and constructed nature of everyday life in classrooms." The metaphor is therefore a useful vehicle to help the "outsider" enter the private world of the classroom.

Perusal of the literature shows that research into teachers' metaphors is not common practice in Trinidad and Tobago. However, under the auspices of the Muster (Multi-Site Teacher Education Research) project, primary school teachers' metaphors of teaching were investigated and reported. A significant finding of this research was that the majority of metaphors of teaching held by the primary school teachers sampled tended to focus on the affective dimensions of the teacher's role. The teacher was often described in the role of nurturer/caregiver, as *responsible for everything* and as *martyrdom* (George, Mohammed, Quamina-Aiyejina, Fournillier, & Otway-Charles, 2001). Significantly, these metaphors depict an active role for the teacher and a role of dependence for the learner. The metaphor *teacher-as-nurturer* is, according to Berliner (1990), a commonly accepted metaphor of teaching at the primary level. In addition to the nurturing role, the primary teachers in the Muster project reported metaphors that focused on teachers' knowledge. However, the metaphors selected conveyed similar relationships between the teacher and the student. For example, the metaphor of *teacher as expert* conveyed the teacher in a role as actor and the student as passive recipient.

The metaphors described give an indication of the types of experiences that are likely to be provided in the primary classroom; however, there is no empirical evidence that there is a match between teachers' metaphors and their actions in the classroom within the primary schools of Trinidad and Tobago. One limitation of the Muster research was that there was no attempt to determine the level of congruence between teachers' metaphors and their actions in the classroom.

It is generally accepted, with support from developmental theories of psychology, that at the secondary level—a period of adolescence—the students are expected to develop their identity (for example, one of Erickson's developmental stages is that of identity vs. role confusion), to assert their independence, and to develop skills of critical and creative thinking. Yet, Berliner (1990) reported that *teacher-as-information-giver* was a common metaphor at this level in the USA. It seems, then, that there is a mismatch between USA teachers' conceptions of their role and

students' development needs. Are the same conceptions of teaching/learning held by secondary school teachers in Trinidad and Tobago? With the exception of James (2005), who analysed the metaphors held by a group of English (Language Arts) teachers, there have been no reports on metaphors of teaching held by secondary school teachers in Trinidad and Tobago in general, or those of secondary science teachers in particular. It is not known, for example, whether science teachers hold the same or similar views of teachers as their primary counterparts—as *experts*—and of secondary teachers in the USA—as *information giver*s. If they do and then they act upon their beliefs in a manner that is congruent with these perceptions of the teacher, then it becomes obvious that the consequences of their actions may be at variance with contemporary views about science teaching/learning and with the students' expectations of the system at the secondary level. In essence, as illustrated below, there may be an epistemological gap (Tsai, 2003) between students and teachers.

In a study that was done in the UK which investigated students' preferences for learning environments, Kinchin (2004) found that of a total of 349 responses from students in Years 7–9 (12- to 14-year-olds or lower secondary level), 11.2% chose an objectivist environment in which teacher is giver versus 88.8% who chose a constructivist environment in which they construct their own understandings as the preferred science classroom environment. The students' desires and expectations for participation and active involvement in the teaching/learning encounter seem to fit naturally with life in democratic societies. According to Dwight and Garrison (2003), in a healthy democracy, one would expect more equity, a decentralization of power, and a problem-posing pedagogy that enables active participation in an ever-evolving process. The active learner engages in metacognition, inherently questioning the privileged status of authority figures such as authors, curriculum planners, and teachers. However Dwight and Garrison (p. 715) cite Foucault who recognizes the gap between theory and practice. He states that "in a democratic society our system enforces a belief in totalitarian authority, thereby creating 'docile bodies' dependent on external authority for meaning and the essence of learning." Foucault's comment is a serious criticism of the education system.

In contemporary society where schooling has become compulsory, at least up to the primary level and in many places even up to the lower secondary levels, teaching within the formal school setting is a familiar activity to most, if not all, persons within the public domain. Yet, paradoxically, while seemingly familiar, much about teaching is private personal knowledge held tacitly by teachers. Little is known publicly

about what propels teachers to choose one activity over another, or to choose one way of proceeding over another. Yinger, cited by S. Johnson (1990, p. 469), captures the mystery that can be associated with teaching and learning in the formal setting, but advocates a study of teacher talk to gain insights into teacher knowledge. He says that "though much of the language of practice is embodied in thought and action and not spoken, the natural language of teachers and learners can give us clues to the way they organize their world." It is evident, then, that an investigation into science teachers' metaphors would provide valuable insights into the underlying beliefs that guide practices of science teachers in Trinidad and Tobago, and would also be useful inputs into the development of education programmes for science teachers.

This research investigates the metaphors held by a sample of untrained secondary science teachers, with experiences of teaching ranging from 3 to 20 years, who were enrolled in the Diploma in Education (Dip.Ed.) programme during the 2004–2005 academic year. Specifically, the questions that guided the enquiry were:

1. What are science teachers' metaphors of teaching at the beginning of the programme?
2. What views about teaching/learning do science teachers' metaphors suggest at the beginning of the Dip.Ed. programme?
3. What are the factors that influenced science teachers' choice of metaphor?
4. Do teachers' preparations for and actions in the classroom early in the programme provide evidence of the enactment of their espoused metaphors?

Metaphors and Teacher Education

Metaphors have been used in many areas of human endeavour, for example, in setting problems in social policy (Schon, 1980), in developing scientific explanations, and in education. "Black believes that some metaphors can function as 'cognitive instruments'" (cited by Ortony, 1980, p. 5), by which he means that metaphors are tools for learning and for developing understanding. Furthermore, he argues that some metaphors do not merely reflect reality but actually shape/construct reality, in that they permit us to see aspects of reality that they themselves help to constitute. In other words, he believes that one of the benefits of using metaphors is that "something new is created when a metaphor is understood" (p. 5), that is, new insights and understandings about phenomena emerge, which allow interpretations of familiar

situations from new perspectives. Adding his support to the benefits of metaphors, Sticht (cited by Ortony, p. 16) posits that metaphors act as "indicators of comprehension, as frames of reference for producing text coherence, and as tools for creative problem solving" (p. 16).

Not surprisingly, along with the benefits of metaphorical language, there are also some limitations. For example, Schon (1980) posits that in social contexts "generative metaphors (metaphors which generate their own solutions) may result in a sort of cognitive myopia in which some aspects of a situation are unwittingly emphasized at the expense of other, possibly equally important, ones" (p. 6). In addition, Kuhn (1980) warns that in conceptualizing issues and solutions, metaphors can be as restricting as they are enabling; the former occurring when one attempts to fit the world into the model so described by the metaphor. Dooley (1998) provides evidence that when confronted with classroom realities some teachers may find it difficult to be guided by the metaphor of teaching that they have constructed, and it is plausible that the internal tension and conflict occurring will undermine such teachers' sense of efficacy. In spite of the limitations described, metaphors can be useful tools to help teachers to convey their understandings of teacher and teaching.

Lakoff and M. Johnson (1980) suggest that all language is metaphorical to one degree or another. They believe that all attempts to symbolize reality is metaphor—an abstraction, an "as if." In developing this argument, Korzybski, cited by Postman and Weingartner (1969, p. 87), insisted that the word is not the thing. He posits that whatever you *say* something is, it is not. Furthermore, in commenting about the difference between reality and a representation of reality, he believes that saying something about the world is not the world—the map is not the territory. Accordingly, he believes that we always wrestle with the question "What words shall we use to represent 'things?'"

Notwithstanding the limitations of the relationship between word choice and what the word chosen is meant to represent, teachers have been asked to describe their views of teaching and to represent their conceptions of the teacher. The literature reports the metaphors that teachers often use to describe teaching/learning at the elementary and secondary levels. Berliner (1990, p. 85) reports elementary school teachers most often subscribe to the metaphor of *teacher as mother earth.* At the high school level, "teacher as information giver was particularly descriptive." In a conceptual paper, Cohen and Lotan (1990, p. 78) report that the *teacher-as-supervisor* metaphor and the *student-as-worker* metaphor are not unusual in educational literature.

Investigations of teachers' metaphors are usually based on the assumption that there is a link between metaphor and action. For example, Bullough (1991) agrees with Connelly and Clandinin that the metaphor teachers use to describe themselves and their teaching shapes their practice:

> It makes a great deal of difference to our practice…if we think of teaching as gardening, coaching, or cooking. It makes a difference if we think of children as clay to be molded or as players on a team or as travelers on a journey. (p. 44)

The assumption is that the teachers act in a manner that operationalizes the selected metaphor (see also Lloyd Yero, 2001–2002). Berliner (1990) proposes that the adoption of *teacher as information giver* at the high school level explains teachers' resistance to change in the classroom. Metaphors therefore reveal how teachers see themselves—their identity—and the dimensions of teachers' roles with which they identify. For example, by rejecting the inclusion of new technology, such as television, movies, or computers, the job of dispensing information is reserved for themselves. Accordingly, along with teachers' narratives, the literature highlights the use of metaphor as a vehicle to understanding teacher identity (Alsup, 2006; Kooy & de Freitas, 2007), since how teachers view themselves and how they behave are clearly elements of identity. Not unsurprisingly then, some literature (see Bullough) suggests that the teachers' metaphors guide them to those aspects of teacher education programmes that they choose to consider and those that are rejected. It is clear that there are implications of teachers' metaphors of teaching for the success of teacher education programmes.

This enquiry is embedded in teachers' metaphors and hinges on the tradition of thinking about metaphor as a frame of reference by which persons make sense of phenomena and by which new frames of reference emerge (Schon, 1980). It differs from the tradition of linguists and philosophers of language who view metaphor as an anomaly of language, which must be dispelled. Accordingly, this enquiry aims to build on the literature on metaphors within the context of education, and attempts to investigate how a sample of science teachers' metaphors reflect their conceptions of who is a teacher—their teacher identity—what teaching is and is not, and the implications for teacher education.

Outlining the Contextual Background and the Research Process

This is an instrumental case study of the nine teachers who were enrolled in the in-service Dip.Ed. programme for whom I served as the science curriculum tutor. The science curriculum tutor is the person who is responsible for delivering two courses—"The Practice of Education" and "Curriculum Process"—as related specifically to the pedagogy of science education. This is the teachers' introduction to methods of teaching within the university setting. In the Republic of Trinidad and Tobago, the entry requirements for teaching at the secondary level are an undergraduate degree in an academic discipline and registration with the Teaching Service Commission. In other words, the participants who enter the Dip.Ed. are experienced teachers, but they have not been formally trained. In this case study, the participants' teaching experiences ranged from 3 years to 20 years. The teachers are employed in a range of schools, which comprise the secondary sector for students between the ages of 11 to 19 years. There are the traditional denominational seven-year schools that are generally thought of as "prestige" schools and there are the newer schools. At the time of enrolment of the cohort in the Dip Ed., the latter comprised the five- and seven-year government secondary schools, the three-year junior secondary schools, and the two- or four-year senior secondary/comprehensive schools and sixth form colleges. Data were collected from the nine teachers, but for some aspects of the study, six of the nine teachers were selected for a more thorough analysis based on the richness of the data available.

The first session of the Dip.Ed. usually begins during the last week of July each year and continues for a month, ending in the third week of August. During this period, the teachers attend classes full time at the university on Mondays to Fridays from 9:00 a.m. to 3:00 p.m. Upon resumption of school in September, the teachers return to their full-time teaching responsibilities from Monday to Thursday and attend the Dip.Ed. sessions on Friday. Alternate Friday sessions are conducted either at the university or as a "Field Day" at selected teachers' schools. On the scheduled field days, three teachers, including the host teacher, each teach a 35–40 minute lesson. In addition, a tutor also visits each teacher during prearranged one-on-one "school visits" during the term. One of the goals of the Dip.Ed. is the development of reflective practitioners. To this end, teachers engage in journal writing, assemble a portfolio, and complete lesson plan forms that include a section devoted to teachers' reflections of the lesson.

During the first week of the course, as an introduction to the process of reflection, all science teachers were asked to write an autobiographical statement that described their journey towards becoming a teacher. This assignment is also used as an artifact that is included in the portfolio. During Week 2, the science teachers were given another assignment in which they were asked to write a metaphor of themselves as teachers (see the Appendix). The task was intended to have students construct their own metaphor, and so a list of metaphors comprising those that are generally reported in the literature was not presented to them. During the school term, teachers were observed in the classroom and on field days, and were also encouraged to submit lesson plans for review. The assessment for this course was a teaching practice examination (accounting for 75%); as well as the examination of a portfolio (25%), which included a portrait of themselves as teacher; and 8–10 entries from their journal that demonstrated significant growth points, which, in general, provided evidence of their growth and development.

The data from the metaphor assignment were analysed qualitatively to determine patterns and themes. In addition, each metaphor submitted was analysed to allow multiple meanings to emerge (a process of deconstruction) "by reading the text against its obvious meaning and intention, teasing forth the conflicts between sense and implication showing that the text never means only what it say or says only what it means" (Powell, 1997, p. 158), and so to interrogate the multiple/ possible meanings of the teachers' understanding of teaching. To facilitate the process of deconstruction of the metaphor, the first two lesson plans and the accompanying teachers' actions in the classroom were analysed. In addition, portfolio productions and artifacts were analysed to gain deeper understandings of the meaning that teachers give to their actions in the classroom.

Findings

The research questions are used as the framework for presenting the findings below. To avoid repetition and for simplicity of presentation, the analysis is sometimes presented in relation to more than one research question.

Research Questions 1–3

1. What are science teachers' metaphors of teaching at the beginning of the programme?
2. What views about teaching/learning do science teachers' metaphors suggest at the beginning of the Dip.Ed. programme?
3. What are the factors that influenced science teachers' choice of metaphor?

Science Teachers' Metaphors

At the start of the programme in July, the nine teachers selected a range of metaphors to describe themselves as teachers. In the main, the focus of the metaphors was on teacher with learner backgrounded. Two teachers chose the metaphor of *sculptor*. The other metaphors that were selected were *gardener*, *house painter*, *eagle*, *peacock*, *mango tree*, *tree swaying in the wind*, and *sieve*. These metaphors, with the possible exception of the *sieve*, in general, foregrounded the teacher as actor/all knowing with the learner being acted upon. However, two teachers who selected the metaphors *mango tree* and *house painter*, in describing/explaining their metaphors, went beyond the teacher/learner interaction to include the other stakeholders, for example, the school administrators and the parents, and to include the notion of *teacher as developing/growing*.

The metaphors were interpreted as indicative of varying levels of teacher control associated with the teachers' role. One of the nine teachers likened the teacher's role to that of an inanimate object—a sieve. This example can be interpreted to indicate a somewhat passive role for the teacher, which suggests minimum teacher control, in contradiction to the idea that a sieve by its very nature controls the passage of substances. The idea conveyed was almost of the teacher as "just there" and almost incidental to learning. The other metaphors suggested a more active teacher role. Following are the teachers' metaphors, the views about teaching/learning that can be inferred from an analysis and deconstruction of the metaphor and other evidence gathered, and the possible influences on the teachers' choice of metaphor.

Levels of Teacher Control

The majority of metaphors seemed to suggest that the teachers in this sample recognized that the teacher/student interaction required/involved students as thinking, knowing beings. However, the metaphors projected a view of teaching on a continuum of teacher control from passive (the

sieve) to teacher control with some student input (*eagle*, *mango tree*, *sculptor 1*, *gardener*, *tree swaying in the wind*)—the latter being the most open to uncertainty and attempting to describe a systems approach—to teacher exhibiting authority and control with little student input (*sculptor 2*).

The analysis presented below begins with the metaphor of the *sieve*, which was selected by a male teacher who taught at a 7-year all-male "prestige" school. He expressed his inability to effect learning for all students and his feelings of "helplessness."

Helplessness

> *I am a sieve*
> When a topic is taught by me, some students will understand and some will not. Those that understand will always follow what is done in class as the school year progresses. Those that do not understand end up remaining in this state, especially when there is a time constraint for the completion of a syllabus. They can sometimes lose motivation and transfer this to other new topics. Hence they remain in a state of loss for the entire school year. I sometimes feel helpless to remove their affliction.

The teacher's expressed feelings of helplessness were not restricted to pedagogical skills (selection of strategies that facilitate concept acquisition and development). They were also related to classroom management, that is, to providing the type of classroom environment in which the benefits of selected strategies are optimized. The teacher's autobiography provided the context for his selection of the metaphor:

> Another influence on my teaching methods occurred during my first two years of teaching. I had very poor classroom management skills with one of my classes being very chaotic everyday, with only a few students doing any work. I asked one of my senior teachers for help. He told me to try to separate the disruptive ones if possible and with more experience, my management skills would improve.

His perception of the organizational structure of the school and the effectiveness of the procedures and systems for maintaining discipline were related to this "helplessness." In his autobiography, he had written:

> There were students who were disruptive and disrespectful in class. When they were punished by teachers, they did not carry out their punishment. The matter would be referred to the dean who also punished them, but they still would not carry out their punishment. The matter would be referred to the principal who

> usually did nothing to the students but gave them a talk. The students would then continue their ways knowing that they were immune to punishment. The dean might refer the matter to the children's parents who also usually would do nothing. Therefore the deans' hands were usually tied and the teachers' hands were tied even tighter. Hence, maintaining discipline and order in the classroom was my major challenge.

The feelings of helplessness also surfaced towards the end of the autobiography:

> During my first year of teaching, I wanted all of my students to succeed in their examinations. As time went on, I realized that this was an impossible task. All I can do is attempt to accomplish this knowing at the back of my mind that it will never happen.

By contrast, other teachers' metaphors suggested a greater level of teacher control and agency. The metaphors *tree swaying in the wind*, *eagle*, *sculptor 1*, and *gardener* reflect teachers' views that teaching involves teacher control with some student input. However, the teachers' understandings of their role and of teaching were not homogenous. The following metaphors can all be interpreted to acknowledge the importance of student input, but they vary in the teachers' response to student input. The presentation begins with the metaphor that implies most student input. This first metaphor is the only one that shows the teacher's susceptibility to change based on the student/teacher interaction. The metaphor (from a Sixth Form teacher—one who teachers students whose ages range from 17–19 years, during their sixth and seventh years of secondary schooling) seemed to capture the idea that students were thinking, knowing, active participants who contributed not only to their own learning but also the teacher's learning.

Reciprocity: Teaching/learning as discourse

Tree swaying in the wind

> I am the tree. The roots and trunk represent my core values and knowledge part of which is the content of my subject area. The breeze represents all the discourse that is going on between the students and myself, and I am swaying because the ideas and opinions of my students affect not only the teacher in me, but all the other aspects of me. I sway in the class, because I am not all knowing in my subject area and sometimes my students ask questions that I do not have the answer to and I do admit to not knowing. Sometime students may ask questions that make you … are a totally different view to what you think.

In elaborating the metaphor above, the teacher draws upon her "limited experience" but recognizes that students have ideas/thoughts that are independent of the teacher. It is plausible that the teacher's perceptions of the students' level of maturity (age range 17–19 years) influenced her view of teaching and learning. The teacher noted in her autobiography:

> In my limited experience, the delivery of the syllabus is made easier if I develop a rapport with my students…helps build bridges to a more respectful and open relationship.

In a similar fashion, in selecting the metaphor of the *eagle*, the next female teacher, with six years experience, acknowledges that students have the capacity for independent thought, and she believes that they should be given the opportunity at times to work independently of the teacher. However, she also believes that the students are not always capable of achieving the learning outcomes independently and, therefore, the teacher's role is to be vigilant and to monitor the students and hence to intervene when necessary:

> **Vigilance**
>
> *I am an eagle*
>
> The eagle maintains a sharp focus on the eaglet, making it easier to detect the earliest sign of trouble. Similarly as a teacher, when I allow my students to go out to seek information on their own, I don't assist them at the first sign of trouble. I sometimes leave them to go through the learning process.

The teacher's autobiography, which indicated that students should be given the opportunity to work at their own pace, provided some insights into her choice of metaphor. The influences on her metaphor were related to her philosophy of teaching and were based on her own experiences at home and school:

> On entry into the teaching service, my philosophy was that children learn best when they are allowed to develop their own style of learning and allowed to work at their individual pace. This philosophy was influenced by my experiences at home and primary school. In primary school, I was a slow developer…. My teachers in school never made me feel stupid, they always left me to develop at my own pace. The same followed at home…. My parents never scolded me, nor did they punish me for performing poorly in examinations…. It was based on those experiences that I developed my philosophy.

In contrast to the above teacher's disposition toward student independence, two teachers selected the metaphor of *sculptor* to theorize about the role of the teacher and of teaching, and both teachers assumed that their role was to take responsibility for shaping the learner. However, each teacher's view was underpinned by very different assumptions about the nature of the learner. The first, *sculptor 1*, recognized that the students are not "uniform" and that their individual differences must be considered during the teaching/learning encounter. As illustrated below, teaching requires "teacher control with some student input," which contradicts the view that the *sculptor* has full control over the final outcome.

Students as individuals

Sculptor 1

The teacher selected the metaphor *teacher as sculptor* and explicitly identified her assumption that the teacher is in control of the students' development:

> This choice of metaphor is supported by the assumption that the teacher is responsible for moulding the learner.

However, the female teacher's elaboration on the metaphor shows that she recognizes the individual differences that her students bring to the teaching/learning encounter. In other words, *teacher as sculptor* deconstructs to reveal a role for student input:

> Learners are not uniform but are different types of media with which I work. A child may be clay, stone, marble or even 'junk,' all of which can be beautiful if worked properly.

Recognition of student differences was also found in the "letter to self" in which her expectations of the Dip.Ed. programme were outlined. Drawing upon her five years experience of teaching, she wrote:

> I want to be able to reach the more difficult students; those who find my approach challenging.

In a similar fashion, the *teacher as gardener metaphor*, as outlined below, can be interpreted to mean "teacher control with some student input."

Teacher in control: Meeting students' every need

In responding to the task presented, the teacher who selected the metaphor of a *gardener* stated her assumptions about teaching and learning explicitly. She said that the teacher is independent, controller, and provider while the student is dependent. It is evident that the teacher is referring to both the cognitive and affective dimensions of the

teacher's role. With respect to the former, it can be interpreted that the teacher's view is that knowledge is a commodity that is prepackaged and which the teacher dispenses. The affective dimension is also evident—the student is dependent, so the teacher must "tend to their every need." The statement can be interpreted to mean that students are not given opportunities to develop independence and to take responsibility for their learning.

> I am a gardener who tends to his plants in the nursery. For the time that I have them, I try to attend to their every need offering food and love.

The influence of the teacher's past beliefs on the selection of this metaphor was stated in her autobiography:

> I can now say that my initial teaching philosophy saw the students as a 'passive learner.' I, on the other hand was the teacher, the adult, the authority on the subject and definitely the one in charge. In other words, I firmly adhered to the sayings that **'Children must recognize authority,' 'Speak when spoken to'** and **'Be seen and not heard.'**

Interestingly, it seemed that the teacher's past beliefs had a greater impact on the selection of metaphor than her reflections upon her personal experiences of student-centred lessons as a student at school, her exposure to the discussions among trained teachers, and, as indicated in her autobiography, her actual practice:

> My philosophy of teaching now placed more emphasis on the student and that lessons should be fun in order for learning to be achieved. This trend of thought was in keeping with the discussions of trained teachers, the hub of conversation being student centered learning, multiple intelligence and its implication to learning to name a few.

Although seemingly contradictory interpretations of the teacher's comments are possible, the metaphor can reflect an amalgamation of views. In biological terms, the plant is a producer—an organism that combines disparate elements to produce a new material via photosynthesis. So that far from student inactivity and passivity that one may at first assume when presented with the *gardener* metaphor, the metaphor deconstructs to provide conceptual space for student independence. The *teacher-as-gardener* metaphor can be interpreted to mean that the teacher provides the externals—conditions and materials—and the student actively engages in making meaning (something new).

Accordingly, the *teacher-as-gardener* metaphor deconstructs to reveal active student involvement.

In contrast with the interpretations of teacher presented by the teachers who chose *sculptor 1* and *gardener* as metaphors regarding individual differences and student involvement, there was less student input conveyed in the description from the second teacher who chose the metaphor *teacher as sculptor*.

Teacher in control: Teacher shapes the students

The second teacher who selected the metaphor of sculptor and who has been teaching for four years thought of the students in terms of a single material, which she has the power and authority to shape, even in the context of student resistance or other challenges that can occur during the teaching/learning process:

> *Sculptor 2*
>
> A sculptor is a person who forms sculptures or forms representations of objects using for example clay. As a teacher, I consider myself to be a sculptor. My students are like the clay I use to mould into a beautifully shaped and decorated sculpture.

