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# Observations from secondary school classrooms in Trinidad and Tobago: Science teachers' use of analogies

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ABSTRACT: This study was undertaken to examine and interpret how science teachers in Trinidad and Tobago used analogies in their science teaching. A total of 30 lessons taught by five different teachers were observed and analysed using an interpretative research methodology to develop generalized observations. The findings revealed that in general science teachers used few analogies in their teaching and that the analogies used ranged from simple to technical. Interviews following the classroom observations revealed that the teachers were knowledgeable about analogy use in science teaching and about some of the benefits and challenges of using analogies to teach science. The research suggests that effective use of analogies in classroom science teaching is an area that needs attention from two perspectives: 1) development or acquisition of relevant analogies for use by teachers and 2) reorientation of teachers through professional training into a view of learners as constructors of knowledge instead of passive knowledge receptors.

KEY WORDS: analogies, use of analogy, science analogies

## INTRODUCTION AND LITERATURE

Over the past couple of decades or so, there has been an increased interest among science educators about teaching and learning in science with a view to transform students from knowledge receptors to constructors of knowledge (Mascolo, 2009; Fosnot & Perry, 2005). Several strategies and approaches have been explored to this end including the use of examples, analogies and models (Maharaj-Sharma, 2011; Ornek, 2008). Thematic research described by Wellington (2015) and used in explorative studies by Loughran, Mulhall and Berry (2008) as well as Minner, Levy and Century (2009) have provided a base which outlines how science teachers have used contemporary classroom approaches to achieve this transformation. This theoretical research base has provided the foundation from which further work in this area continues to emerge. Apart from the theoretical work,

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some recent experimental studies in science education for example by Dilder and Duzgun (2008) and Haglund (2013) highlight a growing interest in this area and document successes science teachers have achieved in this transformation effort.

The use of analogies in particular has been found to be very effective in prompting students to build understandings either through hands-on interactions with tangible resources (Richland, 2015) or by making conceptual links with familiar objects, scenarios or events (Hagkund, Jeppsson, & Andersson, 2012). Guerra-Ramos (2011), has described the many advantages and disadvantages associated with using analogies to teach science and has provided some suggestions for science teachers when deciding to use analogies in their classroom. The low frequency with which science teachers use analogies in their classroom however, continues to be a concern and Brown & Salter (2010) have suggested that the challenge for teachers might be linked either to their lack of confidence with the strategy or to a lack of knowledge about analogies in general and/or the choice of analogy for a particular use. In spite of the documented low frequency with which science teachers use analogies in their everyday teaching, when interviewed in work by Treagust, Duit, Lindauer and Joslinn (1989), and later in a study by Glynn (2007), science teachers were of the view that they used analogies often in their teaching and that in these instances they had used the analogies appropriately.

The literature abounds with definitions of the term analogy but in this work, Harrison and Coll's (2008) interpretation that an analogy is a comparison of certain similarities between objects/ideas/events which are otherwise unlike will be adopted. An analogy consists of two components: the **analogue** and the **target**. The **analogue**; the familiar situation or object; provides a model through which students can make assumptions and inferences about the unfamiliar or new situation or object, called the **target**. For example, one analogy of the structure of an atom; the **target**; is the arrangement of planets orbiting the sun; the **analogue.** Tregidgo and Ratcliffe (2000) speak about two types of analogies – simple analogies and technical or complex analogies. A simple analogy compares and examines similarities between the analogue and the target usually by looking at physical structure with little or no emphasis on process, function or behavior. A complex analogy in addition to comparing physical structure or appearance, compares aspects of process or function and behavior and even links structure and function between the analogue and the target. For example, the comparison between parts of the human eye (target) and the analogous parts of a camera (analogue) is an example of a simple analogy, but the same example can be converted into a complex analogy if the function of the various parts of the human eye are compared to the function of the parts of a camera to show similarities in both structure and function. The lens for example is a feature of both the human eye and of the camera,

and there are similarities in both the analogue and the target in terms of location of the lens, focusing function of the lens and even possible defects of the lens.

In an experimental study which explored primary school students' understandings of rocks, Blake (2004), discussed the use of a series of simple analogies in the classroom to describe and classify rocks. He reported that not only did the experimental group score significantly higher than the control group on tests in this topic but that students from the experimental group were able to make simple analogical comparisons in their explanations which none of the control group students did. The use of complex analogies to improve the performance of pre-service science teachers was described by James and Scharmann (2007) and they reported that the experience prompted teachers to make conceptual shifts after the analogies allowed them to recognize their own misconceptions or limited understandings of certain scientific concepts. There is a difficulty however with the use of analogies, both simple and complex, that Orgill and Bodner (2004) identified as an inability of teachers to discern the difference between analogies and examples. In that work it was revealed that many teachers were of the view that they use analogies in their teaching, but when examined in their practice a number of relationships they presented to students were in fact examples and not analogies. Orgill and Bodner (2004) attribute this inability to discriminate between examples and analogies to teachers' lack of experience with analogies in their own learning and to their limited pedagogical understandings of what constitutes an analogy and the purposes for which analogies can be used.

### *Theoretical Framework*

The role of analogies in the learning process has been analysed from several theoretical perspectives (Kalssen, 2006; Gentner, 1983) but the framework articulated by Glynn and Duit (1995) in which the aim is to promote elaboration – the cognitive process of constructing relations between what is already known and what is new – aligns most closely with the aims of the current work and is the framework that will be adopted here. Elaboration can be defined more precisely as "any enhancement of information which clarifies or specifies the relationship between information to-be-learned and related information", i.e., a learner's prior knowledge. Elaboration can be activated by questions, objectives, personal examples, and other strategies, but analogies seem to be particularly appropriate because they can provide the rich, familiar contexts that successful elaboration requires. Elaboration plays a critical role in a constructivist framework for learning science in which students learn progressively more sophisticated mental models of science concepts over an extended period of time. Often, these concepts represent hard-to-visualize structures, systems or processes which can only make sense to students when linked to what is familiar to them. Parts of a

cell (the unfamiliar target), for example, when compared to areas in a busy factory (the familiar analogue) can easily help students develop mental models that they can use to form limited, but meaningful, understandings of abstract concepts. The analogy usually paves the way for the expansion of the target concept.

### *Trinidad and Tobago Context*

In Trinidad and Tobago, science teachers often lament about the difficulties science students have forming meaningful understandings of new ideas and concepts when these are presented to them. Teachers often draw on their own experiences as learners to come up with strategies and approaches to help students arrive at world view understandings of scientific concepts. Comparisons between the known and the unknown is a frequently employed strategy teachers use to achieve this outcome. Through teacher training courses and programmes as well as personal exploration and networking many teachers in Trinidad and Tobago have recognized the positive impact that models and analogies can have in helping to develop understandings among adolescent students. In spite of this recognition, teachers are generally reluctant to use analogies in their teaching on a regular basis. No sound explanation for why this is so has been articulated by science teachers in Trinidad and Tobago. This concern is what motivated the current work. Furthermore, teachers admit that when they do in fact use analogies in their teaching on occasion, that they are uncertain about the suitability of the analogies they select to use and about the effectiveness of their use in developing students' understandings. With these concerns in mind, the following research questions were crafted to guide the current work:

1. How often do science teachers use analogies in their science teaching?
2. What types of analogies are used by science teachers in their science teaching?
3. What are science teachers' perceptions of their use of analogies in their science teaching?

## METHODOLOGY

An interpretative research methodology (Erickson 1986, Merriam, 1988) was used to investigate the nature and frequency of analogy use by secondary school science teachers in Trinidad and Tobago. According to Merriam (1988), those conditions which define a case study were fulfilled in this work: the targeted participants to which the research question was directed (selected secondary school science teachers), the lack of control over the observed phenomena by the researchers (teachers planned and

delivered their lesson with no input from the researchers), the desired end-product emerging from the description and interpretation of a contemporary phenomenon (findings determined only from interpretation of observations made within the context of the theoretical framework) and the fact that the research involved the observations of science teachers in only one school.