As the teacher elaborated on her interpretation of the metaphor, she admitted that the task of "moulding" was a difficult one in which there might be resistance or a challenge encountered—she described the material as "tough." Yet, in spite of this apparent opportunity for student input (in this context, some teachers might aim to involve students as a management strategy), the teacher relegated the students to a passive role. She expressed the view that the teacher is the authority and is the sole decision maker. She seems to believe that the teacher knows what is right and for whom. She wrote:

> Clay is a type of soil, which is generally tough and on its own assumes no form. However, it is full of potential since it can be used to make any type of sculpture the sculptor desires. The job of the sculptor is to decide what shape the sculpture will assume. In order to develop a good sculpture, the sculptor needs to know how much water to add in order to obtain the correct consistency.

Yet, this interpretation of the metaphor began to unravel as other data were analysed. The following excerpts from the "Letter to self" assignment, the autobiography, and the caption for the autobiography reveal that there was implicit recognition of student diversity and of differences in learning style, which require knowledge of a variety of strategies for teaching:

> In my school I have had experience dealing with all types of students, for example disruptive students, rebellious students, those with academic disabilities and writing and other similar problems. I expect that this Diploma in Education will equip me with the necessary tools to handle such students. (*Letter to myself*)
>
> This entry gives information about me as a child and as an adult. It shows how I learnt at different stages in my life and which learning style worked best for me. (*Caption for autobiography*)
>
> As I grew older I realized a huge part of learning involved experiencing things for myself. Reading from a text book and listening to my teachers helped me in the learning process to some extent but actually seeing a process being carried out made understanding a lot easier…. I really enjoyed laboratory sessions for I felt it made Chemistry much more exciting and easier to understand. My Chemistry teacher at that time influenced me a great deal as a student. He had a very practical approach to teaching Chemistry and this made me look forward to his Chemistry class. When I looked back at his style of teaching and the impact it had on me as a student, I felt that I wanted to have this kind of impact on my students as well. (*Autobiography*)

The analysis above shows that views about the learner and teacher/learner interaction were the dominant concerns; however, the teachers' responses also captured their views about the nature of knowledge.

Nature of knowledge: Knowledge as dispensed

As teachers elaborated on the metaphors selected, most suggested that knowledge was a commodity that was dispensed by the teacher to the somewhat passive student. For example:

> *Sieve*
>
> I try to break this rock into pieces whereby each piece represents the knowledge I have imparted on a particular student.
>
> *Sculptor 1*
>
> The subject matter, which I routinely handle is simply one tool I can use to effect my purpose.
>
> *Sculptor 2*
>
> Just like the sculptor needs to add sufficient water to prevent the sculpture from cracking, I need to impart sufficient knowledge to

> my students. This includes knowledge of an academic nature, social nature and moral nature…. I am assuming as a teacher I know just how much knowledge (subject matter) to impart to students so that they can become well rounded individuals.

Summary

The metaphors conveyed different foci for theorizing about teaching. For example, some metaphors focused mainly on self and on the developmental process of developing teacher self. Most metaphors focused on teacher-student interaction. However, they all revealed perceptions of levels of teacher control, a view of knowledge, and a view of the learner. It seems that those metaphors that characterize students as active, thinking individuals whose views should be acknowledged, and which may even lead to changes in the teacher, are more suitable to the secondary learning environment than those in which the students are passive and the teacher dispenses information. With respect to the science classroom in particular, the latter approach provides little opportunity for students to be introduced to the process by which scientists engage in the scientific enterprise and the outcomes of the scientific enterprise, such as knowledge construction, and for them to engage in this process.

It is evident, however, that although some of the teachers' metaphors may initially be interpreted to be focused solely on the teacher and, hence to suggest high levels of teacher control, the metaphor deconstructs to reveal teachers' recognition of individual learners' input in the teaching/learning process. This latter interpretation contradicts the original teacher-centredness implied. The analysis of autobiographies and journals often supported alternative interpretations of the metaphor and gave a more complete picture of teachers' conceptions of teaching and learning.

Classroom observations also provided another perspective on teachers' understanding of teaching and learning, and contributed to an understanding of whether teachers acted upon their espoused beliefs. In the following section, the findings on the question: "Do teachers' preparation for and actions in the classroom early in the programme provide evidence of the enactment of their espoused metaphors?" are presented. Throughout the rest of the paper, the teachers are at times identified by the metaphor that they selected.

Research Question 4

Do teachers' preparation for and actions in the classroom early in the programme provide evidence of the enactment of their espoused metaphors?

The data used to answer this question were based on the written lesson plans for, and observations of, the first two lessons taught. In preparing the written lesson plans the symbol *T* is used for Teacher's actions and *S* or *Ss* for Students' actions. The teachers' actions were analysed in reference to their espoused (explicitly stated) beliefs/conceptions of teaching. In instances where these beliefs were not stated explicitly, the actions were analysed in relation to my interpretations of the metaphors. Analysis of the data led to the development of three categories: "mismatch between the metaphor and teachers' action in the classroom," "mixed: match and mismatch," and "match between teachers' actions and the selected metaphor."

Mismatch between Metaphor and Action

The data obtained from three of the six teachers provided little evidence of the operationalization of their metaphors in the teaching of science. For example, the teacher who selected the metaphor *teacher as eagle* had expressed the view that there was a role for student independence in the classroom. She indicated that the teacher should be vigilant while providing opportunities for students to work at their own pace. However, the first two lessons were essentially teacher-centred designs of whole group teaching. The first lesson comprised teacher explanations with little student input, and the second was a guided discussion in which the teacher used questions to assist students in developing concepts. The first lesson on meal planning illustrates a didactic approach which is associated with a high level of teacher-centredness. It was designed as follows:

- T explains reasons for individual food groups being displayed in varying proportions on the food group chart.
- T explains that items from all 6 groups need not be consumed at every meal
- T explains the multi-mix principle using the 6 food groups
- T explains the 4 mix, 2 mix, and 3 mix principles and states which ones are recommended.

The teacher recognized the weaknesses of the lesson. In her written reflection at the end of the lesson, she wrote:

> Students were receptive to the lesson only during the introduction when students were shown charts of 6 food groups. As the lesson proceeded the students began loosing [sic] interest in the lesson by talking among themselves or sleeping. In reflection, the lesson was not student centered. Students got distracted. Lesson should have been based around students so that they would be more interested.

It is likely that the teacher was committed to the philosophy of teaching as described by the metaphor but, as an untrained teacher, she did not know how to plan her lessons, that is, the strategies required to put her teaching philosophy into action.

A similar mismatch existed in the classroom of the teacher who had selected the metaphor *tree swaying in the wind*. There was little student participation in this teacher's classes. Some insights into the contradiction between her espoused beliefs and actions came from the autobiographical statement. It is likely that the teacher's behaviour was influenced by the introduction of a new syllabus (CAPE Chemistry) and the ensuing insecurities with respect to the implementation of School-Based Assessment. The new demands of the syllabus paradoxically precipitated a reversion to "old ways of acting," likely drawing upon the part of the description of the metaphor that represented the "knowledge"—the tree and the roots:

> I still recall my first day…. I went into the class introduced myself and conducted my class using a lot of chalk, talk and equations…. With time, I became more comfortable in front of my students as my confidence grew, but I continued with the same old teaching method, the way I remembered being taught.

The teacher recognized the mismatch between her theorizing and her actions. She reflected on her actions in the classroom and produced a caption for the reflective entry. The caption and reflective statement are presented below:

> ***Caption***
>
> From this entry I would like others to realize how easy it was to return to old habits of being teacher-centered.
>
> ***Reflective piece***
>
> I find myself slipping into a more comfortable teacher-centered mode of teaching. CAPE is to be introduced to the Lower Six and the thought of SBA's are frightening me. I have never done

> SBA's before. Sometime I feel overwhelmed by the volume of work and during these times I find the easier and most comfortable way of teaching, the one I am accustomed with. I have all intentions of preparing and executing lesson plans that are student centered, but I find that preparing lesson plans is difficult.

If we proceed on the premise that the student-centredness inherent in teachers' espoused metaphors is desirable and is the standard by which we should judge their actions, then the above two examples reveal teachers' actions in a negative light in relation to their metaphors. The last example below also reveals a mismatch between metaphor and actions, but in a manner that leads to a more student-centred approach than is implied by the teacher's explicit rendering of the metaphor.

> *Gardener*
>
> I am a gardener who tends to his plants in the nursery. For the time that I have them, I try to attend to their every need offering food and love.

In response to part (c) of the assignment (see Appendix), the teacher's assumptions about the role of the teacher and learner were stated explicitly. She described the teacher's and students' roles as: "teacher-independent, controller, provider, student-dependent." However, the teacher's lesson plan shows that she did not "dispense information" as might have been expected from her explicit interpretation of the metaphor. Instead, her students were given the opportunity to synthesize ideas. This type of student activity is in fact congruent with the *gardener* metaphor, if the plant (student) is foregrounded. As the metaphor is analysed, the interpretation that the students play an active role in making meaning of the experiences provided is juxtaposed against the student passivity that is implied by the initial interpretation of the metaphor.

The following lesson plan for Form 1 on "Properties of Matter" reveals student active involvement in the lesson:

- T displays 3 balloons filled with (i) red beans (ii) water and (iii) air
- T asks for 3 volunteers to observe the balloons, feel, touch, smell to identify contents
- T introduces the topic of the lesson

Development:

- S engage in activity "How heavy am I?", etc. after which students make inferences/draw conclusions.

The explanation for the student-centred lesson that seemingly contradicts behaviours that might be expected at first reading of the metaphor could be linked to statements made in the teacher's autobiography and the caption for the "Letter to self":

> Inspiration for change first came from my experience in Secondary school with my most admired Biology teacher…. My attitude to students and my style of teaching changed trying to mirror some of these images. Classes now took the format of a lot of group activities, experimenting for discovery and observations. Students were more eager to come to classes…. My philosophy of teaching now placed more emphasis on the student and that lessons should be fun in order for learning to be achieved.
>
> ***Caption for "Letter to myself"***
>
> I started this Diploma in Education for a number of reasons. The main reason was to become a better teacher so that each child is given a fair opportunity to learn in my classroom. This piece talks about my expectations of this course and the hope that at the end of this course I would have started my journey of self-development.

It appears that in spite of personal experiences as a student and a teacher, the teacher's initial response to the metaphor assignment was to develop a metaphor that was meant to depict teacher as authority and students as passive. However, the use of the phrase "each child" as opposed to "the children" in the caption above implies that student individuality is recognized and addressed. Similarly, the teacher's actions in the classroom revealed another dimension of the teacher's theorizing about teaching and learning. It seems that old deep-rooted ideas about teaching and learning were expressed through the choice of metaphor and its explicit elaboration. However, in the classroom setting, during the interaction with the students, another set of ideas influenced the teacher's actions. It is evident, then, that whether the *gardener* metaphor is interpreted in a manner that reveals a match between metaphor and action depends on whether the teacher or student is foregrounded. The various interpretations can also lead to teachers' actions in relation to their metaphor that can be described as mixed.

Mixed: Match and Mismatch

For the teacher who selected *teacher as sculptor 2*, the actions were somewhat contradictory. Some of the data revealed aspects of a match and some of a mismatch between the teacher's interpretation of the metaphor and her actions in the classroom.

Sculptor 2

The actions of this teacher can be interpreted as revealing mixed understandings of the metaphor. The teacher's selection of the metaphor was meant to depict students as a homogenous group. In the classroom, the lessons were enacted as whole group sessions, and the students were treated as a single unit, which is in alignment with the metaphor. However, by planning for practical work and small group work, the teacher provided a variety of learning experiences, which provided different learning modalities. The following illustrates. In the lesson entitled "Type of mixtures," students were engaged in group work based on specimens provided. They were also given the opportunity to collaborate and to express their understanding of the concept. The lesson was highly structured and well organized, and the teacher determined time spent on activities and, by her selection of tasks, the response that was expected:

- T brings sugar solution, chalk in water mixture and aerosol spray to class
- T sprays aerosol into air
- T asks students (i) if the aerosol in air is a mixture (ii) if the sugar solution is a mixture (iii) if the chalk in water is a mixture
- T explains that all are mixtures of different types
- Ss are placed in groups
- Ss are given 5 substances (each group)
- T asks students to class these substances into colloid, solution, suspension
- Groups are asked to present their results
- T and students discuss results

In the second lesson of this unit entitled: "Separating mixtures," there was also evidence of independent group work and practical activity, which meant that there were opportunities for student input. However, as in the previous example, the class was treated as a unit and the tasks presented required predictable procedures and responses that allowed the

teacher to maintain tight control. In addition, the teacher expected that each group would have contributed to the single overall class outcome:

- T shows Ss a sand and salt and water mixture
- T asks Ss if they can separate the mixture
- T states that mixtures can be separated by filtration, evaporation, and crystallization and that this is the topic of the lesson
- T asks Ss what is meant by the terms filtration, evaporation, and crystallization
- T and Ss discuss responses
- Ss are placed in groups and must separate the given mixture by filtration, evaporation, and crystallization
- T summarizes lesson

The teacher's actions provided opportunities for student active involvement through practical work and small group work. It is likely that these strategies were intuitively selected based on the teacher's conception of the nature of science and her own experiences of learning science.

The last two examples presented below can be interpreted to show a match between metaphor and actions.

Match between Metaphor and Actions

Sieve

For the *teacher as sieve*, his actions were interpreted to match the meanings suggested by the metaphor in terms of classroom management skills. The first observation of the teaching showed evidence of the teacher's overall inability to manage the teaching/learning encounter in the classroom. His actions can be interpreted in relation to the teacher's passivity/helplessness expressed explicitly, as well as to the image of being acted upon that is implied by the metaphor. The first session observed included a practical exercise. It was planned as follows:

> ***Lesson:*** The use of the burette
>
> ***Introduction:*** T shows Ss the use of the burette to test medicine for their correct compositions
>
> ***Transition:*** T links use of the burette with accuracy
>
> ***Development:***
>
> - Ss observe the features of a burette
> - T demonstrates the use of the burette
> - Ss deduce precautions to take when using the burette

- Ss in groups use the burette to measure out different volumes of liquid
- Ss in groups measure the same volumes using 50 ml beakers
- Ss compare the accuracies

Students were expected to work in small groups of three or four to become familiar with and to correctly use simple laboratory apparatus. The classroom session could be described as chaotic. Students were not given adequate instructions and those given were oral only, involving a series of steps. Procedures were not explained, time frames for completion of tasks were not established, work sheets for recording results were not provided, and the teacher attempted to speak above the level of noise in the class. Altogether, the teacher was ignored during much of the activity. However, the lesson plan provided evidence of the teacher's predisposition to involve students actively in the lesson by having them use the apparatus provided, and thus to gain practical hands-on experiences of scientific measurement. During sessions of this type, classroom management was critical. If the class were not managed appropriately, it is highly likely that feelings of helplessness would emerge due to the tension between the situated lived classroom experiences and the traditional image of teacher in control of a quiet, ordered classroom.

During the following two visits to the teacher's school, evidence of the lack of classroom management skills was again apparent. The lessons all catered for student involvement in practical work and in group work to facilitate active learning. However, at the start of the Dip.Ed., the teacher was unable to create a classroom environment that was conducive to productive learning in the context of high levels of student activity. The teacher's selection of metaphor may surprisingly be aligned to having students in control of their learning. But with this type of classroom there are challenges that teachers face in optimizing learning. The net result may be "feelings of helplessness" if classroom management in the student-centred environment is inadequate.

Another match between the teachers' interpretation of the selected metaphor and their actions in the classroom was revealed by *sculptor 1*. For example, *sculptor 1* had expressed concern for student diversity, acknowledging explicitly that students were different. Although there is no denying that this teacher was very much in control of the pace of lessons, of what was learnt, and of the final outcome of the lesson, as was depicted by some aspects of the teacher's interpretation of the metaphor, the lesson plans and the teacher's reflections also reveal a

primary focus on student difference and an attempt to deliberately cater for these differences.

> *Sculptor 1*
>
> This choice of metaphor is supported by the assumption that the teacher is responsible for moulding the learner. Learners are not uniform but are different types of media with which I work. A child may be clay, stone, marble or ever 'junk', all of which can be beautiful if worked properly.

Evidence of the teacher's initial attempts to address student diversity was her use of a multimodal approach to deliver a lesson on atomic structure and bonding. She used visual aids and engaged students in building models, along with the traditional teacher and student question and answer sessions.

In reflecting on the lesson, the teacher explicitly mentioned the concept of multiple intelligences (MI). She wrote:

> This is the start of my attempts to teach for MI. The use of models and diagrams made a huge difference in the reception that the topic got from the students. My students are usually intimidated by the abstract nature of bonding.

The first teacher who selected the metaphor of *sculptor 1* interpreted the metaphor to convey her understanding and acknowledgement of student difference. Her actions in the classroom also demonstrated that she attempted to cater for student diversity.

Summary

For two of the teachers, there was evidence of a match between teachers' interpretations of their espoused metaphors, their teaching plans, and their actions in the classroom. In two of these cases (*sieve* and *sculptor 1*), teachers' intentions and actions were consistent with current learning theory that puts the learner at the centre of the activity, either by employing hands-on practical work or by catering to individual differences.

For four teachers, there was evidence of a mismatch between metaphor and action. Two of the teachers' theorizing (*tree swaying in the wind* and *eagle*) reflected underpinnings of contemporary learning theories, but these beliefs were not reflected in their actions. In the last two cases (*gardener* and *sculptor 2*), the teachers' theorizing was inconsistent, at times being explicitly traditional and at times reflecting contemporary theories, yet the actions reflected current theories.

The metaphors themselves facilitated multiple interpretations, each adding to the understanding of teachers' insights into teaching and learning. It was evident that for a number of these teachers the metaphors focused on the teacher, as had been requested by the task presented (see Appendix, Task a). However, interpretations of the associated learner role were embedded within the metaphor and these meanings often contradicted the teacher-centredness initially implied.

It is clear, then, that the selected teachers' espoused metaphors provided some insights into the teaching/learning interaction in their science classrooms. However, there were instances of mismatch between teachers' interpretations of the metaphor and their actions, which could, however, be interpreted as a match when the metaphor deconstructed. The analysis of the metaphor in conjunction with the analysis of the observations of classroom actions therefore provided evidence that deepened my understanding of the teaching/learning dynamics, and revealed the complex nature of teaching. These findings thus add to the body of literature on teachers' metaphors and emphasize the weaknesses of relying on one source of information, such as metaphor, though a significant one, for understanding the teaching/learning interaction.

Conclusion and Discussion

There were similarities and differences between the metaphors of the science teachers involved in this study and those reported in the literature. The similarities include, firstly, the range of metaphors selected, that is, there is no single metaphor of teaching. A second similarity is that teachers involved in this study selected metaphors, for example, *gardener* and *sculptor*, which are commonly reported in the literature (see Bullough, 1991; Tobin, 1990). The following from the literature illustrates. Developing the idea of the *gardener* metaphor with respect to a study on teacher change, Tobin (p. 123) ponders "if Peter could understand teaching in terms of a gardener nurturing seedlings, is it possible that he would tend to the individual learning needs of the students in his class?" Thirdly, the traditional understandings about the teacher's role and hence about teaching and learning that are usually associated with these metaphors, such as the role of *nurturer/caregiver* (George, et al., 2001) and *information giver* (Berliner, 1990) were noted in this study.

There are at least two plausible reasons for the similarities. Firstly, science teachers in Trinidad and Tobago, as elsewhere, have a similar range of experiences and knowledge that contribute to their conceptions of teaching and learning. Secondly, the science teachers may have

chosen metaphors with which they were familiar. It is likely that the unusual metaphors, for example, *sieve*, and *tree swaying in the wind*, reflected the creativity of the teachers. However, even with these examples, the similarities among these teachers' conceptions of an active student role when engaged in the teaching/learning encounter were revealed.

The science teachers' metaphors were focused on three of the four commonplaces of teaching as described by Schwab (see Novak, Mintzes, & Wandersee, 2000)—the teacher, the learner, and, to some extent, the context or milieu. The fourth commonplace, the subject matter, seemed to have had little influence on the metaphor selected. The science teachers involved in this case study seemed to have focused their theorizing on the interaction between themselves and the learners, and did not focus on their subject/discipline as the vehicle for the interaction. This is a somewhat surprising result because it is commonly reported that secondary school teachers are subject specialists who tend to make the subject matter their main goal. On the other hand, the literature reports that the primary teacher is a generalist whose focus is predominantly on the child. Berliner's (1990) report on metaphors of secondary and primary teachers as *teacher-as-information giver* and *teacher-as-nurturer*, respectively, reflect this thinking.

A possible explanation for the difference between the results of the present case study and findings in the literature regarding the secondary science teachers' focus is that the teachers involved in this study were experienced teachers enrolled in an in-service programme. Most of the research reported in the literature was done in developed countries and was based on metaphors of pre-service teachers. It is plausible that in this study, the teachers' personal experiential knowledge of interactions with students within the school context could have impacted on their responses. A follow-up study to determine science teachers' metaphors when the task is phrased explicitly to include the discipline, as done by Sam (1999) in the area of mathematics, would therefore be a significant contribution to our understandings. Accordingly, there are implications for the manner in which the task on metaphors is presented to future cohorts. Nevertheless, in spite of the limitations inherent in the more generalized question posed in this study, the investigation into science teachers' metaphors did provide important insights into their conceptions about teaching and learning.

Science teachers' metaphors revealed their theorizing about teaching and learning. With the original focus on the teacher, the metaphors deconstructed to reveal a component of student input and active involvement in the teaching/learning encounter, which seemed

appropriate for thinking about teaching and learning for students at the secondary level. Such conceptions in part address Foucault's concern (as cited by Dwight & Garrison, 2003) about providing democratic environments, and Tsai's (2003) concern about meeting secondary students' expectations of classroom procedures. Nevertheless, with each of the metaphors there was an element of teacher control, with the teacher as the centre of the teacher/learner interaction. According to Lloyd Yero (2001–2002), the focus on teachers' actions "casts students as passive receivers." However, it is plausible that this aspect of teacher identity could not have been avoided given the nature of the task used to solicit metaphors and given the power differentials that inevitably exist between teachers and learners.

The analysis of science teachers' metaphors provided some insights into their beliefs about teaching and learning in science classrooms. However, some of the teachers' actions in the classroom revealed a different set of beliefs, which, at fundamental levels, contradicted the meanings espoused in their elaboration of the metaphors. In one case (*gardener*), the mismatch was actually in favour of contemporary theories of learning, which matches the deconstructed metaphor; in others, the teachers' actions were not congruent with the contemporary understandings stated. For example, the actions of the teachers who chose the metaphors *tree swaying in the wind*, and *eagle* showed that they were quite traditional in their approach to lesson delivery. It is therefore evident that the analysis of teachers' actions in context is essential to developing a deeper understanding of their metaphors and their conceptions of teaching and learning.

It is quite plausible that on receiving teachers' metaphors, teacher educators might focus on the central (commonplace/familiar) interpretation rather than peripheral and alternative meanings of the metaphor, and might expect certain attitudes and ways of behaving in the classroom, especially if the metaphor can be interpreted as being congruent with the theories the teacher educators espouse. However, teacher educators should be very careful of such interpretations. The results of this study show that a match between metaphor and action in the classroom was not always evident, in support of Dooley's (1998) findings. There are many possible reasons for this, including the many contextual and personal variables that can mediate teachers' responses in the classroom. Some of the variables include changes in curriculum, availability of resources, teachers' varied experiences, and the core and peripheral meanings that can be associated with the metaphor. Furthermore, as Sacks (cited by G. C. Johnson, 2001) indicates, the intergenerationality of metaphors may lead teachers to uncritical

reproduction of ideas that do not in fact match their actions in the classrooms.

In sum, the teachers' response to the metaphor assignment gave some insights into their theorizing about teaching and learning. However, to fully explore their notions of teaching and learning, teacher educators must obtain multiple sources of data, for example, journal writing, autobiographical statements, and, most importantly, their actions in the classroom. The data from these sources provide the context for reading the metaphor against its obvious meaning and hence reveal multidimensional and often contradictory views of teaching as the metaphors deconstruct. It is also recommended that the metaphor serve as a central referent in all reflective conversations. In so doing, teacher educators can help the teachers themselves to appreciate the tensions that might exist between the more commonplace interpretations of their metaphors of teaching and their actions in the classroom, and hence to understand more fully their own ideas about teaching and learning. As the process evolves, the teachers can be encouraged to develop metaphors that reflect their deeper understandings. In addition, these conversations should help teacher educators to better discern the effectiveness of teacher education programmes such as the Dip.Ed. programme.

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Appendix

Task

a) Write a metaphor that captures you as a teacher.

b) Illustrate how this metaphor is translated into action in the classroom.

c) What are the assumptions about teachers, learners, subject matter, and context that underpin your choice of metaphor?

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SECONDARY SCIENCE TEACHERS' METAPHORS: A Case Study, Part 2

Susan Herbert

Part 2 of this paper reports on a group of five science teachers' metaphors, their responses to the concepts presented on the Diploma in Education (Dip.Ed.) programme, and the changes in their selected metaphors at the end of the programme. The analysis reveals that all the teachers' metaphors accommodated the contemporary ideas, such as student-centredness, lesson planning, and the reflective habit, to which they were exposed. There were no changes in the teachers' selection of metaphor at the end of the programme.

Introduction

Drawing upon Ausubel's (1968) dictum that "the most important single factor influencing learning is what the learner already knows" (see http://www3.hi.is/~joner/eaps/wh_ausub.htm), contemporary theories of learning stress the role of prior knowledge. Teacher educators involved in the education of prospective teachers or in the development of practising teachers, therefore, are advised to attend to their students' prior conceptions of teaching and learning, as any hopes of meaningful learning must target students' prior knowledge. Much of the literature on teacher education is related to pre-service education within the developed countries such as the USA, and the literature reports that prospective teachers are often asked to reveal their prior knowledge of teaching and learning by use of metaphor. The findings have been used to understand teachers' conceptions of teaching and learning, and the development of teachers' professional knowledge (Munby & Russell, 1990). To date, however, there has been no research in Trinidad and Tobago on how science teachers' conceptions of teaching and learning influence their response to teacher education programmes. The question then emerges: Can knowledge of science teachers' metaphors be useful to determine the concepts that resonate with teachers' conceptions of the teaching/learning enterprise and those which do not?

The decade of the 1990s ushered in the most recent reform movements in education. The declaration of Education for All (EFA) in Jomtien has been the primary impetus for reform in developing countries. As the title implies, the reforms are based on the ideas that "all

children can learn." In developed countries, too, reform has occurred apace, and is also premised on education for all. For example, in the USA, the philosophy that every child can learn is captured in the *No Child Left Behind Act*. In Trinidad and Tobago, the *Education Policy Paper (1993–2003)* states explicitly as one of the tenets of the philosophy of education that "every child has the ability to learn and that we must build on this positive assumption" (Trinidad and Tobago [T&T]. National Task Force on Education, 1994, p. xvii). It is upon these beliefs that many contemporary curricula are designed, and it is more likely that the policies will be implemented in the classroom if teachers subscribe to these beliefs.

Teacher education programmes are influenced by the theoretical and political thought of the day. Hence, it is evident that teacher educators will expose their clients to the concepts and pedagogy associated with child-centred education, which, however, are quite likely to conflict with traditional notions of teaching and of the role of the teacher. Furthermore, in adhering to the said contemporary theories about learning, teacher educators are themselves likely to design learning experiences that tap into their students' prior knowledge about teaching and the role of the teacher. For example, metaphor-related tasks might be used to probe teachers' notions of teaching and of the teacher's role.

Part 1 of this paper reported on the investigation into a group of six science teachers' metaphors. The findings provided some valuable insights into teachers' conceptions about teaching and learning. The findings revealed three categories of conceptions of teaching involving levels of teacher control ranging from "teacher as helpless" to "teacher in control but with some student input" to "teacher exhibiting authority and control with little student input." Part 2 focuses on the relationships, if any, between the metaphors from five of the six science teachers from whom rich data were available, their responses to educational ideas and concepts presented on the Diploma in Education (Dip.Ed.) programme, and the influence, if any, of these ideas and concepts on the science teachers' metaphors. The following two research questions were investigated:

1. **What insights do science teachers' metaphors provide into their responses to the ideas/concepts presented in the Dip.Ed. programme?**
2. **What changes in the metaphors occur during the period of training?**

Conceptual Framework

Constructivism, Metaphors, and Teacher Education

It is well established that prospective teachers enter the teaching profession/teacher education programmes with conceptions of teaching and learning that have been developed from their own experiences as learners (Bullough, 1991; Sillman & Dana, 1999). For the special case of Trinidad and Tobago, where the entry requirement to teach at the secondary level is an undergraduate degree in a subject specialization and formal training in pedagogy is not compulsory, secondary teachers are exposed to courses in education after having spent a few years, ranging from 2 to 20 years, in the classroom. So in addition to their own experiences as learners, these teachers would have developed conceptions of teaching and learning while on the job. Furthermore, the experienced teachers who enter the Dip.Ed. programme have had years of acting upon their beliefs in the classroom, which can have either positive or negative impacts on students. Chen (2001) cites Clandinin (1986), Clark and Peterson (1986), and Glasson and Lalik (1993) as stating that "teachers practices are influenced and directed by their beliefs" (p. 264). Also in support of the relationship between beliefs and practices, Carter (1990, p. 112) reports that cooperating teachers involved in a study in which she was engaged "used metaphor to show how conceptions of teaching are reflected in teachers' actions." Additionally, in relation to mathematics instruction, Stipek, Givvin, Salmon, and MacGyvers (2001) also reported consistent associations between teachers' beliefs and their practices. Though more tentative, Tsai (2002) cites Nespor (1987) and Pajares (1992) in reporting that "many educators agree that teachers' beliefs may, in some way, affect teachers' instructional practice" (p. 771). The research on teachers' beliefs parallels the rise in the influence of constructivism as a theory of knowledge and of learning.

Constructivism underpins contemporary discourse in education at all levels of the education system. Among its tenets are that people actively make sense of their experiences and that the knowledge generated from these learning experiences acts as a filter for new learning. Constructivism provides an explanatory framework for learning as the development of schema via a network of coherent propositions. According to Chen (2001, p. 262), "when learners are taught, they construct individual meanings from the material by relating it to their existing conceptions and frameworks of knowledge." In a similar vein, constructivism also provides an explanation for the initial rejection of

concepts that do not fit within a pre-established network of ideas. However, changes in schema do occur. In line with constructivist principles, it is the active and explicit interrogation and questioning of beliefs that can lead to dissatisfaction with conceptual schema, and which can result in change to new ways of thinking or conceptual change. It is therefore not surprising that teacher education programmes include strategies that explicitly solicit their clients' prior knowledge and beliefs and lead to an examination of this knowledge. These strategies include using teachers' metaphors and engaging prospective teachers in individual and collective reflection. It is therefore suggested that given opportunities to reflect, experienced teachers might be more able to discern how their conceptions of teaching have guided their actions in the classroom, and might be more able to relate these actions to their students' performance (positive or negative). Drawing upon the constructivist paradigm, Fosnot (cited by Chen, 2001) posits that teacher education which actively draws upon teachers' prior knowledge will likely have a profound effect on teachers' conceptions of teaching and learning.

As related specifically to teacher education programmes, the literature reports (Zeichner, Tabachnick, & Densmore cited by Bullough, 1991) that for teacher education programmes which do take account of their clients' prior knowledge, the clients tend to respond to/accept the content and experiences that resonate with their schema and related conceptions of self as teacher. Similar findings were also reported by Tilemma (1995), who stated that "the greater the correspondence between teachers' beliefs and what was presented in training, the more likely it was that learning would take place" (p. 291). Conversely, some teachers' conceptions of teaching and the teacher's role can in fact act as hindrances to learning and hence to the development of new actions in the classroom. For example, teacher as *guide on the side* is more in line with contemporary ideas about teachers' role in interacting with students than the traditional *sage on the stage*. The following examples from Carter (1990) reinforce the point. With respect to classroom management, she found that teachers' metaphors could be related to the effectiveness of their actions in the classroom. Furthermore, the metaphors "illustrated how dysfunctional understandings of the task of classroom management negatively influenced the teachers' abilities to teach and students' abilities to learn" (p. 110). Consequently, teacher education programmes that deliberately attend to teachers' prior knowledge aim to have them recognize how their beliefs can impact on learning and to help them to construct new understandings of teaching and learning.

However, research has shown that conceptual change does not happen easily. According to Duit and Treagust (2003), who summarized the research in conceptual change, there are different explanations for conceptual change. For example, the original explanation by Posner, Strike, Hewson, and Gertzog (1982) posits that changes in thinking/ schema occur when persons become dissatisfied with the old frameworks and the new conceptions are intelligible, plausible, and fruitful. This view has been described as cold and rational and as ignoring the affective factors that influence changes in thinking. Duit and Treagust (p. 679) cite Pintrich et al. as proponents of this view. They state that "it is with these ideas in mind that Pintrich et al. (1993) proposed that a 'hot irrational' explanation for conceptual change is as tenable as cold cognition…"; further, they state that "teachers who ignore the social and affective aspects of personal and group learning may limit conceptual change" (p. 679).

The researchers above focus on the conditions that facilitate conceptual change. Others focus on specific activities that enable conceptual change. For example, Sillman and Dana (1999) posit that reflection is critical to the process of conceptual change. They are of the view that through the process of reflection, beliefs and understandings are made explicit, which can facilitate the shift in teachers' thinking from themselves and teaching to students and learning. They suggest that the metaphor is an appropriate vehicle to gain insights into teachers' thinking and hence to assist the process of reflection. In a study done by Sillman and Dana, the metaphor was used to facilitate reflection for four prospective teachers in a pre-service education programme. The results of their study led to two main assertions:

1. Reflection with metaphor helped prospective teacher realize their beliefs and changing beliefs, some of which guided their practice.
2. Learning to teach science depends on the prospective teacher's personal history as a science learner and on the cooperating teacher.

Implied in these assertions is that teacher education programmes can facilitate a change in beliefs if the strategy of reflection with metaphor is used. Sillman and Dana (1999) also imply that there is a relationship between some of the actions of some teachers and the beliefs that they espouse. Supporting the role of reflection in facilitating changes in thinking, Brownlee, Purdie, and Boulton-Lewis (2001) also attest to the impact of reflection on pre-service teachers' epistemological beliefs. In a study comprising two groups of pre-service graduate teacher education

students enrolled in a teacher education programme, they found that the students who were required to reflect explicitly in journal entries experienced more growth in sophisticated epistemological beliefs than those who were not encouraged to reflect.

There are a few reports in the literature on the use of metaphor in pre-service programmes over the year of training, including changes in metaphor used to describe conceptions of teaching science based on teachers' experiences in the programme (see Sillman & Dana, 1999). However, there have not been attempts to investigate science teachers' responses to the in-service Dip.Ed., as described below, within the framework of metaphor.

Outlining the Contextual Background and the Research Process

Teacher education is aimed primarily at introducing untrained teachers to public theories about teaching and learning and in having students access and perhaps to come to accept many of the theories presented during the programmes. In recent times, too, a major goal of teacher education has been the development of the reflective practitioner. The Dip.Ed. programme that is delivered by the School of Education at The University of the West Indies (UWI), St. Augustine can boast of the same goals/aims. The activities in which students are engaged, including the development of a portfolio as one of the significant assessment tools of the programme, provide evidence of the focus on reflection. For example, science teachers engage in journal writing during the programme, and science teachers complete lesson plan forms that include a section devoted to teachers' reflections of the lesson. They are also required to assemble a portfolio that projects their growth and development, which accounts for 25% of their grade in "The Practice of Education."

The Dip.Ed. programme comprises four courses—"Foundations of Education," "Curriculum Process," "Project in the Theory of Education," and "The Practice of Education," which provide opportunities for engagement with the theoretical and conceptual foundations. During the foundations course, the students are exposed to "Philosophy of Education," "Psychology of Education," "Sociology of Education," "Language in Education," and "Health and Family Life Education." "Curriculum Process" exposes students to "Teaching in the Curriculum Area," "Assessment in Education," Classroom/School-Based Research," "The Use of Media in Education," "Electives," and "Arts in Education." Exposure to the course "The Project in the Theory of Education" moves

students beyond local concerns to regional and international perspectives on issues in education. Finally, during the course entitled "The Practice of Education," students are encouraged to reflect upon and develop their lesson presentation skills and their interpersonal skills. This paper is based directly on the experiences provided in two courses for the science curriculum group. These are "Curriculum Process – The Teaching of Science" and "The Practice of Education."

The first session of the Dip.Ed. programme usually begins in the last week of July each year and continues for a month, ending in the third week of August. During this period, the teachers attend classes full time at the university on Mondays to Fridays from 9:00 a.m. to 3:00 p.m. As an introduction to the process of reflection, during the first week of the course entitled "The Teaching of Science," all science teachers were asked to write an autobiographical statement that described their journey toward becoming a teacher. This assignment is also used as an artifact that is included in the portfolio. During Week 2, the science teachers were given an assignment in which they were asked to write a metaphor of themselves as teachers (see Appendix).

Upon resumption of school in September, the teachers returned to their full-time teaching responsibilities from Monday to Thursday and attended the Dip.Ed. sessions on Friday. Alternate Friday sessions were conducted either at the university or as a "Field Day" at selected teachers' schools to satisfy the criteria for the courses "Curriculum Process" and "The Practice of Education." On the scheduled field days, three teachers, including the host teacher, each taught a 35-40 minute session. In addition, a tutor also visited each teacher during pre-arranged one-on-one "school visits" during the term.

To fulfil the requirements of the course "The Practice of Education," science teachers were observed in the classroom and on field days, and were also encouraged to submit lesson plans for review. During the second semester, the science teachers were asked to revisit their metaphor of teaching by doing the assignment a second time. The assessment for this course was an examination of their practice as well as the examination of a portfolio in which they were expected to present a portrait of themselves as teacher, select 8–10 entries from their journal that demonstrated significant growth points—in general, to project their growth and development.

This is an instrumental case study of five teachers for whom I served in the capacity of curriculum tutor. These student teachers were enrolled in the in-service Dip.Ed. programme, and their teaching experience ranged from 3 years to 20 years. The teachers were asked to develop a metaphor that describes them in their teacher's role. These metaphors

were then analysed and the results reported in another paper. This aspect of the study was conducted in order to gain insights into the match, if any, between teachers' metaphors and their responses to the programme elements.

The teachers' comments through journal writing, portfolio artifacts such as their autobiographical statements and curriculum assignments, and their reflections on their lesson plans were analysed qualitatively to determine patterns and themes. These patterns were in turn analysed in relation to the teachers' metaphors and the interpretations of the metaphors as derived when the metaphor deconstructs.

Findings

The research questions are used as the framework for presenting the findings below.

Research Question 1

What insights do science teachers' metaphors provide into their responses to the ideas/concepts presented in the Dip.Ed. programme?

Four of the five teachers responded positively to the use of media in their lessons. The following comment from the teacher who selected the metaphor of *teacher as gardener* illustrates:

Acceptance of use of media

> The two media that I favour for lesson presentations are (i) the overhead projector and (ii) the multimedia. However, my use of media has been restricted to the overhead projector because of the mere fact that we do not possess a laptop. Since I started teaching I have never made use of the media in my lessons, in fact, exposure to its use in presentation came on the Dip Ed Programme. Since then I have tried to make more use of it in my lessons.

The teacher who selected the metaphor *teacher as sieve* (teacher as helpless) was the only one who seemed to have rejected the idea of including media in his lessons. It seems that for this teacher, the metaphor selected was inextricably linked to the school context. He rejected the use of media on practical grounds. His feelings of helplessness were compounded by the physical and financial constraints:

Rejection of media (visual)

Sieve

> Using transparencies however, is not very practical for regular use in my school. There are only two overhead projectors and many of the classrooms either do not have an electrical outlet or are too cramped for space. Using transparencies can also be an expensive affair. The transparencies themselves and also the special markers for them can be very costly if a teacher has to pay for these from his or her own pocket.

However, the teacher was willing to try strategies in relation to classroom organization and to adopt techniques for behaviour modification, which he perceived to be related to classroom management.

Willingness to Try New Strategies: Becoming Empowered to Act

It is plausible that a teacher who selected *teacher as sieve* and who thought of himself as helpless due to the influence of external factors became empowered to act in those arenas over which he had some control—his actions in the classroom. The teacher initially felt helpless with respect to classroom management and he responded to those aspects of the programme that could reduce his feelings of helplessness. Armed with new knowledge, attempts to change behaviour were evident, as illustrated in the caption and the corresponding reflective piece:

Classroom management issues (Caption): Small steps

> These items indicate my progress in the aspect of classroom management. I have tried a lot of intervention strategies with my classes. I have succeeded in some and failed in others. Classroom management is essential for the smooth running of a lesson to achieve its desired outcomes. I will definitely have to continue trying different strategies in the unsuccessful classes until an effective one is discovered. In the past, I just ignored the misbehaving students and continued with my class being noisy. I realize that this practice is wrong since the good students are affected and sometimes the lesson is affected. This is definitely not the attitude of a good teacher.

The journal entry shows that while the teacher reflected on the effectiveness of his actions in the classroom, he still tended to locate the problem within the physical environment. He did not suggest, for example, that the teaching strategies selected might have influenced

students' behaviour or that he had not yet acquired and/or mastered the skills needed to implement some of the new strategies:

Quick fix/external factors insurmountable

> Today, my tutor visited me at school to observe my teaching my form 1 class. She told me that she noticed an improvement in the children's behaviour when compared to the last time she saw them on 2nd October, 2004. I felt very satisfied and happy about this observation…. I also felt motivated to continue trying out different techniques since I think that I have failed with my form 3 class in achieving a suitable level of classroom management. I have tried positive reinforcements, negative reinforcements, giving group work where I hoped that student [sic] would involve themselves in cooperative learning instead of doing useless talk and having lessons with a lot of beneficial discussions where I hoped that students would prefer these interactions instead of their own. All these interventions failed with my form 3 students. I think the overall general breakdown of classroom management in all of the form 3 classes, not just my own, is due to the fact that the classrooms are very cramped for room and are very hot, even on mornings. The students are thus not very comfortable and are uneasy.

The entry below shows that the concept of developing personal relationships with students also found some resonance with this teacher. The teacher began to show concern for his pupils. Again, this is an aspect of the teacher's role for which he could have assumed personal responsibility:

Accepts expanded teacher's role: Care and concern

> This entry showed the care I had for the well being of one of my students. I helped him solve his problem of being too anxious during a test causing his performance level to drop. Ordinarily, I would have ignored the consistent failing by this student and would have blamed him for just not studying his work. I have grown to appreciate that there are other factors around that influence student performance. If I discover these factors, I can research possible solutions and maybe, one day I can get all of my students performing well.

In general, the teacher who thought of himself as "helpless" was open to the ideas and suggestions for which he could assume personal responsibility and which required a more student-centred approach.

The reflective statements showed that the remaining teachers all responded positively to the concept of student-centredness. This positive response could be linked to their metaphors, which deconstruct to reveal core and peripheral meanings. As illustrated below, teachers recognized that they should not ignore students' needs. Irrespective of metaphor selected, the teachers responded positively to the concept of "student-centredness," especially with respect to the notion of student diversity.

The following illustrates teachers' responses to student-centredness in relation to assessment strategies. The theme of student-centredness then continues, with teachers' views on strategies that addressed student diversity in terms of learning styles and student involvement in the learning process. The presentation begins with the teacher (*gardener* metaphor) who explicitly described the students as passive, and continues with two teachers whose metaphors of *eagle* and *sculptor* described teaching and learning as requiring some student input. The final example is the teacher who also selected the metaphor *sculptor*, but who described the teacher as exhibiting authority and control with little student input:

Student-centeredness

Gardener

I view assessment as an important tool to the teacher not only to assess students to discern their achievement/learning, but to offer feedback and for the teacher to make appropriate adjustment to the lesson. While in the past my assessment strategy was limited to the paper and pen test, I am now aware of the numerous strategies that can be utilized for assessment. A multi-faceted approach is even more important with the dawn of the differentiated classroom. This entry marks my varied use of assessment strategies throughout the year.

Eagle

After months of pursuing the Dip Ed., I had learnt a lot, which has again served to alter my philosophy. In addition to my last philosophy (that student should work at their own pace), I believe that the teacher is responsible for creating a learning environment that is conducive to the development of all intelligences and learning styles.

In my view, the underlying principle in most lectures was student centeredness. Prior to the introduction of this theory in so many formats, I used a traditional approach. I taught, gave assignments and left it to the student to learn. During the course

> of this year, I realized that the student-centered approach resulted in more learning and development of interest on the students' part. Due to this fact, I developed these resources.
>
> *Sculptor 1*
>
> The purpose of the Portfolio is linked to this metaphor and my resulting desire to treat my students as individually as I could, to provide learning experiences to which everyone could relate. It was obvious to me at the start of September that I would need to apply the Theory of Multiple Intelligences to my practice. To this end, I planned and delivered lessons and assessments in different formats, using the strategies afforded me by the Dip Ed. I was of course limited by my inexperience with some of these strategies so that not all of my attempts were successful. However, the year provided useful learning experiences for myself as a teacher and as an individual.

Reflecting on ideas presented during the curriculum integration workshop, one of the teachers, who chose the metaphor of *sculptor 1*, was struck by the idea that there are multiple ways of presenting lessons, which would cater to student diversity. The journal entry stated in part:

> Then the third session. We danced to soca-parang and brainstormed the word Christmas. Numerous ideas for lessons in myriad subjects turned up…. That was when I finally got it! The lesson could be presented in so many ways, and quickly.
>
> *Sculptor 2*

Sculptor 2's own experiences of learning led to an understanding of the role of students' input in the learning process. From her autobiography, student input plays a significant role in learning:

> As I grew older, I realized a huge part of learning involved experiencing things myself. Reading from a text book and listening to my teachers helped me in the learning process to some extent but actually seeing a process being carried out made understanding a lot easier…. At Secondary school, I remember being taught in chemistry class how soap is made. My understanding of this process became a lot clearer when I actually did it myself in the laboratory…. My chemistry teacher at that time influenced me a great deal as a student. He had a very practical approach to teaching chemistry and this made me look forward to his chemistry class. When I looked back at his

> style of teaching and the impact it had on me as a student, I felt I wanted to have this kind of impact on my students as well….

As a teacher, however, she saw herself controlling the teaching/learning dynamic with very little input from students:

> Four years ago when I started as a teacher, I was not very experienced in dealing with students. My philosophy was a simple one at that time. It was to teach everything on the syllabus and to complete the syllabus on time. I simply gave notes and gave assignments and discussed topics, which students did not understand. Although this worked on some level, I felt I was not truly reaching all the students. I realized that I needed to do a lot more to hold the interest of students, and it was at this point my philosophy changed.

In response to exposure to the programme, the teacher (*sculptor 2*) tried new strategies for interaction with the students. There was an awakening to the idea that students should be involved in and contribute to the learning process. Based on the new approaches tried, the teacher began to recognize that students can contribute to the learning environment and can think independently. For example:

> As a teacher in the past, I always thought it would be a waste of time to let students try and solve problems like these. I thought instead of doing this I should just give them the theory and then perhaps give them a similar question to see if they grasp the concepts. However, I now realize that by allowing students to work on a problem before teaching the theory can actually help them to come up with similar ideas or techniques on their own. This definitely allows them to develop their critical thinking skills which are so important in today's world.

The metaphor of *teacher as sculptor* can be easily interpreted as indicative of students' active involvement; yet, this particular teacher's interpretation did not convey this understanding of the students' role in the teaching/learning interaction. However, the teacher's observation of her peers during a field visit facilitated her access to, and acceptance of, the idea that students can contribute to their learning. In a reflective piece, she wrote:

> The first lesson was taught to a form 5 class. It was based on the homologous series in organic chemistry. I was really impressed with one of the activities the teacher used to get the students to deduce the general and molecular formulae of certain organic compounds. It was a game using 2 die. One dice bore the first

> part of the name of an organic compound and the other the second part of the name. The students were asked to name the compound formed each time both die were thrown. They were also asked to deduce the general and molecular formula of the compound named. I thought that this was really inventive and the students seemed to enjoy the activity a lot.

The reflective entries below show the teacher's reflections on her own attempts to involve students in the learning process through questioning and discussion strategies:

> Today in my Form 6 class, I taught a lesson on gravimetric analysis. I taught this topic by mainly questioning the students to trigger responses that could be further questioned. In so doing, the students were allowed to develop their thinking skills. This also helped them to build the main concepts of the lesson. They were able to fully grasp on their own what gravimetric analysis is about and how it can be used in the chemical laboratory and everyday life.
>
> I found myself being able to have a discussion with the class rather than actually teaching and at the same time the students were receiving the main concepts of the lesson.