### *Sample*

A secondary school science department in a suburban district in south Trinidad was involved in this study. The science department was comprised of seven science teachers; five agreed to participate in the study. Two teachers in the department were scheduled to go on maternity leave and would not have been able to participate in the study for its entire duration. The five teachers had science teaching experience ranging from 5 to 16 years in the classroom and each had previously had a science education researcher/observer in his or her classes. The teachers were informed that the research team of three persons was interested to explore from observing lessons, the methods employed by teachers to help students understand science concepts. It was explained further that the researchers were interested to see how the teachers used teaching/learning approaches to make difficult or abstract concepts easier to understand.

In total the five teachers were observed teaching 4 different subjects ranging from lower school science subjects in forms 2 and 3 for students aged 13+ and 14+ to upper school science subjects in forms 4 and 5 for students aged 15+ and 16+ years. The lower school subject observed was integrated science in forms 2 and 3 and the upper school subjects observed were physics, biology and chemistry. Three teachers were observed teaching both the lower school subjects and upper school subjects; one teacher was observed teaching only upper school subjects and one teacher was observed teaching only the lower school subject.

### *Data Sources and Data Collection Procedures*

Observations were made and data were collected during four consecutive weeks between October and November 2014. The researchers sat in the teachers' classrooms and carefully recorded what happened during each lesson by writing detailed field notes. These notes included detailed descriptions of the setting, the students, the teacher and the teaching methods, as well as research relevant snippets of what the teacher and the students said during the lesson – including some direct quotations from the students and the teacher (Merriam, 1988). Observers' comments including reactions, hunches, and initial interpretations and working hypotheses arising during the lessons and from discussions with the teachers after each lesson were also recorded in the field notes (Merriam, 1988). In total, 30

lessons each of 45 minutes' duration were observed and comprehensive field notes were obtained.

At the end of the four-week period in the teachers' classrooms, each teacher was interviewed about his or her view of the use of analogies in science teaching and they were each asked at the end of the interview to suggest an analogy, which in their view, best represents students' learning. The questions explored in the interview were:

1. For what topics, concepts or ideas do you think analogies are a suitable teaching/learning strategy?
2. Would you say that you use analogies in your teaching frequently, seldom or not at all?
3. What are the advantages and disadvantages of using analogies in your teaching?
4. If you do use an analogy in your lesson, in what part of the lesson would it most likely be used: introduction, body or conclusion?
5. If you had to give an analogy that can represent students' learning, what would it be?

### *Data Analysis and Interpretation*

Analysis of data took place over the duration of the study. The research team met each week to discuss substantive and procedural aspects of the data analysis exercise. The ultimate purpose of the team meetings was to construct a complete interpretation of the data which were eventually formulated into generalized observations based on a decisive balance of evidence favouring such generalized observations from different teachers in a range of classes. These generalized observations were initially categorized and labelled based on observed instances of the use of analogies to facilitate elaboration of scientific concepts as described by Glynn and Duit (1995). Any discrepant counter-examples that came up during the data analysis process were identified and investigated further. The validity and reliability of the generalized observations were carefully considered by triangulation using supportive data from various sources (field notes from the lessons and discussions with the teachers) and from among as many researchers as possible. As observations were framed, modified and supported they were grouped with other observations in a more general and inclusive form. This process led to the emergence of four generalized observations.

## RESULTS

Of the four generalized observations that emerged, three were related primarily to the findings of classroom teaching while the fourth referred to outcomes stemming from the interviews with the teachers.

***Few analogies were used in the observed lessons***

Based on the data analysed from the 30 lessons observed, there were six clear indications of analogy use and these occurred in six separate lessons. The number of different class levels and the lessons observed being taught by the five teachers are presented in Table 1, together with the number of lessons in which teachers were observed to use analogies in their teaching. The presence of, and number of times an analogy was used in the lesson is indicated by a number in brackets following the number of lessons.