There were attempts at new approaches, but, as seen from above, the *teacher as sculptor 2* still conceptualized "teaching" as "telling." This is in line with the view of a sculptor as one who has control over what shape is taken based on what is done—in the teacher's case based on what is told.

In addition to the above, the teachers also responded positively to (i) arts in education, (ii) the importance of lesson planning, and (iii) the overall development of the reflective habit, which also related to the notion of student-centredness:

Arts in Education

Gardener

> As I sat in plenary sessions, week after week, I notice that numbers were dwindling…. For myself, however, I would not have traded these sessions. Arts in Education was informative and it showed many innovative ways of presenting, assessing, and reviewing learning.

Sculptor1

In recognition of student diversity, this teacher responded naturally to the idea of multiple intelligences. In her caption for a journal entry on the topic "Arts in Education," she wrote:

> In my foray into the world of teaching for MI, I had to train myself in a variety of methods. I started using charts, models, group-work and giving assignments for marks in these same formats. I deliberately avoided using the Arts in my classroom. It was a weak point for me and I naturally shied away from it. At the end of intensive sessions on the incorporation of Music, Drama, Storytelling and other techniques into Education, it became obvious that I could not keep on in this way. The defense of Chemistry being incompatible with the use of Arts was invalid.

In addition to the above elements presented during the course of the Dip.Ed., two teachers also wrote explicitly about lesson planning and about their reflections on lessons. Their responses to these concepts coincide with their interpretations of the metaphors selected—*teacher as gardener* and *teacher as eagle* as described earlier.

The importance of planning

Gardener

The teacher spontaneously developed her own simile for lesson planning. She felt that lesson planning is to teacher as stethoscope is to a doctor:

> ***Caption***
>
> In my entry of Sept 3rd, I describe lesson planning as being 'difficult' and 'time consuming.' However, in subsequent entries, I acknowledge the advantages of lesson planning: students understanding of the relationship between concepts (Big Picture) and the concept itself as well as that time management factor. I conclude that lesson planning is to teacher as stethoscope is to doctor or lesson planning is to teacher as the ledger is to accountant. Whatever the simile, lesson planning is an important tool to the teacher for it ensures goal attainment. As such my changing attitude to lesson planning certainly demonstrates my professional development as a teacher.

Eagle

The teacher linked the importance of lesson planning with student-centeredness:

Caption

At the time lesson one was being planned, I thought it would have been a success because it was a topic I liked. I believed that once I was excited about a topic that excitement would immediately transfer to the children. After several curriculum sessions and much research, I finally planned a lesson that served to increase the students' interest. The lesson was more student-centered.

Reflecting on lessons taught

Gardener

The importance of the set

Two weeks have passed since my initial attempts at lesson plans and I still have not written an entire one. What I have attempted is to identify a 'set induction' for my lessons and to incorporate more group work. This I have managed with some degree of success, students seem to enjoy lessons more.

By Wednesday I had finished the lesson, but I wasn't too comfortable with the set. Finally, I came up with a more attractive set on Thursday. However, I had to work and rework it to ensure it would work.

Throughout this year, I have learnt so much. My main objective was to become a better teacher in the classroom and with the various field days my lesson planning skills as well as delivery of lessons has improved. Even my assessment strategy has moved from standardized test to performance assessment of projects, role-play and group work. Generally speaking, I am a better teacher than when I started, however there is so much more to learn.

Eagle

It was at that point I reflected on some instances when I would join with other teachers and use the following remark in reference to students, "I'm not here for them to like me. I'm here to do my job, and who doesn't want to learn, then that is their business." I remembered feeling so powerful when making this statement, as if it was an indication of my dedication. This

> statement was usually made when we attempted to increase the workload in order to complete the syllabus in the scheduled time.
>
> On reflection, I also realized that when I adopted this attitude, most students complained about not understanding the work and their enthusiasm dies. I always thought that this was because they did not want to work, but now I'm seeing a correlation between my sometimes non-caring attitude and their unwillingness to work. It is now I realize that my students are my job. I must no longer place all my emphasis on completing the syllabus, as no teaching has taken place until they learn. The teachers that I liked the most were the ones who peaked [sic] my interest in the subject area making sure everyone understood the work that was covered.

Summary

The teacher who selected the metaphor of *gardener* responded to most of the elements of the programme, as she related these to increasing student-centredness (which was embedded within the metaphor selected) to enhance student performance. Similarly, as the teacher who selected the *eagle* metaphor developed, the lessons moved away from sole reliance on teacher telling to use of questioning and guided discussion, which were more in line with her explanation of the metaphor initially selected. For example, with the selection of the metaphor of *eagle*, the notion of student-centredness was an intrinsic component of the metaphor. The teacher's autobiographical statement illustrated her orientation toward student-centredness explicitly, which most likely served as the prior knowledge (anchor) on which the ideas presented during the programme were linked.

The examples above illustrated that there were elements of the programme to which teachers related, and which seemed to match some teachers' initial views about teaching. However, this was not always the case. For example, for the teachers who selected the metaphors *sculptor 2* and *sieve*, their responses to some ideas seemed to contradict their explicit renderings of their selected metaphor. In these instances, congruence between implicit and explicitly stated interpretations of the metaphor and ideas presented was not a prerequisite for the teachers to access the concepts presented.

It is plausible that for *teacher as sieve*, the state of helplessness associated with the metaphor was unacceptable and reflected the teacher's response to perceived contextual factors rather than a fixed characteristic of the teacher. For teacher as *sculptor 2*, the influence of

her own learning experiences were perhaps reinforced by the concepts presented on the programme, and hence they became relevant to her teaching/learning interaction. The ensuing tension might have facilitated these teachers' access to some of the ideas and strategies presented in the programme, which were in turn implemented in the classroom. It can therefore be surmised that the ideas presented seemed to be plausible, intelligible, and fruitful.

Overall Summary

From the teachers' reflections and actions, it is evident that they responded positively to many aspects of the programme. For some teachers, their responses could be linked in part to their own conceptions of teaching as revealed by the metaphors selected. Some aspects of the programme that resonated with the teachers' beliefs were: (a) student-centredness, (b) student diversity linked to MI theory and multiple models of presentation, (c) the importance of planning, (d) classroom management issues, and (e) reflecting upon their practice. However, for the participants in this study, the analysis provided evidence that knowledge of the metaphor alone is not sufficient to predict their responses to the programme. Some of their responses to aspects of the programme could be linked to their autobiographical statements or to their actions in the classroom, which were not necessarily related to their explicit elaboration of their metaphors. Additional data sources were therefore required to gain a better understanding of teachers' responses to the programme elements.

Research Question 2

What changes in the metaphors occur during the period of training?

Two teachers indicated that they had not selected a new metaphor (see also Bullough, 1991), and they did not submit the repeat assignment. Of the three teachers who did submit the assignment a second time, the changes occurred at the level of interpretation of the original metaphor instead of the selection of a new metaphor. For the two teachers who chose the metaphor of *teacher as sculptor*, the impetus for change was, respectively, the strengthened view and the new focus on the individual student. For example, *sculptor 1*, who, during the programme, was transferred voluntarily to another school said:

> My first weeks at [new school mentioned] have put me back to this assessing phase of knowing my students. Trying to pigeonhole each of them. This resulted in the realization that the

> fundamental differences among students are still there. Thus, the student is not necessarily clay waiting for me to shape her but may be another type of material needing alternative ways of working. I now see that a student may be like weed, clay, stone or some other material that requires me to get to know the individual before I can decide a means of working with her. The wrong method could be ineffective or even destructive. My classroom management approaches and instructional strategies are currently designed with the class in mind rather than the student. I must find a way to address these singular needs while still maintaining focus on class goals.

For *sculptor 2*, the explicit recognition of student individuality became evident in her theorizing about teaching and learning, but under the framework of the same metaphor:

> My metaphor is basically the same except for a few changes. I realize now that there are different types of clay and some take longer to mould. This is similar to teaching in the sense that there are different kinds of students and some may need more attention than others. There are different methods that can be used to mould the different types of clay to achieve a good end product. Therefore, depending on the type of clay used, the sculptor must use a suitable method for moulding. This relates to teaching because students learn in different ways and not one method is suitable for teaching. I realize now that I must be willing to cater to the different learning styles of my students and therefore I should be able to use different strategies in teaching.

The *Sieve*: (Concluding statement)

In presenting the new interpretation of the metaphor of *teacher as sieve*, the teacher revealed that he related the holes in the sieve to "gaps" or "areas of weaknesses." He believed that the weaknesses were reduced as a result of training. The feeling of helplessness that was originally evident in the teacher's explanation of the metaphor was changed to feelings of empowerment. The teacher began to see himself as an agent in his own professional development and in the teaching/learning encounter. He stated:

> Instead of being a sieve with big holes, I am now one with vastly smaller holes. However, these smaller holes still need to be sealed up. All of the skills I acquired in this Dip Ed programme, I never really thought about ever doing. I have moved from doing zero media items in my classes to being familiar with and

> competent in the most common media sources. I have become more able to properly assess students' performance levels. I have become proficient in unit and lesson planning thus improving the learning done by students…. Although I made a lot of improvements, I still need to enhance my classroom management skills more. Being trained as a reflective practitioner, I am confident that I will improve in this venture. I also have to keep investigating different strategies available for different topics. Certain student-centered teaching methods are better suited for certain topics. I need to further investigate this link.

Summary

Three teachers' reflections revealed changes in the interpretation of the metaphor selected. The changes were made to reflect contemporary ideas presented in the Dip.Ed. programme. These included the recognition of learner individuality/difference within the classroom setting and the role of the teacher in catering to student learning, by developing the reflective habit and continuing professional development through research. The retention of the original metaphor highlights the multiple possible interpretations of words used to represent phenomenon/experiences. In relation to cognition, it is likely that this multiplicity of meanings can facilitate the anchoring of contemporary ideas/theories about teaching, making the ideas presented on the programme plausible and intelligible and, hence, resulting in a different focus in their theorizing about teaching and learning. In addition, for the teacher who selected the metaphor *teacher as sieve*, it is likely that the feelings of helplessness were motivational factors that could be linked to learning.

Conclusion and Discussion

The teachers entered the programme with three categories of conceptions of teaching involving levels of teacher control ranging from "teacher as helpless" to "teacher in control but with some student input" to "teacher exhibiting authority and control with little student input." However, it was evident that the teachers' metaphors, even while quite varied and some seemingly incongruent with contemporary notions of teaching and learning, did not in any way hinder teachers' access to concepts and theories that were presented during the year-long Dip.Ed. programme. Significantly, all teachers, having produced a range of metaphors, responded positively to many of the same aspects of the Dip.Ed.

programme, especially to ideas of student-centredness. This is quite a significant finding because teacher education programmes aim to provide experiences that can facilitate changes in the participants' thinking. In addition, as indicated above, learning occurs most readily when there are similarities between the concepts to which learners are exposed and their prior knowledge. It is plausible that the areas of congruence could be interpreted as indicative of the multiple interpretations that each metaphor accommodates, and aided teachers' access to the concepts.

As illustrated in Part 1, the metaphors deconstructed to reveal marginalized meanings, which were congruent with contemporary theories. For example, the *gardener* metaphor centres around the actions of the teacher but, at the same time, the student can be interpreted as an active rather than passive learner. And it is this inherent contradiction that aligns with contemporary learning theories and would have fit with students' mental schemes. Significantly, for the teacher who espoused most teacher control (*sculptor 2*), her own experiences as a school learner pointed to the direction of student-centredness and, hence, these prior experiences could have facilitated her access to concepts presented. It is also possible that the teachers' reflections were designed to convey what they thought they were expected to write for the purpose of a grade. The real test of their commitment to the new understandings suggested is that their practice after graduation from the Dip.Ed. programme reflects the contemporary notions observed during the programme. Such an investigation should be the next step in the research.

Teacher educators might also be tempted to evaluate the success of the programme by having their students develop new metaphors, and assessing these metaphors in terms of their obvious alignment to the contemporary ideas to which students were introduced. However, this reasoning may be flawed. In this study, there were no changes to the initial metaphor selected, a finding which is consistent with some reports in the literature. For example, Sillman and Dana (1999) have reported that prospective teachers retained their initial metaphors. However, in this particular study, the retention of the original metaphor did not mean that there were no changes in thinking about teaching and learning on exposure to programme elements. It is evident that the teachers' interpretation of the metaphor was based on their unique experiences and that the same metaphor can be interpreted differently.

Accordingly, a selected metaphor can allow new aspects of the teaching/learning interaction to become prominent. This phenomenon was noted in the current study with the different interpretations provided by the two teachers who selected the metaphor of *teacher as sculptor*. It was also reported by Lloyd Yero (2001–2002), who presented a number

of interpretations of the *lesson as a journey* metaphor. Additionally, the findings from this study support Lederman's (1997) view, as cited by Monk and Dillon (2000, p. 85), that teachers' conceptions are not necessarily reflected in their planned or actual behaviours. However, knowledge of metaphors and of the multiple interpretations can serve as a framework for dialogue and discussion between teacher educators and their students regarding teaching and learning. The metaphor is therefore a useful tool to give some insights into teachers' conceptions of teaching and their responses to teacher education programmes. However, in-depth longitudinal studies of teachers' metaphors and their actions in the classroom on a case-by-case basis would be a meaningful contribution to the literature.

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Appendix

Task

d) Write a metaphor that captures you as a teacher.

e) Illustrate how this metaphor is translated into action in the classroom.

f) What are the assumptions about teachers, learners, subject matter, and context that underpin your choice of metaphor?

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LOWER SECONDARY SCIENCE STUDENTS' MISCONCEPTIONS OF OZONE DEPLETION AND GLOBAL WARMING

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This study focused on students' misconceptions related to ozone depletion and global warming. Six open-ended diagnostic questions were administered to 103 randomly selected lower secondary school science students in Trinidad and Tobago. A subsample of 15 students was purposively selected and interviewed to clarify their written responses and to further probe their understandings based on their responses to the six questions. The findings revealed that students have a number of misconceptions about ozone depletion and global warming. The results have implications for the teaching of these concepts at the lower secondary science level and for a review of the teaching resources and teaching strategies used.

Introduction and Literature Review

The international science education literature provides extensive coverage of a number of misconceptions held by students at different levels of the education system on a variety of science topics. Many of these reports show that students' conceptions are often times inconsistent with the scientific concepts they are expected to learn. Some of these have been identified and labelled by different researchers as alternative conceptions and/or naïve conceptions (Garnett, Garnett, & Hackling, 1995; Vosniadou, 2002). In the local context, lower secondary science students exhibit an array of misconceptions about the processes involved in global warming and ozone depletion. Such misconceptions are also a concern in the international context (Boyes & Stainsstreet, 1997; Fisher, 1998a).

Krishnan and Howe (1994) and Mortimer (1995) have articulated that learning takes place when the learner is able to move successfully from the domain of the known into the domain of the unknown through metacognitive negotiation and reconciliation of the unknown with the known. In this regard, science teachers have placed increasing emphasis on students' prior knowledge before new instruction. When these prior conceptions are misconceptions, they prove to have severe negative impact on students' learning (Toby, 1997). The result is that students do

not construct appropriate understandings of the concepts being taught. This is the case with respect to the concepts of global warming and ozone depletion. Further research has shown that those students' ideas are resistant to change, so that simply alerting them to the errors does not transform their misconceptions (Swan & Spiro, 1995). With this in mind, Kerr and Walz (2007) suggest that teachers need to be aware of some of the possible prior misconceptions that their students might have, so that they can craft appropriate teaching strategies using relevant stimulus material to accommodate and reform these misconceptions. Some effective teaching/learning strategies for such conceptual reform have also been suggested by Chi and Roscoe (2002), which include the use of credible and current video clips, simulations, and factual reports and papers that highlight common misconceptions but which also provide convincing and scientific explanations aimed at addressing the identified misconceptions. The caution here is that any strategy/teaching aid used in the classroom must be age-appropriate and experientially relevant for the students involved.

There is evidence in the literature that not just students, but some teachers as well have misconceptions about global warming and ozone depletion. Khalid (2001) suggests that, in some instances, teachers transfer their misconceptions to students when teaching these topics. In a survey of 113 pre-service science teachers regarding greenhouse effect, ozone depletion, and acid precipitation, Khalid found that 65% of the teachers interviewed were of the view that ozone depletion causes global warming. Even though this work focuses on students' misconceptions, mention of teachers' misconceptions is being made since this will be the focus of a future study.

The concepts of global warming and ozone depletion are included in the local curricula of primary schools, through lower secondary, to upper secondary science education. Christidou and Koulaidis (1996) conducted a written test and interviews with elementary school students to elicit their mental models of the ozone layer and their understandings of ozone depletion, and found that elementary school students had a variety of ideas, models, and explanations for these two concepts. In a later study done by Boyes and Stainsstreet (1997), with a similar sample, in regard to the ozone layer and greenhouse effect it was again revealed that students had several models in their mind that were not scientifically correct—one of the more frequent misconceptions being that ozone depletion is responsible for global warming. Fisher (1998b) found that students interpreted the word *hole* literally and perceived the statement "a hole in the ozone" as an actual opening in the ozone layer through which "more heat gets to the earth."

Research at the high school and university levels reveals that many high school students, and even university students, experience difficulties with fundamental ideas in science even after exiting introductory science courses (Sozbilir, 2002). In a study of fourth year secondary science majors in the United States, it was found that 56% of the majors held the idea that holes in the stratospheric ozone layer would increase the greenhouse effect (Khalid, 2003). In another study, Cordero (2002) found that 40% of first year science students at an Australian university believed that the ozone hole causes global warming.

In Trinidad and Tobago, the situation is not very different. At all levels of the education system, educators are discovering that students do not have a clear understanding of these two fundamental concepts. Students are also unclear about the causes of the phenomena and their impact on the physical and biological environment. In fact, many students, especially at the lower secondary levels, cannot explain the phenomena, and many collectively share the misconception that ozone depletion is a major factor responsible for global warming.

It is against this background that the motivation for this work emerged. The researcher wanted to determine, in a very general sense, what were lower secondary science students' understandings of the terms *global warming*, *ozone depletion*, and *greenhouse effect*. Additionally, the researcher sought to find out the students' beliefs about the causes and effects of global warming and ozone depletion. Finally, the researcher wanted to elicit from the students if they thought there was a relationship between both phenomena.

Ozone depletion and global warming, though not difficult ideas individually, often tend to be misconceived because in many science classrooms both phenomena are taught simultaneously, suggesting that perhaps one is linked to or even responsible for the other. Studies in this area in the local and regional contexts are few and do not necessarily focus on the students' ideas, interpretations, and misconceptions in great detail. The findings and educational implications derived from this research are expected to provide useful references for science teacher preparation and training as well as for curriculum design. In addition, the recent increased focus on global environmental problems, particularly climate change, makes this work topical and timely. Both these occurrences—ozone depletion and global warming—are the result of activities of, and choices made, by human beings either because of ignorance or blatant disregard. On both accounts (ignorance and disregard), it is imperative that the urgency of these global environmental problems be addressed head-on and among those who will inherit the existing environmental crisis—the current pool of students, who will be

the decision makers of the future and for whom environmentally friendly decisions and actions can be taken when misconceptions are eliminated. In a more general sense, this work will add to the body of knowledge on the conceptions and misconceptions about global warming and ozone depletion that is already in the literature.

The key research question in this study was:

What are lower secondary science students' misconceptions regarding ozone depletion and global warming?

Methodology

The Sample

The sample for the present study was composed of lower secondary science students pursuing Integrated Science in Forms 1, 2, and 3. All the students would have been exposed to some degree of science at primary school and therefore would have met the terms *global warming*, *greenhouse effect*, and *ozone depletion* at some point in their primary school science experience.

Lower secondary science students were chosen because it is at this level that the misconceptions are detected when students are called upon to relate and apply their understandings of these concepts to the impact of man's activities on the environment. At this level, science teaching is guided by the Secondary Education Modernization Programme (SEMP) syllabus, which has as one of its stated goals that students should demonstrate appreciation for the environment.

A random selection of 103 lower secondary science students were asked to participate in the research. They all agreed and, under normal classroom conditions, the open-ended questionnaire was administered to them. The students were guaranteed that their responses would be kept confidential and would be used only for research purposes. A subsample of 15 students was purposively selected (McMillan & Schumacher, 2001), with the aim of seeking maximum diversity with respect to the misconceptions presented in their written responses. These 15 students were each subsequently invited for an interview. Through the interviews, the students' written responses were not only clarified and confirmed, but their conceptual understandings and misconceptions were further probed. The interview time ranged between 10–15 minutes. All interviews were tape-recorded after first obtaining the interviewees' consent. The interviews were subsequently transcribed, coded, categorized, labelled, and analysed using the constant comparative

method for qualitative data analysis (Boeije, 2002), in which comparison is the main intellectual tool.

Data Collection

A diagnostic test composed of six open-ended questions was specifically developed for this study (see Appendix). Question 1 aimed to elicit students' understandings of the terms *global warming*, *ozone depletion*, and *greenhouse effect*. Questions 2 and 3 aimed to reveal students' knowledge of the causes of global warming and ozone depletion, while Questions 4 and 5 asked students to state what they knew were some of the effects of global warming and ozone depletion. The final question (Question 6) explicitly asked students to state whether or not there was a relationship between global warming and ozone depletion, and to explain their responses. All six questions were piloted prior to the administration of the questionnaire. The content validity of the test questions was assessed by two chemistry lecturers, a physics lecturer, and an environmental science lecturer.

Data Analysis

Students' written responses to the diagnostic questions were qualitatively analysed to identify the different misconceptions students held. The interviews were used to further probe, explore, and exemplify the misconceptions determined. The interviews were transcribed, and the transcriptions were reviewed and cross-checked several times to ensure that there was no misrepresentation of the interviewees' responses. The responses were subsequently coded and grouped in respect of each misconception that emerged, and based on the number of students interviewed the percentage of students with each particular misconception was calculated.

Results and Findings

Analysis of students' responses revealed several misconceptions, as presented in Table 1.

Written responses obtained from students for Question 6 on the questionnaire showed that 87% of the students believed that ozone depletion causes global warming. The students holding this view stated that because the protective ozone layer is being destroyed, more light and heat can enter the atmosphere and that the increased light and heat caused global warming. In other words, they viewed the ozone layer as a shield against heat. In fact, during the interview phase, many of them stated that a hole allows objects to pass through it and that the "ozone

hole" simply allows more heat from the sun to pass through it and into the earth's atmosphere. They did not seem to know that the ozone layer specifically protects the earth from the ultraviolet rays/radiation emanating from the sun. The following quotation from a student's written response encapsulates the perception that ozone depletion is the cause of global warming:

"the ozone hole lets in more heat…this makes the earth hotter…when the hole gets bigger more heat will come in and the earth will get more hot…which will cause global warming…"

Table 1. Range of Misconceptions Among Students

Misconceptions	Students (%)
Ozone depletion causes global warming	87
The ozone hole means more heat enters the earth and that is the cause of the warming up of the earth	91
Use of aerosols is responsible for global warming	64
Air pollution causes global warming	92
Increased levels of CO_2 cause the ozone hole	24
Ozone depletion causes climate change	60

Another student said that the ozone hole is an actual physical "hole" which needs to be "covered" to control global warming. The following excerpt from this student's interview exemplifies this notion:

Researcher: Can you describe for me exactly what we mean when we say there is a hole in the ozone layer?

Student: It is like a hole in a covering…like your shirt if it gets a rip…you have a hole in your shirt and things can pass through….

Researcher: Is this the kind of hole you think is in the ozone layer?

Student: Yes, because if there was no hole, not so much heat will come to the earth…the opening makes more heat come in….

Comments of this kind may suggest that the students lacked an understanding of the concept of ozone depletion, and that perhaps the use of the term *ozone hole* may have been the more frequent expression they were exposed to rather than the term *ozone depletion*. Furthermore, it may be that students are unfamiliar with the stratification of the layers of

the atmosphere and, further, that they may not have a conceptualization of what an atmospheric layer is.

This misconception was shared and explicitly expressed by 91% of the students: the "ozone hole" means more heat enters the earth and that is the cause of the warming up of the earth (responses given to Question 2). They thought that the size of the hole was directly related to the amount of heat that reaches the earth's surface. Again, there was no indication that students were aware of concepts such as "thinning of the ozone layer" or "depletion" to mean that molecules of ozone are gradually being broken down, thus reducing the protective capacity of the ozone layer. The following excerpt indicates students' views:

Researcher: OK. Do you remember this question [showing Question 2 on the questionnaire]? Are you saying that the hole in the ozone layer is the cause of global warming?