**Table 1 Science lessons of five teachers showing the presence of analogy use.**

| Science Subject | Number of Lessons Observed by 5 Teachers | | | | |
|---|---|---|---|---|---|
| | **Teacher 1 (Lower and Upper)** | **Teacher 2 (Lower)** | **Teacher 3 (Lower and Upper)** | **Teacher 4 (Lower and Upper)** | **Teacher 5 (Upper)** |
| Integrated science | 2 | 6 (2) | 2 | 2 | |
| Biology | 1 | | 1 (1) | 2 | 2 |
| Chemistry | 1 | | 2 | 2 (1) | 1 |
| Physics | 2 (1) | | 1 | 1 | 2 (1) |
| Total Lessons per teacher | 6 | 6 | 6 | 7 | 5 |

Using the analysis of analogies described by Curtis and Reigeluth (1984), three of the six analogies use in in the science lessons observed were of the simple type in which physical structure between the analogue and the target was compared. Three of the analogies used were of the complex type in which functions and/or processes between the analogue and the target were pointed out to aid understanding. Also observed in some lessons, some teachers used activities and gave examples that had analogical potential that were not fully developed or explored. Overall though, only few analogies were used by the science teachers observed in this work.

It was quite interesting to note that in cases where the analogies used were described as complex, the teachers not only carefully and clearly showed the relationship between the analogue and the target, but they also dealt with the analogy's limitations and explained common misunderstandings likely to occur with each analogy. The six analogies

observed during the science lessons are described in Table 2 in terms of the target concept, the analogue and the type of analogy used by the teacher.

**Table 2 Types of analogies used in science lessons**

| Science Lesson | Target | Analogue | Type of Analogy |
|---|---|---|---|
| Integrated Science – Teacher 2 | Classification of living things | Supermarket sorting and display | Simple |
| Integrated Science – Teacher 2 | The process of photosynthesis | Baking a cake | Complex |
| Biology – Teacher 3 | The human circulatory system | Plant circulatory system | Complex |
| Chemistry – Teacher 4 | Movement of gas molecules in the kinetic theory | Demonstration with spherical beads | Simple |
| Physics – Teacher 1 | Electric circuit | String circuit | Simple |
| Physics – Teacher 5 | Half-life in radioactive decay | Playing the lottery | Complex |

***Simple comparison type analogies were used***

Three of the six instances where analogies were used by teachers in this work were of the simple comparison type. In a form 3 integrated science class the teacher was discussing classification of living things and made the comparison by analyzing the display of items in a supermarket store and pointed out that items are sorted according to similar features, properties and function and that items with certain similarities are grouped together and displayed in a common place in the supermarket. For example, the analogue that all cleaning agents such as soap powders and detergents share similarities because of the substances they are made from and because of what they are used for was used to compare the cold-blooded characteristic of reptiles and the fact that they often live in water. Students were able to use the analogy to easily remember the characteristics of different type of living creatures. Another simple analogy used by a form 4 chemistry teacher was a demonstration of rolling spherical beads in an enclosed container to show the randomness of the movement of gas molecules in the kinetic theory. The analogy worked well to show the randomness of

movement and of collisions but could not demonstrate concepts such as thermal heating. Students therefore had no opportunity to appreciate thermal heating as consequence of the kinetic theory. In this case however, the teacher went beyond the analogy to explain the concept of thermal heating to students by showing a video clip simulation of gas molecules in motion. The simulation apparatus included a temperature gauge, which the teacher referred to in her explanation of kinetic energy being converted to heat energy. This was an example of where the simple analogy broke down and the teacher used additional resources to ensure that students developed a complete understanding of the phenomenon.

The form 4 physics teacher observed in this work missed a valuable opportunity to expand on a simple string circuit analogy he used to explain how current flow in an electric circuit occurs. The use of this simple analogy limited conceptual development to the notion of a closed circuit or an unbroken path and to the function of a switch. The choice of analogue limited the number of electricity concepts that could have been discussed using and analogy. If instead water flowing in pipes or a train moving around a circular track was used, concepts such as resistance, voltage and power could have been explored. The teacher indicated in the subsequent interview that he would have to teach these concepts in a later lesson, but admitted that had he selected a complex analogy instead he would have been able to cover a lot more content in a meaningfully linked way with the students.

***Complex analogies used three times.***

The use of complex analogies was observed on three occasions – once in an integrated science lesson, once in a biology lesson and once in a physics lesson. In the integrated science lesson, the teacher was teaching the process of photosynthesis and used baking a cake as the analogue. The ingredients of the cake were likened to the raw materials required for photosynthesis and the teacher went into detail to explain that each raw material was needed because it served a unique function in the process and that there is a prescribed ratio in which the raw materials must come together to get the desired product in a particular fixed amount – just as when combining ingredients to make a cake. Further, the teacher spoke about heat from the oven and explained that while it was not a tangible ingredient added to the cake mixture, that it was absolutely essential in the baking process to transform the mixture of ingredients into a baked cake and that so too sunlight is a critical condition that must be satisfied in order for photosynthesis to occur. The teacher went further to liken the baked cake to the main product of photosynthesis – glucose – and the delightful aroma which emanates from a baked cake to the by- product of photosynthesis – oxygen.

The circulatory systems of humans and plants were used by a form 5 biology teacher to show similarities in both systems by relating the structure of each part of each system to the function they served. This analogy was complex because it required some prior knowledge of parts of the human body and parts of the plan system. Students seemed to have had this prior knowledge, so it was easy for them to follow through with the analogy, but it is an analogy that would not work well if this prior knowledge is absent. Xylem vessels and phloem vessels in plants were compared to veins and arteries in the human body to point out the specificity of function – that only a certain type of material is transported in each one in both the plant system and in the human body. The teacher also emphasized to the students the unique design of each type of vessel in both systems to allow for each to transport the particular type of material that it did. Location too, of each type of vessel in the respective system was explored with the students and the teacher made the point to students that function influences structure and that both structure and function influences where in the system the particular type of vessel is located. This was one example in which a complex analogy was effectively used to teach science.

In a form 5 physics lesson in the discussion of half-life in radioactive decay, the teacher made the analogy between the target concept (radioactive decay) and probability-controlled games such as the lottery. In the analogy the teacher explained that every nucleus in the radioactive sample has the same probability to "be changed" [decay or disintegrate] in much the same way that every lottery player has the same chance of selecting the correct number. The teacher presented this analogy quite effectively not only by establishing clearly the randomness of occurrence in both the analogue and the target, but went further to discuss with the students the limitations of the analogy. He explained that in radioactive decay, time is involved, that is, that the chance of decay happening is within a certain period of time but that in the case of the lottery the randomness of a person winning was not a function of time. The teacher also used the opportunity to mention the notion of luck, as a consideration in the lottery, but explained that there is no such notion in the case of radioactive decay.

### *Teachers recognized their limits in effectively using analogies to teach science*

While the observations of lessons indicated infrequent use of analogies, when interviewed, the teachers were of the opinion that they used analogies frequently. The interviews however suggested that most teachers used examples and not analogies frequently in their teaching but that they were unable to discern the difference between both. In fact, one teacher during the interview said that "analogies are like examples…." while another teacher said "they [analogies] are useful to compare…." Responses like these might explain the contradiction between the observations of

infrequent use of analogies and teachers' claims that they use analogies frequently. It seems that they are viewing examples and even simple similes/metaphors as analogies.

The interview responses revealed that teachers were aware of some advantages and some disadvantages of using analogies either from their own experiences of using analogies or from reading about using analogies to teach science. One teacher referred to a previous reading and said that one disadvantage of using analogies is "failing to show students where the analogy breaks down". Another disadvantage of analogy use pointed out by two teachers was the one-analogy-teaches-all concept. Even though the teachers did not refer to this term explicitly, it was clear in their interview responses that they felt that a selected analogy used for a particular topic might not result in the same learning experience for all students because of prior knowledge, social background or cultural context. This is an area that Guerra-Ramos (2011) has attempted to explore and suggests that teachers must be mindful of these factors when selecting and using analogies in their classrooms. Two of the teachers interviewed stated explicitly that analogies are useful tools to help students "visualize abstract ideas" or "unfamiliar structures". Even though teachers admitted that their own skill and competence in using analogies were limited, they recognized the many advantages (similar to those described by Guerra-Ramos, 2011) that can be derived from deliberate selection and use of analogies to teach science.