Student 1: Yes, I think so….because with a hole up there more heat from the sun can come down to earth.

Student 2: Global warming is related to ozone depletion…more ozone depletion means more global warming.

In further response to Question 2, 64% of the students surveyed said that the use of aerosols is responsible for global warming—only one student wrote that aerosol usage causes ozone depletion. When probed further during the interview, this particular student revealed that he had seen a *"documentary on television that explained the harmful effects of aerosols on the ozone layer."* He suggested further that he knew of *"other substances"* that cause ozone depletion "*such as refrigerants and CFCs*." When asked about the causes of global warming, this student said that the "*bush fires and industrial wastes*" are the causes of global warming. Except for this student, none of the other students were able to suggest what might be causes of global warming other than their misconceived notion of the "ozone hole." Responses to Question 2 obtained from about 8% of the students were vague and were not used in the analysis.

Responses obtained for Question 3 revealed that most students did not know what the causes of ozone depletion were: 92% of the sample suggested [in their written responses] that ozone depletion was due to air pollution. Even when probed during the follow-up interview they maintained this view. Written responses obtained from a few students were vague and efforts to clarify these during the follow-up interview proved futile. The following are some of the vague responses obtained for Question 3:

Student 1: …the gases in the air cause ozone depletion….

Student 2: …ozone depletes…by…things that happen in the sky…

Student 3: ….nuclear reactions destroy the ozone….

Student 4: …the heat from the sun destroys the ozone…

Student 5: …smoke makes the hole in the ozone layer…

In the responses given by Students 1 and 5 there is the implicit suggestion that pollution ("gases," "smoke") causes ozone depletion, but their use of the terms *gases* and *smoke* to mean pollution could not be explicitly verified during the interviews.

Analysis of students' written responses to Question 5 revealed a significant misconception: ozone depletion leads to climate change (60%). This was identified from students' detailed explanations in their written responses to Question 5. All the students holding this misconception were part of the larger group of students (92%) who believed that air pollution causes global warming. It was clear from the analysis of their written responses, as well as their interview transcripts, that the terms *air pollution* and *climate change* were familiar to these students. They were using the terms in context and with ease and comfort in their explanations.

What emerged, however, as some of them articulated in responses given during the interview, was that air pollution led to/caused ozone depletion, which in turn led to/caused global warming, which in turn led to/caused climate change. In addition, most of the students interpreted global warming to mean higher ("hotter") temperatures. The following excerpts from two students (in response to Question 5) capture this stated understanding:

Student 1

Researcher: You wrote on your questionnaire that an effect of ozone depletion is climate change. Can you explain further what exactly you mean by this?

Student 1: Well, with the ozone hole…I mean ozone depletion, a lot more heat from the sun comes into the earth…. And this causes the climate to get hotter…

Researcher: Are you saying then that climate change means higher [hotter] temperatures?

Student 1: Yes, because more heat is getting to the earth.

Student 2

Researcher: Could you explain to me why you say that ozone depletion leads to climate change?

Student 2: Ozone depletion means a hole in the ozone layer…which means more heat comes in…which mean that the temperature will be higher…and so the climate will be hotter….

Researcher: Are you saying then that climate change means higher temperatures?

Student 2: Yes.

Responses obtained for Question 4 were in large part a duplication of those given to Question 5. The reason for this was obvious: many of the students believed that there was a cause-effect relationship between ozone depletion and global warming, and, further, that there was also a cause-effect relationship between global warming and climate change. Their perception, however, of global warming and climate change was only in relation to higher temperatures. Students were unfamiliar with the concept of, and the role of, the [enhanced] greenhouse effect in global warming and, ultimately, its impact on climate change. Instead, their understanding was a simplistic one—ozone depletion causes global warming which leads to climate change. Furthermore, it was clear after the analysis of students' responses obtained from Questions 4 and 5, that the single major misconception in their minds was that ozone depletion, or in their terms the "ozone hole" [which in their view was caused by air pollution], is responsible for more heat getting to the earth, thus causing global warming, which eventually leads to climate change. Additionally, it was evident that most of the students interpreted climate change to mean higher temperatures or in their words "hotter weather."

To a lesser extent, students responded that the use of aerosols [sprays] caused global warming which also led to climate change. To an even lesser extent, some students were of the view that increased levels of carbon dioxide [which they suggested came from industries and car exhausts] is responsible for the ozone hole, which causes global warming and ultimately leads to climate change. None of the students surveyed suggested explicitly that increased levels of carbon dioxide in the atmosphere caused global warming. It was also clear that the students did not have an understanding of the [enhanced] greenhouse effect and the role of carbon dioxide in this process and ultimately in global warming. In fact, most of the students seemed to believe that the terms "greenhouse effect" and "global warming" meant the same thing.

Summary of Students' Written Responses From the Questionnaire

Question 1: Explain what you understand by the terms: global warming, greenhouse effect and ozone depletion.

Students' responses to this question were varied, suggesting that they had a range of understanding of these three phenomena. Some of these are presented below.

Global Warming:	The earth gets hotter (68%)
	More heat on the earth (12%)
	Higher temperatures on earth (10%)
	More light and heat in the atmosphere (7%)
Ozone Depletion:	A hole in the ozone layer (92%)
	Less ozone (7%)
Greenhouse Effect:	The warming up of the earth (12%)
	More heat trapped on earth (15%)
	Higher temperatures (29%)

Question 2: What causes global warming?

The responses to this question suggest that many students did not have a clear understanding of what activities and behaviours lead to the global warming phenomenon. The following were put forward by students as being responsible for global warming:

- The ozone hole (91%)
- Pollution (92%) – Students giving this response believed that pollution was responsible for the "ozone hole"
- Aerosols (64%)
- Carbon dioxide (5%)
- Nuclear power stations (2%)

Question 3: What causes ozone depletion?

The following were students' ideas/beliefs about the causes of ozone depletion:

- Air pollution (92%)
- Gases in the air/Smoke (4%)
- Nuclear reactions (1%)
- Heat from the sun (1%)

Question 4: What are some of the effects of global warming?

Two major ideas emerged from the responses given to this question:

1. Increased temperatures
2. Climate change

Question 5: What are some of the effects of ozone depletion?

Three ideas—all implicitly suggesting that students believed there was a direct relationship between ozone depletion and global warming—emerged form the responses students gave to this question:

1. Global warming (87%)
2. Higher temperatures (82%)
3. Climate change (60%)

Question 6: Is there a relationship between global warming and ozone depletion?

The general consensus among the students surveyed was that there is a relationship between both phenomena, summarized simply as "ozone depletion causes global warming."

Discussion, Conclusions, and Implications for Teaching

It is obvious from what is reported in this work that students have many "confused" understandings about the meanings of *global warming* and *ozone depletion*. Furthermore, they were unclear as to the scientific explanations of both phenomena and were even more unclear about their effects on the environment and on their lives. What was obvious, however, was that many students believed that the two phenomena were related—specifically that ozone depletion causes global warming—which they ultimately interpreted to mean that ozone depletion is responsible for climatic changes.

What is disappointing from the findings of this work is that none of the students seemed to have known that ozone depletion has severe effects on their personal lives in terms of its effects on their bodies and on plant and animal life. None of the students suggested that ozone depletion puts human beings at increased risk for skin cancers and eye diseases, or that it could have an effect on crop yields and on animal tissues. None of the students suggested, even implicitly, that there is need for humans to monitor and control their activities by the choices they

make so as to minimize activities that could lead to further depletion of the ozone layer. No one indicated that there was a need to revisit certain kinds of human activities which have resulted in increased consequences of global warming. In all instances, written and oral responses revealed that the students were unaware of the implications and importance of the phenomena on human beings and on the environment. Teaching approaches seemingly did not focus on the risk/harm to society that ozone depletion and global warming can cause.

The empirical findings of this research—similar to that obtained by Christidou and Koulaidis (1996) and Boyes and Stainsstreet (1997)—revealed very clearly that students had several misconceptions about the concepts of ozone depletion and global warming and, further, that some misconceptions were common to a significant extent. These misconceptions could be summarized as follows: ozone depletion causes global warming (87%); the ozone hole allows more heat into the earth which results in the earth warming up (91%); aerosols are responsible for global warming (64%); air pollution causes global warming (92%); increased levels of carbon dioxide are responsible for ozone depletion (24%); and ozone depletion causes climate change (60%).

These misconceptions held by students, particularly the perception that ozone depletion causes global warming, are very worrying to the researcher. It seems obvious that students would have developed these misconceptions as a result of their prior learning experiences, either within a classroom setting or from experiences outside the classroom. The alarming concern that arises here, as presented by Toby (1997), is to what extent are the understandings of the general public—and particularly teachers, more so science teachers—scientifically accurate. It would seem, as suggested by Vosniadou (2002) and Khalid (2001), that perhaps teachers themselves have similar misconceptions which they naturally transfer to students during the teaching/learning interface.

Questions arise about the resource material that teachers use when preparing for their class. How credible are these resources? Do teachers question these sources? Do they interrogate their own knowledge and understandings and the resources (such as textbooks and websites) as they prepare for classroom delivery? What level of research (of subject/content material) do teachers engage in? Is there knowledge sharing and discussion of ideas among teachers or members of departments in relation to teaching these topics?

These and many similar questions of concern seem to be what needs to be addressed in detail, at the causal level, to find ways of dealing with students' misconceptions, which seem to be a manifestation of a deeper issue. If perhaps, as Fisher (1998b) and Khalid (2001) suggest, students'

misconceptions are as a result of knowledge transfer from teacher to students, then it is at the levels of teacher content capacity and teacher pedagogical content knowledge that the issue must be treated. The exploration of this perception, in the local context, is a valid topic for future research.

In this regard, it would mean that the local myth which portrays teachers as storehouses of knowledge must be dispelled. Indeed, curriculum design, both in content coverage and teaching strategies that specifically target students' misconceptions, is needed. Teacher guides and classroom aids (structured written documents) to assist teachers in identifying misconceptions and then systematically moving students from misconceptions to conceptions must form part of the curriculum redesign process.

It would seem, further, that there is urgent need to revisit the knowledge-dispensing image of teachers and perhaps to create a new image—one that is more research-based, collaborative, and dynamic—not simply of teachers but of the teaching profession in general. However, since the profession is shaped largely by the personalities, attitudes, conduct, and knowledge base of our teachers, the ultimate responsibility lies with the teachers.

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Appendix

Dear Student,

The following is a questionnaire consisting of six (6) questions related to ozone depletion and global warming. Please answer the questions as honestly and as completely as you can in the spaces provided. Your responses will remain confidential.

Thank you,

…….. Rawatee Maharaj-Sharma (Dr.).

Question 1 – Explain what you understand by the terms: global warming, ozone depletion, greenhouse effect.

Question 2 – What causes global warming? Explain as fully as you can.

Question 3 – What cause ozone depletion? Explain as fully as you can.

Question 4 – What are some of the effects of global warming?

Question 5 – What are some of the effects of ozone depletion?

Question 6 – Is there a relationship between global warming and ozone depletion? Explain your answer.

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A QUALITATIVE EVALUATION OF THE LOWER SECONDARY SEMP SCIENCE CURRICULUM OF TRINIDAD AND TOBAGO

Dorian Barrow and *Jerome De Lisle*

Timely and systemic evaluations of educational innovations continue to be two challenges faced by education reforms in Trinidad and Tobago (T&T). This paper is, therefore, an attempt to counter this pattern by placing in the public domain a report of a small-scale evaluation of 24 randomly selected science teachers in T&T. A focus group interviewing technique was used to evaluate the teachers' stages of concerns and their levels of use of the new lower secondary science curriculum—a curriculum initiative launched in 2002. Using the Concerns-Based Adoption Model (CBAM) and grounded theory as the theoretical frameworks, an analysis of the focus group interviews of the science teachers revealed that these teachers had very high levels of concerns with the innovation, that is, they had thought critically about some of the major issues surrounding the innovation, but had very low levels of use. However, because the study involved a small sample of science teachers' views (n = 24), the findings should, at most, be considered exploratory, and therefore must be subjected to later verification using some quantitative or mixed methods curriculum evaluation techniques on more samples of science teachers.

Background

The Secondary Education Modernization Programme (SEMP) is a major undertaking by the Government of the Republic of Trinidad and Tobago (T&T). This new education reform project was conceived and developed in the latter half of the 1990s, and was finalized, funded, and launched in 1999, in time for the 2000 World Education Forum in Dakar. Its stated aim is to reform the secondary education system of the country.

In this regard, SEMP can be considered as the latest wave of secondary education reforms in T&T, which had its origins some 30 years earlier. In 1968, the Government of T&T took the position that secondary schooling would no longer be only for a privileged few, but would be the right of every eligible child successfully exiting its primary education system (Alleyne, 1995). However, constrained at the time by

limited physical infrastructure and trained personnel, the Government took a phased approach to the implementation of this new access to secondary schooling policy.

Consequently, in the decades following 1970, the Government, in an effort to actualize this mandate, constructed some 29 three-year junior secondary schools. It also built additional five-year secondary and four-year senior comprehensive schools to augment the elite state and denominational secondary schools in existence at the time. Additionally, in this wave of secondary education reforms, the Government introduced a "shift" system. In this system, the new secondary schools admitted two cohorts of students, with one cohort attending classes in the morning and a second cohort in the afternoon. In time, with the construction of the additional secondary schools and with a shift system in place, more and more students who would not have gone on to secondary schools were being encouraged to do so.

SEMP, then, can be considered as one of the latest vehicles by which the Government of T&T is attempting to renew and expand the process of secondary education reforms in the country. At the same time, SEMP is also being used as a framework to address those other important complementary matters of equity, quality, access, and efficiency that have arisen over the last 30-odd years in the education systems of the Anglophone Caribbean in general (Sweeney, 2003) and T&T in particular.

One of those issues has been, and continues to be, the lower secondary science curriculum, that is, what science is taught, and how that science is taught, to all students in Forms 1, 2, and 3, since there has never been a common standard parallel to the standards of science taught in Forms 4, 5, and 6 (Grades 7–9). In this new reform thrust, a major aim of the state has been to develop in all secondary school students what the Ministry of Education (MOE) has described as "scientific capability" (Trinidad and Tobago. Ministry of Education [MOE], 1998). *Scientific capability* is the label the Government has given to the eclectic notion that all graduates from the secondary education system of T&T must be what historically has been described as being *scientifically literate*. Graduates from a secondary school system are considered scientifically literate according to the international literature when they possess the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity (National Science Teachers Association, 2003).

Scientific capability, like scientific literacy, highlights even more clearly the focus of science education for action, personal satisfaction,

and enlightenment. It includes five interrelated, though also somewhat distinct, outcomes—competence, curiosity, understanding, creativity, and sensitivity. Hence, the Government's vision of scientific capability not only encompasses the epistemology of science, but also emphasizes the skills, resources, and perspectives that are transferable to domains outside of science (MOE, 2002; Ramkissoon, 2007).

According to Pamela Fraser-Abder (1985b), the pursuit by the Government of T&T of some version of this vision of scientific capability in all secondary school graduates may have begun as early as 1977, with new developments in primary science education in T&T. She noted that despite the existence of the primary science syllabus of 1956 and 1975, little science had been taught in primary schools. In 1977, the MOE and the School of Education of The University of the West Indies (UWI) launched an elementary science curriculum development programme—Science – A Process Approach for Trinidad and Tobago (SAPATT). This curriculum was developed for children 5–12 years old, and involved 700 teachers in its development from 1977–1983.

In another article, based on a paper presented at the 1981 Annual Meeting of the National Association of Research in Science Teaching, in which she described a study that she had conducted to determine the status of cognitive development of primary school students of T&T, Fraser-Abder said that: "secondary science curriculum developers in Trinidad and Tobago will have to make some effort to achieve some match between the cognitive demands of the curriculum and the cognitive levels of the students" (1985a, p. 5). This suggests that as early as 1981 there may have been some preliminary science curriculum development work being undertaken in Trinidad and Tobago, which was trying to link the competencies that the secondary science curriculum was developing in students to their cognitive developmental levels.

By 1994, a lower secondary school science curriculum with scientific capability as one of its major goals was in place, ready to be piloted. The National Certificate of Secondary Education (NCSE) Science programme was designed for the lower secondary schools, and was introduced by the MOE in 25 pilot schools in September of 1994. An evaluation of this pilot initiative by George (1997) found that the programme was having an impact on the science experience of students at the lower secondary level. She reported that many students were enjoying science, had a good idea of what the discipline entailed, and wanted to continue studying science beyond Form 3.

The nature of the impact of this programme, however, appeared to vary depending on the orientation of the teacher. In her report, George (1997) noted that teachers in the junior secondary schools seemed to

value most the fact that the programme attempted to relate science to the daily lives of the students. Those in 7-year schools valued the emphasis placed on the nature of science and the work of scientists, as well as the development of science process skills in students. However, she further noted that the extent of the impact appeared to vary depending on the commitment of the teachers to the programme. Additionally, she reported that: "some of the problems identified in the programme [were] related to the syllabus itself, while others were contextual problems" (p. 13).

The contextual problems were not limited to the science pilot alone. For the whole NCSE pilot programme it was found that:

> A major shortcoming of the Pilot Project was the failure to design and make provision for formal evaluation of the programme before implementation, so that feedback of empirical data could be provided on an on-going basis. The lack of adequate monitoring systems, as well as insufficient time to observe the process, severely limits the ability to provide an in-depth analysis of the running of the programme. (MOE, 1998, p. 15)

The report went on to strongly suggest that the programme be suspended unless all its recommendations were accepted and fully implemented.

Following this report, the NCSE pilot initiative was suspended and subsequently replaced by the SEMP programme initiative in 1999. The lower secondary SEMP science curriculum, along with seven other core curriculum subjects, was developed in three stages. The first stage of the curriculum development process consisted of stakeholder consultations held with representatives from a cross-section of the national community. In the second stage of the process, the officers of the Curriculum Development Division (MOE) studied the reports of the consultations, together with the 1996 Education Policy Paper and the reports of the Curriculum Task Force and the Task Force for the Removal of the Common Entrance Examination, "as well as newspaper articles and letters to the editor on education over the past five years" (MOE, 2002).

Finally, at the third stage, 10 existing schools were identified to pilot the new curriculum. Science teachers were drawn from these schools to form a Curriculum Writing Team. Other teachers with specific subject or curriculum development skills from other schools were also included in the team. In this phase, specific science learning outcomes were identified, and content, teaching, learning, and assessment strategies were developed to support these outcomes. The science curriculum document to be evaluated here was the outcome of these efforts.

Purpose

This study was designed to provide some insights into the perceived value of the lower secondary SEMP science curriculum to a small but diverse sample of secondary science teachers. Additionally, the study sought to determine the implementation status of this science curriculum in 24 of the 140 secondary schools in T&T, and to recommend possible ways forward for these select schools with respect to the successful implementation of this curriculum innovation.

The 24 teachers who participated in the study were selected from large and small schools; urban, semi-urban, and rural schools; single-sex and co-educational schools; three-year, five-year, and seven-year schools; and prestige and new sector schools. Hence, all school types in the country were represented in the sample. The individual assessments of the 24 teachers were aggregated and a composite view of their concerns and their levels of use of the SEMP lower secondary science curriculum was generated.

Though no attempt was made to generate a system-wide view of teachers' levels of concerns or level of use of the innovation, the authors used this opportunity to speculate about some of the implications that the findings might have for science education reforms in the wider secondary school system of Trinidad and Tobago.

Methodology

Because of resource and time constraints, the study had to be limited to only 24 secondary schools and 24 science teachers. There are approximately 140 secondary schools in T&T, so that a sample of 24 schools represents 17% of all the secondary schools in the country. Furthermore, schools in T&T are distributed in varying numbers in the eight education districts of the country, with several types of secondary schools located in urban, semi-urban, and rural sectors of the country. These include government secondary, assisted secondary, junior secondary, senior comprehensive, and composite schools (T&T. Central Statistical Office, 1998). The sample of schools used in this study included at least one of each type of school, from each of three geographical locations—north, east-central, and south.

Following focus group protocols outlined by Richard Krueger (1988), and capitalizing on one of the researchers' intimate knowledge of the secondary school system of T&T following 20 years of experience working with the system in various capacities, the study brought together 24 teachers who had been implementing this new SEMP science curriculum in their schools over the period September 2002 to June 2007. They were placed in three separate focus groups of eight teachers per

focus group. The following screening process was used to select the 24 science teachers:

1. The school principal of each of the 24 four schools identified was contacted and the project was introduced, with supporting documentation to verify that this was a MOE initiative.
2. Each principal was asked to recommend two science teachers who could speak authoritatively about the school's experience with the lower secondary school SEMP science curriculum. It was stipulated that these teachers had to have had direct experience with teaching the curriculum in at least one of the form levels.
3. From the 48 nominees, the research team selected 24, one from each school, to form three focus groups of eight science teachers each. One group consisted of science teachers who worked in schools in the north, the second group consisted of teachers who taught in schools in the east and central, and the third group was made up of science teachers who taught in schools in the south of the country. Each of the focus groups included teachers with approximately the same mix of teaching experience, gender, and content area specialization.

The three groups met in two-hour sessions for approximately six hours on the same day at a common location in central Trinidad. Graduate students from the School of Education with training and field experience in moderating focus group sessions were tasked with moderating the sessions following a brief orientation. Each focus group had two moderators and one of the researchers was on site to coordinate the sessions. Each focus group, through the moderators, was asked the following eight key questions:

1. What is your overall impression of the lower secondary SEMP science curriculum?
2. How is the lower secondary SEMP science curriculum different from the general science syllabus it has just recently replaced?
3. How can the curriculum be improved or revised?
4. How do you judge the curriculum in terms of meaningfulness of its content and activities?
5. How integrated is the SEMP science curriculum?
6. What do you understand to be the specific outcomes of each of the three levels of the SEMP lower secondary science curriculum?
7. What are some of the challenges you are facing in implementing the curriculum?

8. What do you see as some of the specific barriers to implementing the curriculum?

Each question was discussed until the moderators felt that the group had reached data saturation point, at which point they would move on to the next question. All sessions were audiotaped and the moderators took field notes. The tapes were later transcribed, and the transcripts checked for accuracy. Transcripts and field notes were used as the basis for the content analysis of the data (Berg, 2007; Creswell, 2004).

Analytic Framework

The two researchers were solely responsible for the coding and the analysis of the transcripts, which were, in part, grounded in codes generated from the focus group data,. However, they were also interpretive, in that codes were also "borrowed" from a conceptual analytic framework—the Concerns-Based Adoption Model (CBAM)—which was viewed as consistent with, and helpful to, this type of applied research. Consequently, the coding frame used to analyse the data comprised of a mixture of grounded codes and codes borrowed from the literature (Berg, 2007; Oppenheim, 1966; Strauss, 1987).

Several themes emerged from a qualitative analysis of the related coded sections of the transcripts. The themes generated could be grouped under one of two major categories, namely: teachers' concerns about the new curriculum; and teachers' levels of use of the new science curriculum. The emergent themes under these two major categories were then further examined in light of the codes generated from the CBAM framework (Hall & Hord, 2001).

As was indicated above, only parts of the CBAM conceptual framework were adopted in generating the coding frame used to analyse the emergent data. This decision was made in part because the CBAM framework was developed to explain teachers' concerns about innovations, and to explain why educational innovations were not always adopted and used as extensively as innovators intended, which parallels the situation in T&T. To do this, CBAM uses three conceptual frameworks, namely Innovation Configurations, Stages of Concerns (SoC), and Levels of Use (LoU). In this analysis, codes were adopted from only the latter two conceptual frames.

Stages of Concerns (SoC) address the affective side of change, that is, the teachers' reactions, feelings, perceptions, and attitudes to the new SEMP science curriculum. Levels of Use (LoU), on the other hand, "has to do with behaviours and portrays how people are acting with respect to a specified [innovation or] change" (Hall & Hord, 2001, p. 81). Hence, only these two dimensions of the analytic framework were adopted as the

study sought to explore the affective outcomes as well as the behaviours of the science teachers as they adopt and implement the new SEMP science curriculum, and to diagnose their progress in implementing the innovation.

Most significantly, these dimensions of the CBAM framework were selected from the many other change models available in the education evaluation literature because other curriculum evaluators who have used the framework attest to Hall and Hord's claim that "[CBAM] makes it possible to understand and predict what is likely to occur with people in change and to determine whether a new innovation was making a difference" (2001, p. 81).

Findings

Affective Outcomes: Teachers' Concerns

The answers the teachers provided to those questions that reflected their stages of concerns were derived from a qualitative analysis of the relevant episodes of their respective focus groups' conversations and the moderators' field notes. Several themes emerged from the analysis of the related coded sections of the transcripts. Where possible, the moderators' field notes were used to triangulate the findings that emerged from the transcripts. An elaboration of these themes, or affective outcomes, forms the basis of the summary evaluation of the science teachers' concerns.

Satisfaction: The first clear theme to emerge from an analysis of the transcripts of the focus groups sessions was that of satisfaction with the new SEMP science curriculum initiative:

> *I wouldn't say that the SEMP science curriculum is ambitious. [What] I would say is that it is innovative, [especially] in bringing out the philosophy that all children can learn and in keeping with that philosophy, which I totally agree with and I hold on to that notion. [However] one of my concerns is [with] the course assessment.* (Teacher I, Focus Group I)

Though most of the teachers from the focus groups were generally impressed with the new SEMP science syllabus, especially with its philosophical orientation and its activity base, some teachers thought that the curriculum was not balanced, "*being too heavy on certain topics*." Others felt that there were too many topics to cover in a year, and that the syllabus was not sufficiently integrated. Still others felt that there was a mismatch between the proposed teaching/learning strategies and the evaluation strategies, while others felt that "*several important things*

…have been left out of the syllabus document." However, despite this string of "consequence concerns" (Hall & Hord, 2001, p. 62), the general consensus of the teachers who participated in this review was that this new SEMP science curriculum was not only different from the "*old science syllabus it has replaced, but was also substantially better.*"

Essentially, the teachers felt that the SEMP lower secondary science curriculum is better than the old science curriculum it replaced, partly because "[it is] *so different from the old curriculum*." These differences were more pronounced in some areas than in others. For example, although the old science syllabus covered more content material and was better integrated, it was in fact organized as a set of prerequisite courses for the Caribbean Secondary Education Certificate (CSEC) science syllabuses that students take in the upper secondary school. The "old general science" curriculum, therefore, was not as holistic in its approach to the science education of students as the SEMP science syllabus. This is so in part because the SEMP science curriculum is a cohesive programme that is projected over the entire five years of the students' secondary school life.

Furthermore, the old science syllabus prioritized breath over depth of content, and so it was not as focused as the SEMP programme on engendering in students such critical competencies as the scientific literacy and science inquiry process skills "*that the CXC would like the students to have*." Additionally, the SEMP science curriculum had some unique features to specifically address the needs of special students, that is, to address those Form 1 Special (1S) students who are socially promoted from primary into secondary schools without the appropriate academic and literacy skills regarded as necessary at the secondary level. All of these may have contributed to why the teachers felt that the SEMP science curriculum catered to a much wider range of student abilities than the old general science syllabus it replaced.

Challenges: Even though the teachers felt that the SEMP science curriculum is substantially better than the previous general science curriculum it replaced, the second theme to emerge from an analysis of the focus groups' transcripts is challenges, that is, the strong sentiment that the innovation still posed some new, and old, challenges to science teachers. One such problem is that it challenges secondary school teachers to extend their own science content knowledge, as this teacher with 12 years experience points out:

> *To me if we are going to extend to where we're looking at providing students with quality education, I feel very strongly that you have to seriously narrow the gaps in teachers' science knowledge…. I am*

> *not saying that is the situation [now], just that teachers need as much help as possible. [For example] if you are looking at mixtures, chemical changes, etc. and you are a physics person, you need the help of an experienced chemistry teacher. If somebody is not experienced, for example, when I started to teach, I was the only chemistry teacher on staff, there was nobody to help me with anything. So when you have nobody to go to, you learn these things by making mistakes, trial and error, practising on the children, sending them out there with half the knowledge they should have and so on.* (Teacher I, Focus Group III)

This challenge might in part exist as a consequence of how teachers are appointed to teaching positions in secondary schools in T&T. Because secondary school science teachers enter the teaching profession usually just after they have completed a B.Sc. degree in some specific science discipline (e.g., chemistry, physics, biology), it is not unreasonable to assume that their content knowledge of other science fields may sometimes be limited.

Furthermore, the focus groups' transcripts suggest that many of these 24 science teachers' attitudes to this challenge were: "*this topic is not a part of my subject area, so I don't know much about it myself. How do they* [the significant others in the society] *expect me to teach something I barely know myself*?" Some of these teachers in their focus group discussions even admitted to "*not feeling comfortable with teaching content outside their field*." Teachers also adopt several untenable pedagogical strategies, such as resorting to the chalk-and-talk method of teaching science. By teaching in this disjointed manner whereby science is presented to students at times as inquiry and at other times as "telling," teachers convey mixed messages to students about the nature of science and how scientific knowledge is constructed, instead of the meaningfully coherent message about the nature of scientific knowledge the SEMP syllabus intends to be conveyed to them.

Another challenge that the new SEMP science curriculum poses for teachers is how to proceed with integrating the various topics into teachable coherent science units. As currently constructed, these science teachers do not view the SEMP science curriculum as integrated. Technically, these teachers consider it more a "*combined than an integrated science curriculum*." By a combined science curriculum, teachers mean that the content of the syllabus is made up of topics from the fields of chemistry, physics, biology, and earth/space science, and that these topics are only "*loosely stringed together under the headings of Living things, Matter and Energy, etc. etc*." Because most science

teachers have not been exposed to how to teach science in a multidisciplinary, interdisciplinary, or integrated manner (Glasgow, 1997), the levels of integration of the SEMP science curriculum varies from school to school, and sometimes even from teacher to teacher within schools.

Additionally, the teachers claim that what further compounds the task of integrating the SEMP science syllabus into coherent teachable science units is the way the curriculum topics are sequenced. For example, Form 1 topics like the "Cell" and the "Particulate Nature of Matter" are sequenced too early, since at this level many of the Form 1 students do not have the prerequisite knowledge and skills "*to appreciate these topics*." Lastly, the teachers found that the topics in the SEMP syllabus are not sequenced in the "*best way to fully engage students in an optimal way*." Hence, even though most of the teachers do not find the SEMP science syllabus to be very dense [a few of the teachers sampled do], that is, it is not mandating that a lot of outcomes be covered in a relatively short period of time, they cautioned that whether the outcomes could actually be achieved over the three years also depended on the quality of the school's student intake. The schools that take in a lot of academically weak students, the teachers claim, would most likely be the most challenged to meet the standards of the outcomes set by the curriculum.

Leadership: The final theme to emerge from the analysis of the focus groups' transcripts was leadership, that is, a yearning for a new type of curriculum leadership. The teachers, especially those who have participated in science curriculum innovations in the past, spoke about "*wanting to get this one right*"; about "*us learning from our mistakes of the past*"; and of "*the Ministry doing things differently*." They would, for example, like to see more "*regular and direct involvement from the Ministry*" in these reform initiatives. They also would like to be supported in more concrete, even "*more mundane*" ways. For example, some teachers would like to see some model lesson plans added to the curriculum document, or to the resource booklets that are expected to accompany the SEMP science curriculum document in the future. Furthermore, some teachers, like the one quoted below, need help in how to introduce and develop an engaging science lesson:

> *Listen to what she said. She is right. In terms of teaching the objectives, we could have a set induction so we could know how we should be introducing the students to each objective and from that we could build the content. It would help us a lot if for each objectives we get that set induction.* (Teacher 1, Focus Group II)

In essence, this last emergent theme suggests that these teachers are crying out for help in those practical areas such as how to use a curriculum document in planning and organizing for instruction (Quinn, Haggard, & Ford, 2006), that is, with unit and lesson planning.

In summary, the teachers had nine major concerns, mostly in the management and consequence domains:

1. The SEMP lower science curriculum is not balanced.
2. The curriculum covers too many topics.
3. The topics are not properly sequenced to engage the students in an optimal way.
4. The curriculum has left out some "big ideas" of high school science.
5. The teachers feel uncomfortable with the way the curriculum challenges them to expend their pedagogical content knowledge.
6. The curriculum is not sufficiently integrated.
7. The onus of integrating the topics into coherent teachable units falls on the shoulders of the teachers and they feel that they lack the training/competence to carry out this task properly.
8. There is a mismatch between the curriculum's recommended teaching/learning strategies and the strategies that the MOE uses to evaluate the students in the NCSE examinations.
9. The curriculum lacks features that specifically address the concrete needs of some science teachers.

Hence, the affective side of the change process that these 24 science teachers are experiencing as they implement the new SEMP lower secondary school science curriculum can be characterized by three themes, namely: a sense of satisfaction with the new curriculum; the feeling of being challenged by some aspects of this innovation; and a sense of yearning for new leadership, that is, hoping that this time around the support provided by the leadership of the innovation (invariably the MOE) will be much more substantive.

Using the CBAM framework as the lens, one sees that the affective side of the change process that these science teachers are experiencing as they implement the innovation would be categorized as at the levels of management and consequence concerns (Hall & Hord, 2001). That is, most teachers' attention at this point in the implementation process is focused on the processes and the tasks of using the innovation and the best use of information and resources. Consequently, issues related to efficiency, organizing, and managing, and the time demands associated

with the implementation of the curriculum are of utmost importance to them at this stage.

At the same time, the teachers' attention is also focused on the strategic impacts the new curriculum innovation is having on the students in their immediate sphere of influence, even though they spend a considerable amount of their time thinking about the relevance of the topics for their students; how best to evaluate student outcomes, including performance and competencies; and on adjusting different topics to make them more teachable.

Ultimately, the hope of the MOE, as articulated for example in the SEMP science curriculum document, is that teachers will go beyond the management and consequence stages of concerns to those concerns of collaboration and refocusing (Hall & Hord, 2001). The latter level of concern would be where the science teachers' focus shifts to coordinating and cooperating with other science teachers in their schools, as well as those in other schools, regarding the use of the innovation, and even to the elaboration of more universal benefits from the innovation for both teachers and students, including the possibility of major changes or replacements with a more powerful alternative to the existing SEMP science curriculum.

This notwithstanding, it might still be fair to say that the science teachers have made significant progress in responding affectively to the change process associated with this innovation, given the relatively short period of time over which the innovation has been introduced and the "cautious" manner in which it has been implemented.

Given their current levels of reflective engagement with this innovation, it is also reasonable to say that the teachers have adjusted in a satisfactory manner to the affective demands of the curriculum change process (Rakes & Casey, 2002), given the history of teachers' affective responses to science curriculum innovations in Trinidad and Tobago in the past (Fraser-Abder, 1985b). This is especially encouraging since the records show that in the past, teachers' affectivity to change has been at such low levels that many of the innovations have had to be abandoned after a few years.

In the past, many science teachers, especially more experienced teachers, have been unable to find effective ways of dealing with the affective dimensions of the change process. This study further validates the common-sense notion that one obvious way of overcoming this challenge is to bring practising teachers together to talk about their concerns with the innovation, in part to have them find out for themselves how widespread their concerns are (Rakes & Casey, 2002) and, at the same time, to provide them with opportunities to map out a

common path forward. Before we look at what these 24 teachers are suggesting as the way forward, we first have to examine their levels of use of the new SEMP science curriculum in their schools, that is, how affectivity translates into behaviours.

Behavioural Outcomes: Teachers' Levels of Use

This section explores the teachers' behaviours in the classroom as they implement the new curriculum. It seeks to portray how the 24 science teachers are behaving as they seek to learn about new practices for teaching the new science curriculum to their students. Again, the answers the teachers provided to those questions that reflected their levels of use of the SEMP science curriculum in their classrooms were derived from an analysis of the relevant episodes of the respective focus group interviews using the CBAM conceptual framework. Where possible, these outcomes were triangulated by the field notes of the moderators. Themes consistent with those predicted by the CBAM model, as well as other themes, emerged from this analysis. A further elaboration of these themes, or behavioural outcomes, forms the basis of the discussion that follows.

Hall and Hord (2001) have identified and verified, through their 25 years of research, "eight classifications, or levels, of how people act or behave with change" (p. 81). They have argued that since "levels of use deals with [teacher] behaviors it is possible to develop operational definitions of each level" (p. 82). Although their eight levels of use are fundamentally hierarchical, that is, going from the lowest level of "non use" through the "mechanical use" median to the optimal use of "renewal," the adaptation to levels is not necessarily linear and a person's level of use may vary by context.

Of the eight levels of use, the one that seems to best characterize these 24 science teachers' current classroom levels of curriculum use is Level III, or Mechanical Level of Use. This quote from Teacher 2 was typical of how the teachers categorized their level of use of the new SEMP curriculum:

> *I am having problems daily with the way the syllabus has been presented.* [For example] *some of the things they have listed as concepts are not concepts. I don't know what they are, but under the section "Concepts" there are some things there that are not really concepts.* [Furthermore], *some* [teachers] *by me had trouble understanding, for example, how they have the specific outcomes broken down into inquiry skills, conceptual understandings, etc …It's kind of confusing for people to understand*. (Teacher 2, Focus Group III)

As can be discerned from the text above, at this level the teachers focus most of their efforts on the short-term, day-to-day use of the curriculum, with minimum or no time spent on long-term strategizing and reflection. Furthermore, as Hall and Hord (2001) point out:

> Changes in use are made more to meet the user [teacher] needs than client [student] needs. The user is primarily engaged in a step-wise attempt to master the tasks required to use the innovation often resulting in disjointed and superficial use. (p. 82)

However, this mechanical level of use of the curriculum by the teachers must be placed in the context of the potential for other levels of use, both higher and lower. At one level, the use of the curriculum is stabilized. On another level, the teachers are just preparing for first-time use of the innovation. Here, teachers are varying the innovation to increase its impact on students within their immediate environment. On another level, the teachers have little or no knowledge of the innovation, have no real involvement, and are not doing anything towards becoming involved. Hence, their mechanical level of use is more a central tendency (an average) rather than an exclusive categorization.

It is important to note that nearly all of the 24 science teachers are clearly mechanical level users of the new SEMP science curriculum and that this level of use is characterized by a wide variety of behaviours. The significance of this is that it provides some insights into some of the actions that the MOE must take if they are to help to move teachers beyond the mere mechanical level of use of the curriculum in their classrooms.

This evaluation, though limited in its scope, does suggest that such a facilitation must take into account that science teachers in general, and these 24 science teachers in particular, are experiencing, at varying intensities, different combinations of the nine challenges identified in the previous section while at school. Furthermore, facilitators in the future must realize that these teachers' low mechanical level of use is in part a consequence of how teachers are responding to the challenges, or levels of concerns, they are experiencing at their respective schools.

The recognition of this link is especially important since this mechanical level of use of the curriculum is further confirmed by many other classroom behaviours exhibited by these teachers. For example, many of these 24 science teachers constantly find themselves having to select which of the many topics to include in their teaching and which ones to leave out. Some of these teachers complain that that this "*is sometimes done on a daily basis*."

Future facilitators will also have to become aware of another common behaviour in which these teachers are engaged, that is, matching the cognitive and psychomotor demands of the topics in the curriculum with the mental ages and skill levels of their respective students. Many of these teachers support the claim that this teacher makes: "[that] g*enerally …the cognitive and skills demands of many of the content topics of the new syllabus are beyond the reaches of many of their Forms 1, 2, and 3 students.*" Some teachers further complain, as this one quoted below, that even after they have eliminated those topics they are still finding that they "*cannot successfully cover all the remaining topics in the three years allotted.*" Hence, as a consequence of this low mechanical level of use, the full implementation of the SEMP science curriculum is being compromised in many of these 24 schools.

What then are some of the other specific barriers that are preventing these teachers from moving beyond the low level of mechanical use of the SEMP science curriculum in their schools? One of these barriers is contextual, the others being: the teachers themselves, the students, the subject matter of the curriculum, as well as other elements of its design.

Contextual barriers include the administrative bureaucracy of the school. The teachers who participated in the study have found that the levels of administrative bureaucracy at the school impact significantly on how extensively and, consequently, how successfully the new SEMP curriculum is being implemented. This, the teachers say, is especially so when it comes to the matter of securing the material resources needed to implement the programme. They report that in those schools where administrators are efficient at securing the materials, the implementation process is much less frustrating to the teacher. Additionally, the speed with which the school administrator can get the MOE to deliver on the physical infrastructure needed to successfully implement the programme, including such needed facilities as functional science and computer laboratories and audio-visual rooms and equipment, is also very important. Again the teachers' claim is that "*schools with administrators who have been able to get these facilities built and operational are currently poised to proceed more smoothly to* [higher levels of curriculum use], *than those schools that are experiencing these 'bureaucratic inefficiencies."*"

Some of these teachers, however, have pointed out that: "*even in some of the schools where the administrators have been efficient in securing the resources and in putting the physical infrastructure in place use of the SEMP science curriculum by the teachers*" is not even fully operational at the CBAM's mechanical level. In such cases, some of the teachers have suggested that "*there are at least two additional counter*

forces at work." The first is that many of the science teachers in those school have not been provided with the opportunity, or have not taken advantage of the opportunity, to learn to use the material resources to support the programme's learning outcomes.

Secondly, because the new curriculum requires "*considerable time to be spent by teachers on out-of-class planning and because some teachers do not possess good time management skills,*" many of the required pre-planning activities never get done. As a result, "*some* [of these teachers] *have not even fully operationalized the SEMP science curriculum*" at the mechanical level. It must be noted that those teachers in the sample who have been able to manage their time to do the required pre-planning activities have been implementing the SEMP curriculum more effectively at the mechanical level than those who are saying that they "*cannot find the time to do the required planning.*"

Hall and Hord (2001), claim that the first step in determining whether any new curriculum is making a difference is to determine if the curriculum is being used. Hence, this section of the evaluation has attempted to make that determination within this microcosm by aggregating the individual assessments of 24 science teachers from 24 different secondary schools. While this small sample of teachers does limit the study, it does identify some consistent themes that might be found in a system-wide view of the extent of the use of the SEMP lower secondary science curriculum in schools in T&T.

One possible projection from this micro study to the system-wide view would be that the curriculum is being used in all the secondary schools, but that the level of use is low. Viewed through the lenses of the CBAM framework, these teachers are suggesting that system-wide the new science curriculum is possibly being used at the mechanical level in most of the secondary science classrooms in T&T. It must however be emphasized that the caveat here is that this study involved small samples of science teachers in three focus group interviews, and as such cannot be considered a representative sample of the targeted population groups. As a result, this finding must be considered exploratory and must be subjected to later verification.

One possible implication of this, however, is that though the new science curriculum is being used widely in schools, it is not being used at the optimal levels intended. The broad picture that these 24 teachers paint, if projected on to the wider system, is that science teachers often use the curriculum in disjointed and superficial ways. Most of their efforts are spent on short-term, day-to-day use, with little time for reflection on the impact the curriculum is having on their students. When they do make changes to the curriculum what we should find, if this

projection is borne out, is that it is more to meet their needs than their students' needs, as they are now just attempting to master the many and varied tasks required to teach the new curriculum. Hence, if in doing the more extended study this turns out to be the case, their efforts could be characterized as being fragmented, step-wise, and short-term, that is, mechanical.

Another implication of this finding is that other key interventions must be put in place if the level of use of the innovation is to advance to the intended level of "Renewal" (Hall & Hord, 2001), that is, the level where the science teachers are involved in the re-evaluation of the quality of use of the innovation. This is where they seek modifications of, or alternatives to, the present curriculum to achieve increased impact on their students' learning of science. Furthermore, use of the curriculum at this level will significantly increase the probability of teachers enabling students to become more scientifically capable. But to ensure that this occurs, other key interventions are needed if the reforms are to achieve their ultimate stated goal of wanting science teachers to constantly examine new developments in the fields of science education and to proceed with confidence in exploring new goals for themselves and the wider education system (MOE, 2005). A few of these needed interventions are proposed in the final section of the paper.

Conclusion and Recommendations

The concluding section that follows highlights, in their own voices, some of the teachers' recommendations on what those key interventions might be, and, where possible, an attempt is made to reference these recommendations in the literature

> *If they could put the practical activities in the front of the curriculum document, that would help most teachers to think a certain way. It is not about getting the content across, it is about trying to get the students to think a certain way and understand and love what it is we are teaching them and at that point you putting them first instead of putting yourself first.* (Teacher 3, Focus Group II)

Most of the 24 science teachers who participated in the focus group interviews are aware of the low level at which they are using the new SEMP science curriculum in their classrooms, and would genuinely like to move to those levels of use where, as Teacher 3 above put it, they are "*putting them* [students] *first instead of putting yourself* [teachers] *first.*" That is, most of these teachers want to move from their current mechanical, teacher-centred use of the curriculum to the more learner-

centred use intended. But in order to do so they need help. They need to see "*some changes made to the curriculum*."

The first thing some teachers would like to see changed is the format adopted for the SEMP curriculum, as these two teachers point out:

> *I guess what every one is trying to say is that the formant of the curriculum, not the actual content, the way it is laid out, that you are not sure if you are achieving your objective at the end of it*. (Teacher 4, Focus Group II)

> *Yes, I fully endorse what* [Teacher 4] *was saying because with objectives at the front and the activities at the back we tend to focus on the activities more. I find myself looking to see what I have to do …then saying 'look, I have some practical activities here!' …*[But this is] *after the fact, after you have finished teaching the topic*. (Teacher 3, Focus Group II)

The format, one teacher suggest, could be changed to the one currently being used to frame the primary science syllabus, with "*the content, structure, strategies, and assessment on the same page*."

Secondly, many teachers would also like to see some model lesson plans added to the curriculum document "*or even to the resource booklets that will in the future be accompanying the SEMP science curriculum document.*" Furthermore, a few teachers, like the one quoted below, need help in how to introduce and develop an engaging science lesson:

> *Listen to what she said. She is right. In terms of teaching the objectives, we could have a set induction so we could know how we should be introducing the students to each objective and from that we could build the content. It would help us a lot if for each objectives we get that set induction.* (Teacher 1, Focus Group II)

In essence, then, the teachers who participated in this study are crying out for help on how to use a curriculum document in planning and organizing for instruction (Quinn, Haggard, & Ford, 2006).

This is not entirely surprising given that many, if not most, of the science teachers who participated in the study have not yet had any formal pedagogical training, where they are exposed formally to curriculum theory and instructional design. One of the consequences of this deficiency in pedagogical training seems to be that many of them do not see the need for careful and complete reading of a science curriculum document. For example, most of the teachers who participated in the study did not become familiar with those parts of the science curriculum document that spelt out the philosophy, the aims, the goals, and the

expected outcomes that the curriculum is trying to get students to achieve through their lower secondary school science experiences. Many of these teachers admitted that when they were using the SEMP curriculum document as a resource in their planning, they skipped the first two parts of the document and proceeded directly to the back of the document to the "*content and activity sections*."

Many of those teachers who approach the SEMP science curriculum in this back-to-front manner, said that "*it is the science content, and its related suggested activities, which is* [the engine that is driving] *my classroom curriculum use*," that is, how they plan, organize, and use the new science curriculum in their classroom teaching. Some of these teachers suggested that this invariably led to their "*planning being disjointed and short-term*," since they were planning without always having the "*big picture*" foremost in their minds.

This action also suggests that many of the teachers who participated in this study may have assumed that the new science curriculum's underlying philosophy is subject-centred (Zais, 1976) instead of the learner-centred curriculum that the curriculum designers are claiming the SEMP innovation to be (MOE, 2002, p. 13). Using the document in this "subject-centred" and fragmented manner is, in part, what is implied by the claim that many teachers selected for this study are using the SEMP science curriculum mechanically. Hence, if these teachers are to extend their levels of use of the SEMP science curriculum they will have to learn, among other things, how to utilize the document differently.

In addition to being facilitated in how to use the SEMP curriculum differently, many of the teachers interviewed are saying that they also need to be provided with an expanded inventory of pedagogical tools that would help to further empower them to make better decisions on how best to scope and sequence the proposed content topics in the curriculum. Specifically, these teachers are asking for further training in the type of pedagogy that would empower them to make better decisions about what science content they should include in the unit and lessons plans and which topics they should leave out. For example, the two teachers quoted below would like to be empowered in ways that would allow them to justify omitting those topics included in the syllabus that they consider are too difficult for high school students, since their inclusion not only "*frustrates*" both teachers and students, but also contribute to them not "*finishing*" the syllabus in a timely manner:

> *There are a couple of things in there that are too advanced for these kids. That is not required at this level. Some of the things you try to explain totally blow them off! For me…depending on the class I*

> *have…I totally dilute the content. That is why I don't ever* [get to] *finish the content*. (Teacher 4, Focus Group II)

> *I agree with what they are saying. Cells and Atoms and these kinds of things are out of space for them. They have no idea what you are saying to them…They don't understand what your are talking about because even those who try to learn it end up doing the wrong thing. At the end of it the teachers get frustrated and the students get frustrated.* (Teacher 8, Focus Group II)

These teachers clearly articulate the difficulties that many teachers operating at this level invariably have, that is, tremendous difficulties with consistently linking the science content of the curriculum innovation with its aims and goals. What these teachers are in fact saying here is that they need further training, including some basic training, that would orient them to the basic processes in science curriculum development and design.