In responding to what topics teachers thought were suitable for analogy use, most of them felt that analogies were tools to help with the learning of "difficult" and "abstract" concepts and to promote visualization to help students relate abstract concepts to the real world. In addition to those topics in this work, in which analogies were used other science topics such as electricity, homeostasis, the mole concept, planetary motion, enzyme activity and convection currents were topics these teachers cited as science topics they thought the use of analogies would result in meaningful learning.

In all six lessons observed in this work in which analogies were used, teachers used analogies in the body of their lessons. When interviewed about this, their responses were consistent with what was observed – all six teachers said that if they decide to use an analogy in a particular lesson that they would use it in the lesson's development to "facilitate" and promote "discussion, sharing and elaboration" of the "topic" or "concept" among the students.

The six teachers interviewed were noticeably challenged when asked to give an analogy that in their view can represent student learning. They all took a while to reflect before responding to this question. Surprisingly, they each gave a different analogy and when probed, explained why they selected the analogy that they did. Their responses are represented in Table 3.

**Table 3 Analogies that Reflect Student Learning**

| Teacher | Analogy | Reason for Choice of Analogy |
|---|---|---|
| Teacher 1 | Building a house | A sound foundation is needed…. there are no limits to how intricate it can be designed |
| Teacher 2 | A pyramid | Broad-based in the early years…peaking at higher levels |
| Teacher 3 | A never-ending staircase | Learning is a lifelong process |
| Teacher 4 | Planning a successful event | It cannot be done alone…help/input is needed from different sources |
| Teacher 5 | Tying shoe laces | Basic skills must be mastered… to get to the end product |

## SUMMARY AND DISCUSSION

The result of this study, completed with a small sample of five staff members in a secondary school science department in Trinidad and Tobago for four consecutive weeks, provides valuable, though tentative data for researchers interested in how science teachers use analogies as part of their regular classroom practice. The teachers in this study were observed to use few analogies in their teaching and of the six analogies used, three were simple analogies and three were complex analogies.

The literature suggests explicitly that analogies can be effective tools to help learners understand complex and/or abstract concepts covered in classroom learning especially when conceptual change in the constructivist paradigm is considered a critical aspect of learning. The observed low frequency with which teachers in this work use analogies in their everyday teaching – a total of six analogies across 30 lessons – is even lower than the frequency of analogy use found by Brown and Salter (2010) which reported that on average teachers were found to use analogies once in every three lessons. Granted that the sample is small in this work, but recognizing that science teachers in Trinidad and Tobago have pointed out that they are searching for effectively approaches to help students develop conceptually sound scientific understandings, the finding is instructive. It suggests that more needs to be done perhaps through additional teacher training initiatives to encourage science teachers to use analogies more often in their teaching.

This work notes that both simple and complex analogies are used by science teachers but further that in some instances where complex analogies were used to describe and discuss non-observable concepts, opportunities for making comprehensive use the analogies as a teaching/learning tool were not always taken. Some simple analogies used had the potential for expansion into complex analogies or analogies that provided deep conceptual understandings and in one case this was observed. Some of the simple analogies used in this work were used in previous work, for example the electric circuit and the string circuit was discussed in work by Guerra-Ramos (2011) but whereas in that work the heating property of an electric current was included in the analogy, that aspect was not discussed by the teacher in this work. This may be an indication that the teacher in this work either did not understand completely the potential of the analogy or that she may not have known how to use the analogy effectively to demonstrate the heating aspect. This lack of knowledge about analogy use and its effectiveness and/or appropriateness came out in an implicit way during the interviews in which many of the teachers described examples they used in the classroom suggesting that they were using analogies. Their explanations in describing these examples made it clear that they had difficultly discerning the difference between an analogy and an example.