This is an especially important request, since it suggests that the current SEMP training is not providing the teachers with all the critical skills they need to fully implement the new curriculum. The additional training they now need should further empower them by providing them with an added set of pedagogical tools that would better enable them to make the kinds of decisions needed to extend their level of use of the curriculum. If this new SEMP science curriculum innovation is to be fully explored and successfully implemented, the teachers implementing it will have to be able to decide for themselves, based on a sound analysis of their idiosyncratic classroom context, if a suggested science topic will or will not do the job of helping with the development of the type of critical competencies the curriculum is trying to foster in students. These include such competencies as problem-solving and communications skills, aesthetic expression, citizenship, personal development, and technological competence.

Furthermore, this training should ensure that teachers have the competence to be able to substitute more appropriate science topics for the ones they find inappropriate for their classroom contexts. Hence, customizing the pedagogical training opportunities for these, and possibly other, science teachers with these goals in mind would be one appropriate way forward.

Finally, these teachers made it clear that they would not only like to be provided with further specific training opportunities but would also like a "*proper*" re-orientation to the SEMP curriculum, with an emphasis on how the new SEMP curriculum expects them to deal with the

challenges of those students with special needs, as the following two teachers underscore:

> *I feel that what everybody is saying has to do with teachers getting more training in how to deliver the topics.* (Teacher 5, Focus Group II)
>
> *Sometimes the kids we get they cannot read and write and sometimes you get a group of students and the syllabus would work and for others it just would not work. I don't know what adjustments can be made.… I don't know what can be put in place to make us* [teachers] *see what can be done*. (Teacher 6, Focus Group II)

At this stage in the implementation process of this science curriculum innovation, what other things, in addition to the training and the re-orientation of the teachers to the curriculum recommended by the teachers, can be put in place to "make [science teachers] see what can be done"? Probably the single most important "other thing" that should be done is to intensify the facilitation process. This would mean that the agency that is responsible for coordinating the implementation efforts needs to restructure the system that is now in place in these schools to provide support for the curriculum implementation processes.

One possible new structure would be one in which the heads of science departments, curriculum supervisors, and, to a lesser extent, school principals would become even more central to the implementation process. The justification for this new structure is that because the general affectivity levels and the behavioural characteristics of the mechanical user of any new innovation are unique, a unique kind of facilitator and facilitation is needed to help in moving the mechanical user of an innovation to higher levels of use (Hall & Hord, 2001). Hall and Hord describe what the ideal traits and tasks of such a facilitator might be. For example, such a facilitator "must be willing to do all sorts of seemingly low-level, nitty-gritty tasks to help teachers achieve short-term success in use" (p. 84). Furthermore, they must be willing to offer teachers short-term tips, must be prepared and capable of doing such things as "publish[ing] newsletters and establish[ing] telephone hotlines to answer mechanical questions as they arise" (p. 84). Hence, curriculum supervisors and science department heads will have to be re-oriented to take on these new roles if they are to become effective facilitators of the curriculum implementation process.

To be effective, these facilitators will have to help the teachers with many new tasks. For example, they will have to help the implementing teachers with finding and organizing the SEMP science materials for use, and with scheduling time to plan while they manage their classrooms and

students. They will also have to model for the implementing teachers how to use the SEMP science materials effectively in the classroom. Furthermore, they will have to be prepared to co-plan with the implementing teacher, co-teach or demonstrate teaching in the implementing teacher's classroom, bring in substitute materials when glitches occur, and even be prepared to run and fetch what is needed should such occasions arise. Being prepared to become engaged in tasks such as these is what Hall and Hord (2001) mean when they say that the persons charged with facilitating the mechanical user of an innovation must be willing and able to do all sorts of "low-level, nitty-gritty tasks" (p. 84). Hence, another recommendation is that a structure of support be put in place that would involve facilitators with the kinds of traits described.

In conclusion, it is fair to say that these science teachers perceive the new science curriculum as being better suited to help to meet the national human development needs of the country than the old general science curriculum it replaced. However, most science teachers still have some concerns about the innovation. Seen through the CBAM lenses of stages of concern, the teachers' nine articulated concerns could best be characterized as being at the relatively high consequence levels of intensity. This means that, generally, these teachers have given considerable thought to the new initiative.

Though the teachers' reflections on the SEMP science curriculum innovation appear to be at a commendably high level, there does not appear to be a correspondingly high level of use of the innovation in their science classrooms. The level of use, at best, can be characterized as being mechanical. In mechanically using the curriculum in their classrooms, the teachers' efforts are mostly focused on short-term, day-to-day use, spending little time on connecting the individual daily science lessons to the "big science ideas" or on the long-term impact their teaching is having on students achieving the strategic aims, goals, and competencies the curriculum is endeavouring to engender in all students.

In conclusion, it must be noted that data from such a small sample (24 teachers) does limit the generalizability of these findings. Furthermore, due to the deficits in the scope of this research, which resulted in such a small sample size and other limitations that ensued, the findings have to be considered tentative. Substantial variability in the science teachers SoC and LoU remain unexplained by the current synthesis, indicating the need for further study. Despite this however, the study does suggest consistently that, at this stage of the implementation process, the following are needed to move the SEMP science curriculum innovation

forward: more appropriate customized teacher training, a reorientation of the science teachers to the curriculum, and facilitation and support for the mechanical use-type teacher.

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FACTORS IMPACTING ON STUDENT LEARNING: A Preliminary Look at the National Test of Trinidad and Tobago

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National assessments of student achievement in the basic skills or curricular domains of reading, writing, mathematics, and science are conducted in many countries with the aim of improving the quality of education. This paper presents an overview of the findings from a study conducted by a consortium of research staff from the Ministry of Education in Trinidad and Tobago, and university researchers from The University of the West Indies in Trinidad and Tobago and the University of Victoria in Canada on data from such a national assessment programme in Trinidad and Tobago. Preliminary statistical analyses were conducted on data generated by the 2006 administration of the National Test, which included not only the administration of achievement tests in Language Arts and Mathematics, but also the administration of questionnaires to students, parents, teachers, and principals. The findings from this preliminary study suggest that student and parent traits and perceptions are substantially related to student achievement in the foundational skills of language arts and mathematics as measured by the National Test.

Introduction

Many nations conduct annual assessment of student achievement in the basic skills or curricular domains of reading, writing, mathematics, and science. The programmes take various forms—some being focused on accountability of schools and teachers for student performance (such as the *No Child Left Behind* initiative in the United States); others having a focus on curricular reform based on the evidence generated by the assessment programme (this form requires some form of national or centralized curriculum). Regardless of specific focus and format, the assessment programmes have the aim of improving the quality of education as indexed by the achievement of students in the basic skills and competencies of schooling.

However, the ways in which testing and test results are related to system-level characteristics such as educational quality are not well understood. Factors in addition to curriculum and instruction—such as

student characteristics on entry, teacher and school traits, and home and community characteristics—have been shown to be significantly related to student achievement scores, and these relationships vary from one grade to another, one school to another, and one subject area to another (Anderson et al., 2006; Fitz-Gibbon, 1998; Ma, 2001; Mandeville & Anderson 1987; Rumberger, 1995). There has been much research conducted on international and national assessment datasets, yielding a wealth of information about patterns of student and school characteristics: the *Programme of International Student Assessment* (Fuchs & Woessmann, 2004; Willms, 2004); the *School Achievement Indicators Program* of Canada (Anderson et al., 2006); the *Primer Estudio Internacional Comparitivo* of Latin American nations (Willms & Somers, 2001); the US *National Education Longitudinal Study* (Dumais, 202); the US *National Longitudinal Survey of Adolescent Health* (Watt, 2003); and state level datasets in Australia (Hill & Crévola, 1999), Canada (Anderson, 2002), and the US (Reeves & Bylund, 2005). This paper reports on related work done in one Caribbean country, Trinidad and Tobago.

Trinidad and Tobago has had a long history of the national assessment of student achievement, which spans the period from colonial times when examinations were controlled by British examination bodies to the present time when national assessments are developed and administered mainly by the regional Caribbean Examinations Council (CXC) and the Ministry of Education (MOE). The MOE administers three major national examinations set by CXC for students at the primary and secondary levels as follows:

- The Secondary Entrance Assessment (SEA), which is used to facilitate the placement of students in secondary schools throughout Trinidad and Tobago, and which is comprised of three papers in *Creative Writing, Mathematics,* and *Language Arts*
- The Caribbean Secondary Education Certificate (CSEC) examinations, which certify the successful completion of 5 years of secondary education in a number of subjects
- The Caribbean Advanced Proficiency Examinations (CAPE), which are used to assess a student's academic achievement at the end of each of the 6^{th} and 7^{th} years of secondary level education, and which cater for students who wish to continue their studies at tertiary level institutions

In addition, the MOE, through its Division of Educational Research and Evaluation (DERE), develops and administers two major assessment

programmes—the National Certificate of Secondary Education (NCSE), which is designed to assess the academic performance of students who have completed three years of secondary schooling, and the National Test. The latter, which is intended to generate information for decision making at the school, district, and national levels and to track students' progress through school, is the focus of this article.

The National Test is a relatively recent annual standardized assessment programme for primary students in Standards 1 and 3 (who are approximately 7 and 9 years old, respectively), covering the subjects of Language Arts and Mathematics. Beginning in 2008, the test expanded its focus to include students in Standards 2 and 4 (ages 8 and 10 years, respectively) and its curricular coverage to Science and Social Studies.

Specifically the objectives of The National Test are to:

- gather information for decision making at the school, district, and national levels;
- identify areas of the system that require further investigation;
- identify national norms;
- compare students' performance by school and educational district;
- track student progress through school. (Trinidad and Tobago. Ministry of Education [MOE], 2005, p. 1)

Since 2004, formal reports of the results of the analysis of the National Test data have been prepared and distributed to schools. School and district means for Language Arts and Mathematics for each level are reported. Student performance by gender is also included. Further, the MOE has stated that it is expected that teachers and administrators at the school and district levels will work together to interpret the results of the National Test, and to devise strategies that will build upon strengths and reduce deficiencies at the school and classroom levels. Accordingly, the Chief Education Officer states in the foreword to the 2005 National Test report:

> I recommend that principals widely discuss the national test report and the school report with staff and parents. All divisions of the Ministry of Education including, School Supervision, Curriculum Development, Educational Research and Evaluation and Student Support Services are committed to assisting schools in raising the level of student performance and are therefore available to all principals. (MOE, p. i)

This paper presents an overview of the findings from the preliminary analyses conducted on data generated by the National Test administration of 2006, which included not only achievement tests in Language Arts and Mathematics, but also the administration of questionnaires to students, parents, teachers, and principals. The questionnaires were designed to generate information about the school-related behaviours, attitudes, and perceptions that could have significant relationships to student achievement, thus providing the opportunity to conduct research to explore the student, home, and school correlates of learning outcomes. This research was conducted by a consortium of research staff from the MOE and university researchers from The University of the West Indies (UWI) in Trinidad and Tobago and the University of Victoria in Canada.

The research consortium works to support the objectives of the National Test programme by exploring the relationships between student achievement and the traits of schools, the classroom, the home, teachers, and the student. The primary purpose of identifying significant correlates of student learning, and collecting and analysing the data is to describe, predict, and ultimately influence educational processes and outcomes. The development of models of variables that serve as correlates of student learning should facilitate better and deeper understanding of student and school performance, and lead to better informed policy initiatives and educational programmes (Raudenbush & Willms, 1991; Willms & Kerckhoff, 1995). This is directly related to the MOE's strategic research directions in the area of learning outcomes, particularly in understanding and evaluating the achievement of students in the core areas of Language Arts, Mathematics, and Science in relation to the contextual characteristics of schooling. The research focus of the consortium is based on the belief that a necessary step toward addressing these issues within a policy framework involves assembling, organizing, and analysing educational indicator data in ways that identify and incorporate linkages among variables from students, schools, and the home. An initial challenge is to access, analyse, and interpret the information in meaningful ways that will inform our understandings of schools and educational outcomes—and our initial work to meet this challenge is the focus of this paper.

The Context

In the Republic of Trinidad and Tobago, there are two main categories of primary schools—public and private—located within eight educational districts. The two categories give rise to three types of primary schools.

The public schools comprise the government primary schools and the denominational primary schools. In this report, the government primary schools are referred to as Type 1 schools, the denominational primary schools as Type 2 schools, and the private primary schools as Type 3 schools. The schools use the National Curriculum document and prepare their students for the National Test in Standards 1 to 4, and for the SEA at the end of Standard 5.

The SEA, which started in 2001, is a high-stakes test, which is used to place students into the secondary system. The SEA replaced the Common Entrance Examination (CEE), which began in 1961. These tests are described as high-stakes because the demand for school places in the older, more established secondary schools, which are perceived by the public as "prestige" schools, is greater than the supply. Consequently, there is intense competition among students for the few available places. As with the predecessor CEE, the results of the SEA are published in the newspapers, and primary schools are often judged on the basis of their students' performance on the examination. Therefore, schools whose candidates gain places in the "prestigious" secondary schools are themselves perceived as "prestige" primary schools. In addition, the top 100 students receive special awards from the Government of the Republic of Trinidad and Tobago. That there are no rewards and sanctions based on the results of the National Test, which is held annually in the month of June, is likely related to the different purposes served by each test. While the SEA is a summative examination, the National Test can be described as formative in nature, with diagnosis and development as the intended outcomes. In the foreword to the 2005 report on the National Test, the Chief Education Officer states that: "the information on the National Test provides us with a base on which to build. We have an opportunity to focus on improving the identified areas of weakness, to improve quality in all aspects of teacher/student relationships…" (MOE, 2005, p. i).

Formal reporting of the results of the National Test began in 2004. In 2004, the data obtained were analysed to obtain descriptive statistics (means and standard deviations), which were used to compare performances among educational districts and also to compare performance on the basis of gender. The 2004 analysis pointed to differences in performance among the educational districts, with five of the eight educational districts performing below the national mean of 50.0. In addition, it was found that "in every single district, gender differences are larger in Language Arts than in Mathematics for both Standards 1 and 3" (MOE, 2004, p. iii). In 2005, the analysis was expanded to include differences among school types. In addition to the

previous general trends, the findings revealed that the private primary schools (Type 3) consistently outperformed the public primary schools, with the denominational primary performing significantly better than the government schools.

Having obtained a general sense of what was happening at the primary levels investigated, it was evident that further analysis of student achievement in relation to school type and other significant factors is now required. The purpose of this study was, therefore, to build on and deepen the analysis done in previous years by exploring the relationships between student achievement and the traits of schools, the classroom, the home, teachers, and the student.

The Data and Results

This study focused on the Language Arts and Mathematics tests administered to Standard 3 students in 2006. The Language Arts test assessed students' performance on seven dimensions—spelling, vocabulary, comprehension, study skills, creative writing, punctuation, parts of speech, and sentence structure. The Mathematics test tapped the areas of number, measurement and money, geometry, and statistics. Both tests were of the free response format.

A sample of 1,391 students, and their parents, teachers, and school principals was selected by the MOE to complete questionnaires to elicit their experiences, perceptions, and attitudes related to schooling. This dataset provided an opportunity for secondary data analysis (Anderson, Lin, Treagust, Ross, & Yore, 2007) and an analysis of student and parent data constitutes the focus of this paper.

The questionnaires were designed to obtain a range of background information, as well as information on a variety of factors that could impact on school performance. The student questionnaires were adapted from instrumentation developed by the Consortium on Chicago School Research (2000). In the Consortium's *User's Manual*, student surveys are described as follows:

> While the content between the elementary and high school surveys did differ somewhat, all students were asked about their academic experiences, including classroom activities, homework, and the behavior of other students. In addition to their academic experiences, students were also asked about issues of safety and discipline, their motivation and expectations for learning, the peer culture of the school, the community and their involvement in it, the degree to which their parents were

> involved in their education, supports for new students or students after absences, the summer school they attended in 1998, and their educational plans and aspirations. Background questions, such as whether English is the language spoken in the home, whether they were born in the United States, and questions about their parents' education. (p. 8)

The parent questionnaires were developed by the MOE (drawing on existing questionnaires) specifically for administration with the National Test. All questionnaire items (see Appendix A) were in a Likert selection format.

In Language Arts there were significant differences in the mean performance of female and male students (Table 1), whereas there were no significant differences between female and male students on Mathematics (it should be noted that the scores reported are raw scores that have not been transformed to the National Test scale with a mean of 50). School type showed significant differences on both Language and Mathematics, with Type 3 schools outperforming both Type 1 (effect sizes ≈ 1.0) and Type 2 schools (effect sizes ≈ 0.7) on both Language and Mathematics; and Type 2 schools outperforming Type 1 schools (effect sizes ≈ 0.3 on both Language and Mathematics). There were moderately strong correlations between Language and Mathematics achievement (0.77 overall), and these were relatively consistent across genders and across school types.

Although the original student questionnaires were ordered into subtest categories on the basis of response data from US students, it was considered prudent to re-analyse the response data from the Trinidad and Tobago students to empirically estimate the structure within this context. This also facilitated further analyses, and so item responses by both students and parents to each questionnaire were subjected to principal component analysis to reduce the number of variables to a more manageable set. The resulting solutions were rotated orthogonally to generate non-correlated factor scores, which were then used in the subsequent regression analyses. From the Student responses, nine factors were derived from a total of 59 items accounting for 42% of variance in the student items (Table 2); and from the Parent responses nine factors were derived from a total of 49 items accounting for 51% of the variance in the parent items (Table 3). Complete item listings and factor loadings for both Student and Parent questionnaire results are tabulated in Appendix A.

Table 1. Mean Results for National Test 2006 – Language and Mathematics

	n	Language Mean (SD)	Mathematics Mean (SD)	Correlation Language-Math
Total sample	1,391	26.11 (10.9)	26.39 (12.9)	0.77
Gender				
Female	696	28.54 (10.2)[a]	26.84 (12.5)[b]	0.77
Male	695	23.68 (11.0)	25.93 (13.4)	0.80
School type				
One	306	23.40 (10.9)[c.]	22.48 (12.2)[d.]	0.77
Two	999	26.30 (10.6)	26.87 (12.8)	0.76
Three	86	33.61 (10.5)	34.67 (12.4)	0.73

[a] Female-Male difference on Language is significant (p=0.000).

[b.] Female-Male difference on Mathematics is non-significant.

[c.] Type differences are significant on Language – all pairs.

[d.] Type differences are significant on Mathematics – all pairs.

The Student and Parent factors were then regressed on both Language achievement and Mathematics achievement to explore the relationships of student and home characteristics to achievement. Initially, Student factors were regressed on the achievement measures separately, followed by regressions using the Parent factors—these results are reported in Appendix B (Tables A to D). However, to achieve more parsimonious reporting in this paper the final regressions were run on the combined Student and Parent factors (Tables 4 and 5) with no loss of overall pattern of relationships. It should be noted that a preliminary regression was run with the Socio-Economic Index derived from the Parent responses to evaluate its influence on achievement results. Since the R^2 was relatively low—0.038 for Language and 0.028 for Mathematics— it was decided not to condition the analyses by SEI and simply include SEI as one the predictors in the regression. It should also be noted that the mean SEI varied substantially across school type, with the parents in Type 1 schools yielding a mean of 0.05, those of Type 2 schools a mean SEI of -0.11, and those in Type 3 schools a mean of 1.14. Further, the correlation between SEI and achievement measures, although low, is much higher for Type 3 schools (r=0.28) than for either Type 1 schools (r=0.13) or Type 2 schools (r=0.15).

Table 2. Student Factors

Teacher Engagement	
Items include:	My teacher praises my effort when I work hard. My teacher expects me to do my best all of the time. My teacher really listens to what I have to say.
Reading Self-concept	
Items include:	I am a __(poor/fair/good/very good) ___ reader. My friends think that I am a __(poor/fair/good/very good) ___reader. I read _(a lot better than /a little bit better than/about the same/not as well as)__ my friends.
View of Reading	
Items include	Reading a book is something I _(never/not very often/a few times/always) like to do. People who read a lot are _(very interesting/interesting/ not very interesting/boring)_. Knowing how to read well is _(not important/a little important/important/very important)__.
Parent Involvement	
Items include:	How often does a parent or adult living with you wait for you at home after school? How often does a parent or adult living with you make sure you are prepared for school? How often does a parent or adult living with you praise you for doing well at school?
Teacher Care	
Items are:	My teacher cares if I don't do my work in class. My teacher cares if I get low scores in class.
Attitude to School	
Items include:	I often count the minutes until the class ends. I'm bored in school. I wish I did not have to go to school.
Writing at Home	
Items include:	How often did you write in a private diary or journal outside of school? How often did you write stories or letters for fun outside of school? How often did you write e-mails to your friends or family?
Writing Activity	
Items include:	For this school year, how often did you write a story? For this year, how often did you write a letter? How often do you organize your story or letter before you write?
Reading Engagement	
Items include:	I worry about what other children think about my reading. I would like for my teacher to read books out aloud to the class. I am glad to go back to school after vacation.

Table 3. Parent Factors

Reading Encouragement	
Items include:	How often did you or someone else in your home listen to your child read aloud? How often did you or someone else in your home encourage your child to read? How often did you or someone else in your home encourage your child to write?
Reading Readiness	
Items include:	When your child began Primary School how well could he /she read some words? When your child began Primary School how well could he /she read sentences? When your child began Primary School how well could he /she write some words?
Socio-Economic Index	
Items include:	About how many books are there in your home? What is the highest level of education completed by the child's father? What kind of work does the child's father do? Compared with other families, how well off do you think your family is financially?
Reading at Home	
Items include:	When you are at home, how often do you read for work? When you are at home, how often do you read for enjoyment? When you are at home, how often do you read to get news?
School Engagement	
Items are:	My child's school includes me in my child's education. My child's school cares about my child's progress in school. My child's school does a good job in helping my child become better in reading.
Early Reading	
Items include:	Before your child began Primary School, how often did you read a book to him or her? Before your child began Primary School, how often did you play with alphabet toys, etc. with him or her? Before your child began Primary School, how often did you talk about things that you had read with him or her?
Parent Reading Attitude	
Items are:	I read only if I have to. I read only if I need information. In a typical week, how much time do you usually spend reading for yourself at home?

Table 3. (continued)

Pre-School		
	Items are:	Did your child attend pre-school? How long was your child in pre-school? How old was your child when he/she began Primary School?
Parent Reading Activity		
	Items are:	I like talking about books with other people. I like to spend my spare time reading. Reading is an important activity in my home.

The results of the regression of Student and Parent factors on Language achievement accounted for 41% of the variance in the student Language scores for Standard 3 on the National Test (Table 4). The extent to which students view themselves as competent readers (Reading Self Concept: $\beta = 0.29$) and have a positive focus towards school and reading (Reading Engagement: $\beta = 0.28$) are positively related to achievement in Language. Student perceptions of teacher encouragement, attention, and expectations are also positively related to higher levels of Language achievement (Teacher Engagement: $\beta = 0.19$). Further, student perceptions of teachers caring about their school performance was related to Language achievement (Teacher Cares: $\beta = 0.08$). The extent to which students perceive their parents as involved with their school-related activities such as homework, school focus, and preparation is positively related to Language achievement (Parent Involvement: $\beta = 0.10$). Student attitude towards attending school in general was related to Language achievement—students indicating negative attitude tended to lower levels of achievement (Attitude to School: $\beta = 0.16$). The amount of writing activities that students reported to have engaged in was related to Language achievement (Writing Activity: $\beta = 0.10$). The extent to which students reported that they liked reading and read outside of school was not related to Language achievement (View of Reading: $\beta =$ n.s.), nor was the extent of student-reported writing activities outside of school (Writing at Home: $\beta =$ n.s.).

In relation to Language achievement, six of the Parent factors had a significant relationship. The extent to which students could read and write before entry to school, as reported by parents, was related to Language achievement (Reading Readiness: $\beta = 0.21$). A related factor—the extent of reading-based activities at home before entry to primary school—was positively related to Language achievement (Early Reading: $\beta = 0.06$). Attendance in a pre-school environment was also

related to achievement in Language (Pre-School: β = 0.06). The reported attitude of parents towards reading was related to the child's Language achievement (Parent Reading Attitude: β = 0.07). The parent-reported levels of education, employment, and financial status were related to Language achievement (Socio-Economic Index: β = 0.13). Somewhat counterintuitively, the extent to which parents reported that they or another adult in the home listened to or talked with the child about their reading or read with the child (Reading Encouragement) did not have a significant relationship to Language achievement. The extent of reading reported by parents (Reading at Home) and the kinds of reading they did (Parent Reading Activity) were not significantly related to Language achievement of these students.

Table 4. Regression of Student and Parent Factors on LANGUAGE

Variable	B	SE_B	β	p
Constant	26.19	0.23	-	.000
Student factors				
Teacher engagement	2.06	0.23	0.19	.000
Reading self-concept	3.10	0.24	0.29	.000
Parent involvement	1.13	0.23	0.10	.000
Teacher cares	0.87	0.23	0.08	.000
Attitude to school	1.77	0.23	0.16	.000
Writing activity	1.07	0.23	0.10	.000
Reading engagement	3.00	0.24	0.28	.000
Parent factors				
Reading readiness	2.26	0.23	0.21	.000
Socio-economic index	1.41	0.23	0.13	.000
School engagement	1.03	0.23	0.10	.000
Early reading	0.60	0.23	0.06	.009
Parent reading attitude	0.78	0.23	0.07	.001
Pre-school	0.69	0.23	0.06	.003

$R^2 = 0.41$

The regression of the Student and Parent factors on Mathematics achievement generated similar results (Table 5) as those from the Language analysis. Overall, 31% of the variance in Mathematics achievement was accounted for by the Student and Parent factors. The significant predictors are also similar. The Student factors related to Mathematics achievement were Teacher Engagement (β=0.19); Reading

self-concept (β=0.20); Parent involvement (β=0.10); Attitude to school (β=0.13); Writing activity (β=0.07); Writing at home (β=0.10); and Reading engagement (β=0.28). The Parent factors significantly related to Mathematics achievement were Reading encouragement (β=0.06); Socio-economic index (β=0.11); School engagement (β=0.08); Parent reading attitude (β=0.07); and Pre-school (β=0.05). Three differences to the Language results are the non-significance of the Parent factors of Reading readiness and Early reading, and the non-significance of the Student factor related to student perceptions of his/her Teacher caring.

In order to further explore these results, student and parent scores were aggregated at the school level along with achievement results to generate mean scores for each school included in the analyses. It must be noted that the data set was reduced from 89 schools to a total of 56 schools—only those schools with at least 10 students in the data set were included in the analysis. The regression of student and parent factors at the school level shows strong linkage to achievement, with an R^2 of 0.71 for mean school achievement in Language (Table 6) and 0.62 in Mathematics (Table 7). It should be noted that at the school level, the socio-economic index was not a significant predictor of school level performance in either Language or Mathematics achievement. However, both students' reading engagement and writing activities in school were significantly predictive of school level achievement—as were parent-reported averages of school engagement and reading readiness, and reported levels of pre-school attendance.

The analyses of school-level results demonstrate strong relationships between school-mean achievement in Language Arts and Mathematics, and student and parent traits and perceptions. However, these are trends in the data and do not predetermine achievement status of a specific school. For example, if we look at the mean results reported in Table 1, we see that Type 3 schools generally outperform Type 1 schools by almost one standard deviation (a 9.8 difference in mean scores) and Type 2 schools by 7.1 points. However, with a consideration of the top five schools in Language achievement it is found that one of the top schools is in fact a Type 1 school, which the general results would not suggest to be the case. So we find that although there is a large effect size in regard to school type in relation to Language achievement, at least one school does not conform to this trend.

Table 5. Regression of Student and Parent Factors on MATHEMATICS

Variable	B	SE_B	β	p
Constant	26.49	0.29	-	.000
Student factors				
Teacher engagement	2.50	0.30	0.19	.000
Reading self-concept	2.61	0.30	0.20	.000
Parent involvement	1.35	0.30	0.10	.000
Attitude to school	1.60	0.29	0.13	.000
Writing activity	1.29	0.29	0.10	.000
Writing at home	0.87	0.30	0.07	.003
Reading engagement	3.68	0.30	0.28	.000
Parent factors				
Reading encouragement	0.68	0.26	0.06	.010
Socio-economic index	1.52	0.30	0.11	.000
School engagement	0.97	0.30	0.08	.001
Parent reading attitude	0.95	0.30	0.07	.001
Pre-school	0.67	0.30	0.05	.024

$R^2 = 0.31$

Table 6. Regression of School Average Scores of Student and Parent Factors on LANGUAGE Achievement

Variable	B	SE_B	β	p
Constant	26.31	0.53	-	.000
Student factors				
Writing activity	4.85	1.02	0.38	.000
Reading engagement	5.75	1.26	0.40	.000
Parent factors				
Reading readiness	8.91	1.96	0.40	.000
School engagement	2.89	1.45	0.16	.050
Pre-school	5.75	1.79	0.26	.002

$R^2 = 0.71$

Table 7. Regression of School Average Scores of Student and Parent Factors on MATHEMATICS Achievement

Variable	B	SE_B	β	p
Constant	26.43	0.74	-	.000
Student factors				
Writing activity	4.14	1.43	0.27	.006
Reading engagement	7.14	1.82	0.41	.000
Parent factors				
Reading readiness	6.67	2.72	0.25	.018
School engagement	4.32	2.03	0.19	.038
Early reading	6.54	2.64	0.23	.017
Pre-school	5.99	2.49	0.22	.020

$R^2 = 0.62$

Discussion

It is evident that student and parent traits and perceptions are substantially related to student achievement in the foundational skills of Language Arts and Mathematics as measured by the National Test. These skills are likely to be fundamental to academic performance in the long term. So by knowing something about a student's reading readiness, self-concept, reading engagement, and perceptions of teacher engagement we may be better able to predict success in school. And this can lead to informed policy initiatives and instructional enhancements being developed and implemented to improve student achievement and overall school performance. By knowing about relationships of parent encouragement and attention to the academic performance of their children, schools could encourage parents to attend to their child's reading and other school-related activities, and even encourage positive parental attitudes towards reading in general. Through the development of better communications between schools and parents these attitudes and activities could be enhanced—leading to improved achievement by the students.

Given that these findings were obtained for students at a very early stage in their school career (Standard 3), it is possible that a significant impact can be made on student achievement in the long term if attention is paid to the factors identified above as contributing to student achievement. This enhanced focus on schooling could also lead to better

perceptions of the value of education in later life and decrease the current levels of dropout, particularly by male students in Trinidad and Tobago who have relatively high levels of droupout as reported in a recent study (George, 2006).

It is to be noted that many of these student and parent factors cross over from Language to Mathematics achievement, suggesting that they have a general relationship to academic performance. Consequently, by developing school-based initiatives to address these factors—for example, student attitudes towards schools, student perceptions of teacher caring, or parental encouragement of student reading—there could be enhanced achievement by students and higher levels of school performance in Language Arts and Mathematics.

It is also shown that a factor such as the socio-economic index is significantly related to achievement, although family economic, educational, and vocational levels are not accessible to educational policy intervention. However, in future rounds of analyses we will be conducting multi-level analysis using teacher and school (principal) level perceptions, attitudes, and traits to investigate traits that could modulate the effects of SEI on student achievement, and to identify those teachers or schools that enhance equity of achievement across students from variant socio-economic backgrounds. By identifying these teachers and schools, we should be able to learn the kinds of instructional and organizational approaches that could be generalized across schools in Trinidad and Tobago.

In suggesting the need for the development of evidence-based policy and the implementation of educational programmes and approaches, we are keenly aware of the need to monitor and evaluate the effects of any such developments. The current research and the results for the National Test could be used as a baseline measure of educational performance in Trinidad and Tobago. The nature and levels of future achievement, student and parental factors, and school traits could then be measured, analysed, and compared to monitor educational performance in Trinidad and Tobago schools, and to further our understandings of student achievement and school performance.

Some initial steps that could be taken based on our results include the development of initiatives that would target the manner in which students view their schooling environment, since these perceptions are consistently related to achievement. It would be worthwhile to investigate the extent to which these relationships are directional, in the sense that enhanced perceptions result in enhanced achievement as opposed to the conjecture that students with higher levels of achievement tend to develop more positive perceptions of themselves and their school

environment. Another initiative could focus on teacher caring and encouragement, which is positively related to student achievement—creating professional development programmes for teachers to enhance their caring and encouraging behaviours in the classroom, aimed particularly at schools that have been identified as having lower levels of both student achievement and student perceptions of teacher caring and encouragement. Our analyses suggest this could lead to higher levels of student and school achievement. A third initiative based on the results of this research would be aimed at parents—to encourage parental engagement in their children's schooling and achievement.

In summary, many of the factors significantly related to student achievement in this study have a fair degree of commonality, in that they are centred on the attention given by students and parents to what could be termed the general elements of schooling: reading engagement; student self-regard for their own abilities (reading readiness in this case); parental encouragement of student engagement with their studies; student perceptions of teacher caring and encouragement; and parental perceptions of feeling welcomed to and engaged with the school. When aggregated at the school level to yield school traits, school level performance is also strongly related to student and parental factors. These factors could be viewed as a generalized positive academic focus—awareness and attention to schooling by students, parents, and teachers. Perhaps steps could be taken that could help to build a positive influence on student achievement—help students attend more closely to school-based learning activities and environmental elements, promoting teacher behaviours that are likely to be viewed by students as caring and encouraging, and have the school consciously take steps to further parental perceptions of participation.

Future Directions

The adoption of an evidence-based based approach to policy development and curricular implementation is a positive step toward better education in Trinidad and Tobago: higher achievement, more equitable schooling, and more enhanced access and engagement by students, teachers, and parents. These are the intended outcomes. However, achieving these outcomes would require attention to at least three issues: the development of assessment literacy in the education community; the nature of the research conducted by the consortium as we move forward; and the expanded role of the School of Education (SOE), UWI, St. Augustine. Each of these issues will be discussed below.

The educational system of Trinidad and Tobago has made substantial investments in the production and collection of achievement information—the expansion of the National Test from 2 primary school levels to 5 is one index of this interest—and there should be concomitant attention paid to the wise use of the results of these investments. The use of these data to improve the quality of schools demands a high level and broad presence of assessment knowledge or literacy. Assessment literacy can be defined as the assessment-related knowledge, skills, and competencies of educators. Stiggins (2001) states: "assessment literacy comprises two skills: first is the ability to gather dependable and quality information about student achievement; second is the ability to use that information effectively to maximize student achievement" (p. 21). So that not only is the development and administration of high-quality achievement tests a part of assessment literacy, but also competencies such as the communication of results (report cards, school and system level reports, student grades and scores); understanding how to use assessment information to maximize student motivation and learning by involving students as full partners in assessment, record keeping, and communication; and how to effectively communicate with parents so they better understand the meanings and limitations of assessment information.

However, more recently, other formal attempts to conceptualize the term *assessment literacy* have widened the group of stakeholders for whom assessment literacy is applicable. For example, in addition to teachers, Orrell (2005) refers to the need for assessment literacy at various levels, including community stakeholders, parents, students, and student associations. Further, Newfields (2006) states that assessment literacy is not a single phenomenon "with some unitary sort of meaning…it means different things to different populations" (p. 1).

The desire for increased participation by, and dialogue among, the numerous stakeholders directly and indirectly involved in the process of education requires shared understandings around assessment issues. Within the context of Trinidad and Tobago, the programme for assessment literacy should be developed to help stakeholders to come to shared understandings about current practices, as well as the history of assessment in the country; the complex nature of assessment, for example, the various purposes of assessment, various assessment concepts, such as reliability and validity of tests; and the specific findings of annual National Tests and the interpretation of these findings. However, any programme that is developed to address the assessment literacy of the various stakeholders—teachers, parents, business, and the media, for example, must be cognizant of the many possible entry points

in relation to knowledge about assessment issues and concepts and, hence, of the various possible outcomes. Accordingly, the programme devised should include clear paths to numerous outcomes with seamless movement from one point to another.

Secondly, the research reported here is based on a statistical analysis of assessment data and student, parent, and educator questionnaire responses, which generates general patterns of relationships among student achievement, behaviours, attitudes, and perceptions. As we have pointed out, there are certainly specific situations in which the patterns do not hold. The meanings, reasons, and motivations underlying the relationships are not revealed by the analyses conducted here. To explore these areas, which are likely to yield valuable insight into student and school performance, will require research utilizing alternate methodologies. Further research should expand our repertoire of methodologies leading to a more comprehensive programme of research that would include qualitative studies and adopt mixed methods designs (see Brown, 2005; Gorard, 2002; Smyth, 2006; Trochim, 2006). Over time, with a broad spectrum of research approaches it is likely that the consortium would develop a more nuanced and holistic understanding of education, schooling, and schools, which should in turn lead to more insightful, meaningful, and realistic policy recommendations.

Finally, the SOE, as a member of the research consortium, should not restrict its role to participation in the research activities, but should also collaborate with stakeholders to disseminate the findings of the research, which would be tailored to the audience to which it is presented. This would require publications that are not only appropriate for academic journals, but public reports, presentations, and discussions that can be understood by the various groups of stakeholders without compromising validity and meaning of the main ideas being communicated.

What we (the research consortium) have done is a good start, but we suggest that the initiative of using empirical evidence to help better understand, and, over time, improve education within schools in Trinidad and Tobago is far from over.

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Appendix A

Factors from Student & Parent Questionnaires

Student Item Factors

FACTOR 1		**Teacher Engagement**
ITEM5A	0.419	My teacher encourages me to do extra work when I don't understand something?
ITEM5B	0.543	My teacher praises my effort when I work hard.
ITEM5E	0.702	My teacher expects me to do my best all of the time
ITEM5F	0.610	My teacher expects me to complete my homework every night.
ITEM5G	0.680	My teacher thinks that it is important that I do well in class
ITEM6D	0.452	I usually look forward to the class every day.
ITEM6E	0.512	I work hard to do my best in the class
ITEM7A	0.557	My teacher really listens to what I have to say
ITEM7B	0.665	My teacher helps me to improve if I am behind.
ITEM7C	0.629	My teacher notices if I have trouble learning something
ITEM7D	0.613	My teacher is willing to give extra help on schoolwork if I need it
ITEM7E	0.734	My teacher believes that I can do well in school
ITEM8A	0.387	I am glad to go back to school after vacation
FACTOR 2		**Reading Self-concept**
ITEM1A	-0.793	My friends think that I am a ___reader
ITEM1B	-0.695	I read ___ my friends
ITEM1C	-0.547	When I come to a word I don't know, I can ___ figure it out
ITEM1D	-0.650	When I am reading by myself, I understand____ I read
ITEM1E	0.836	I am a ___reader
ITEM1G	0.480	When my teacher asks me a question about what I read, I __ think of an answer.
ITEM1I	0.307	When I am in a group talking about stories I ___ talk about my ideas
ITEM1J	0.764	When I read out loud I am ___ reader
FACTOR 3		**View of Reading**
ITEM2A	0.488	Reading a book is something I ___like to do
ITEM2B	-0.549	My best friend thinks that reading is __.
ITEM2C	0.350	I tell my best friends about good books I read
ITEM2D	-0.565	People who read a lot are ___.
ITEM2E	-0.531	I think a Library is ___ place to spend time

ITEM2F	0.386	Knowing how to read will is __.
ITEM2G	0.615	I think reading is ___ way to spend time
ITEM2H	0.461	When I grow up I will spend ___ of my time reading
ITEM2I	-0.341	I would like for my teacher to read books out aloud to the class
ITEM2J	-0.571	When someone gives me a book as a present I feel __.

FACTOR 4 **Parent Involvement**

ITEM9A	0.422	How often does a parent or adult, living with you, wait for you at home after school?
ITEM9B	0.561	How often do a parent or adult living with you, make sure you are prepared for school?
ITEM9C	0.548	How often does a parent or adult living with you, make sure you get to school on time?
ITEM9D	0.430	How often does a parent or adult living with you, is somewhere that you can get in touch with any time you need to?
ITEM10A	0.514	How often does a parent or adult living with you help you with your homework?
ITEM10B	0.675	How often does a parent or adult living with you check to see if you have done your homework?
ITEM10C	0.565	How often does a parent or adult living with you praise you for doing well at school?
ITEM10D	0.556	How often does a parent or adult living with you encourage you to work hard at school?

FACTOR 5 **Teacher Care**

ITEM5C	0.806	My teacher cares if I don't do my work in class.
ITEM5D	0.832	My teacher cares if I get low scores in class.

FACTOR 6 **Attitude to School**

ITEM6A	-0.559	I often count the minutes until the class ends.
ITEM6C	-0.662	I am usually bored with what goes on in the class.
ITEM8B	-0.697	I 'm bored in school.
ITEM8D	-0.574	I wish I did not have to go to school.
ITEM8E	-0.468	I wish I could go to a different school.

FACTOR 7 **Writing at home**

ITEM4A	0.496	How often did you write in a private diary or journal outside of school?
ITEM4B	0.465	How often did you write stories or letters for fun outside of school?
ITEM4C	0.692	How often did you write e-mails to your friends or family?

ITEM4D	0.704	How often do you use a computer at home to make changes to the story or letter that you are writing at home?
ITEM4E	0.347	When you write at home how often did your parent talk to you about what you were writing?

FACTOR 8 **Writing Activity**

ITEM3A	0.634	For this school year how often did you write a story?
ITEM3B	0.658	For this year, how often did you write letter?
ITEM3C	0.367	How often do you organize your story or letter before you write (for example make an outline, draw a chart)?
ITEM3D	0.388	How often did you make changes to your story or letter to fix mistakes/ errors and improve it?
ITEM3E	0.405	How often did you work with other students in pairs or small groups to discuss and improve your story or letter?

FACTOR 9 **Reading Engagement**

ITEM1F	-0.561	I worry about what other children think about my reading
ITEM2I	-0.389	I would like for my teacher to read books out aloud to the class.
ITEM6B	0.447	I get so interested in my work, I did not want to stop..
ITEM8A	0.422	I am glad to go back to school after vacation.

Parent Item Factors

FACTOR 1 **Reading Encouragement**

ITEM7AP	0.565	How often did you or someone else in your home listen to your child read aloud?
ITEM7BP	0.476	How often did you or someone else in your home talk to your child about things we have done?
ITEM7CP	0.646	How often did you or someone else in your home talk with your child about what he/she is reading on his/her own?
ITEM7DP	0.471	How often did you or someone else in your home talk with your child about what I am reading (or what someone else in my home is reading?
ITEM7EP	0.638	How often did you or someone else in your home discuss your child's classroom reading work with him/her?
ITEM7FP	0.226	How often did you or someone else in your home go to the library or bookstore with your child?
ITEM7GP	0.728	How often did you or someone else in your home encourage your child to read?

ITEM7HP	0.709	How often did you or someone else in your home encourage your child to write?
FACTOR 2		**Reading Readiness**
ITEM6AP	0.705	When your child began Primary School how well could he /she recognise most of the letters of the alphabet?
ITEM6BP	0.810	When your child began Primary School how well could he /she read some words?
ITEM6CP	0.804	When your child began Primary School how well could he /she read sentences?
ITEM6DP	0.735	When your child began Primary School how well could he /she write letters of the alphabet?
ITEM6EP	0.783	When your child began Primary School how well could he /she write some words?
FACTOR 3		**Socio-Economic Index**
ITEM12P	0.441	About how many books are there in your home?
ITEM13mP	0.644	What is the highest level of education completed by the child's father, stepfather or male guardian?
ITEM13fP	0.640	What is the highest level of education completed by the child's mother, stepmother, or female guardian?
ITEM15mP	0.532	What kind of work does the child's father, stepfather or male guardian do for their main jobs?
ITEM15fP	0.610	What kind of work does the child's mother, stepmother or female guardian do for their main jobs?
IITEM16P	-0.492	Compared with other families, how well off do you think your family is financially
FACTOR 4		**Reading at Home**
ITEM10AP	0.557	When you are at home, how often do you read for work
ITEM10BP	0.553	When you are at home, how often do you read for enjoyment
ITEM10CP	0.483	When you are at home, how often do you read for to get news
ITEM10DP	0.635	When you are at home, how often do you read for my education/school
ITEM10EP	0.526	When you are at home, how often do you read for other reasons
FACTOR 5		**School Engagement**
ITEM8AP	0.772	My child's school includes me in my child's education
ITEM8CP	0.848	My child's school cares about my child's progress in school
ITEM8DP	0.798	My child's school does a good job in helping my child become better in reading

FACTOR 6		**Early Reading**
ITEM2AP	-0.639	Before your child began Primary School, how often did you or someone else in your home read a book to him or her?
ITEM2BP	-0.659	Before your child began Primary School, how often did you or someone else in your home tell stories to him or her?
ITEM2CP	-0.620	Before your child began Primary School, how often did you or someone else in your home sing songs with him or her?
ITEM2DP	-0.636	Before your child began Primary School, how often did you or someone else in your home play with alphabet toys etc. with him or her?
ITEM2EP	-0.515	Before your child began Primary School, how often did you or someone else in your home talk about things you had done with him or her?
ITEM2FP	-0.604	Before your child began Primary School, how often did you or someone else in your home talk about things what you had read with him or her?
ITEM2GP	-0.658	Before your child began Primary School, how often did you or someone else in your home play word games with him or her?
ITEM2HP	-0.675	Before your child began Primary School, how often did you or someone else in your home write letters or words with him or her?
ITEM2IP	-0.646	Before your child began Primary School, how often did you or someone else in your home read aloud signs and labels with him or her?
FACTOR 7		**Parent Reading Attitude**
ITEM9P	0.439	In a typical week, how much time do you usually spend reading for yourself at home, including books, magazines, newspapers and materials for work
ITEM11AP	0.778	I read only if I have to.
ITEM11DP	0.781	I read only if I need information.
FACTOR 8		**Pre-School**
ITEM3P	0.628	Did your child attend Pre-school?
ITEM4P	-0.366	How long was your child in pre-school?
ITEM5P	0.749	How old was your child when he/she began Primary School?
FACTOR 9		**Parent Reading Activity**
ITEM11BP	0.675	I like talking about books with other people.
ITEM11C P	0.654	I like to spend my spare time reading.
ITEM11EP	0.545	Reading is an important activity in my home.

Appendix B

Regression Results from Separate Analyses of Student & Parent Data

Table A. Regression of Student Factors on LANGUAGE

Variable	B	SE_B	β	p
Constant	26.12	0.24	-	.000
Teacher engagement	2.30	0.24	0.21	.000
Reading self-concept	3.91	0.24	0.36	.000
Parent involvement	1.38	0.24	0.13	.000
Teacher cares	1.12	0.24	0.10	.000
Attitude to school	1.92	0.24	0.18	.000
Writing activity	0.93	0.24	0.09	.000
Reading engagement	3.51	0.24	0.32	.000

$R^2 = 0.34$

Table B. Regression of Student Factors on MATHEMATICS

Variable	B	SE_B	β	p
Constant	26.40	0.30	-	.000
Teacher engagement	2.69	0.30	0.21	.000
Reading self-concept	3.28	0.30	0.25	.000
Parent involvement	1.53	0.30	0.12	.000
Attitude to school	1.76	0.30	0.14	.000
Writing activity	0.68	0.30	0.05	.024
Writing at home	1.10	0.30	0.09	.000
Reading engagement	4.22	0.30	0.33	.000

$R^2 = 0.26$

Table C. Regression of Parent Factors on LANGUAGE

Variable	B	SE_B	β	p
Constant	26.21	0.26	-	.000
Reading encouragement	0.68	0.26	0.06	.010
Reading readiness	3.44	0.26	0.32	.000
Socio-economic index	2.12	0.26	0.20	.000
Reading at home	0.53	0.26	0.05	.043
School engagement	1.29	0.26	0.12	.000
Early reading	1.39	0.26	0.13	.000
Parent reading attitude	1.47	0.26	0.14	.000
Pre-school	0.97	0.26	0.09	.000

$R^2 = 0.20$

Table D. Regression of Parent Factors on MATHEMATICS

Variable	B	SE_B	β	p
Constant	26.52	0.33	-	.000
Reading readiness	3.16	0.33	0.32	.000
Socio-economic index	2.15	0.33	0.17	.000
School engagement	1.26	0.33	0.10	.000
Early reading	1.15	0.33	0.09	.000
Parent reading attitude	1.60	0.33	0.12	.000
Pre-school	0.86	0.33	0.07	.009

$R^2 = 0.13$

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