The three complex analogies used in this work were adequately implemented and explored to help students construct knowledge and understanding of the relevant science concepts in terms of structure function and process. As James and Scharmann (2007) have described and as was shown in this work, when analogies are selected that are topic relevant and which match the developmental levels of students, and when teachers are confident and knowledgeable about the use of analogies to facilitate knowledge construction by moving students from the unknown into the known or from abstract to concrete that students exit the learning experience with richer and more thorough understandings and details about concepts.

The interviews revealed that, in contrast to the empirical findings, teachers felt that they used analogies frequently in their everyday teaching. Their responses and descriptions however indicated that they were in fact using a lot of examples which they thought were analogies. However, when probed about these by referring to specific comparisons they described or had used in the lessons observed, their cautious responses suggested that many teachers did not discern examples and analogies. Clearly communicated through the interviews, was the conclusion that many of the teachers had limited exposure to analogy use in their own schooling and that even beyond their schooling experience, they had not developed pedagogical competency in analogy use either formally or informally. This finding aligns almost exactly with what Orgill and Bodner (2004), found among pre-service science teachers and as a result of which a

recommendation was made for science teacher preparation programmes to include this approach to knowledge construction in very explicit ways.

Teachers offered some interesting analogies that in their view reflected student learning. While their particular choice of analogy was not probed, their explanations for the selected analogy was insightful. In a general way, their reasoning seems to suggest that student learning is a continuous spiral process in which knowledge acquisition is collaborative, skills-based and geared towards a defined end purpose. This is one aspect of analogy use in teaching and learning that can be explored further in follow-up work, specifically to determine if there is a link between the way the teachers view student learning and the choice and type of analogies they use in their lessons.

In summary, therefore, based on the four generalizations that emerged from the data in this work, the assertion is that effective use of analogies in everyday science teaching leaves much to be desired. Within the Trinidad and Tobago context, it seems clear that any attempt to encourage science teachers to increase the frequency and their skill and competence in analogy use to teach science cannot be arbitrary or superficial. It must be deliberate and it must be the result of a comprehensive effort in which science teachers are formally exposed to a well-prepared teaching repertoire of analogies using specific content in specific contexts and that they are trained in pedagogically sound practice for analogy use in their classrooms. Teachers are aware of the advantages and disadvantages of analogy use and are cognizant of science topics in which analogy use will be effective, but they do not have the confidence or the pedagogical content knowledge base to use them effectively in their classrooms. They tend to use analogies only in the body of their science lessons, seemingly unaware of how it can be used in the introductory or concluding phases of a lesson. Brown and Salter (2010) suggest that once teachers' knowledge base in these areas are enhanced that they will develop the confidence to use appropriate analogies more effectively, and in different phases of their lessons, and would therefore be inclined to use them more frequently in their classrooms.

## REFERENCES

Blake, A. (2004). Helping young children to see what is relevant and why: Supporting cognitive change in earth science using analogy. *International Journal of Science Education*, 26(15), 1855-1873.

Brown, S., & Salter, S. (2010). Analogies in science and science teaching. Advances in Psychological Education., 34(1): 167-169, doi: 10.1152/advan.00022.2010.

Curtis, R.V. & Reigeluth, C.M. (1984). The use of analogies in written text. *Instructional Science*, 13, 99-117.

Dilder, R., & Duzgun, B. (2008). Effectiveness of analogy on students' success and elimination of misconceptions. *Latin American Journal of Physics Education,* 2(3): 174-183.

Erickson, F. 1986. Qualitative methods in research on teaching. In M. C. Wittrock (ed.), Wittrock, M. C. (ed.), *Handbook of Research on Teaching*, pp.119-161. New York: Macmillan

Fosnot, C.T. & Perry, R.S. (2005). Constructivism: A psychological theory of learning. In C.T. Fosnot (Ed.) Constructivism: Theory, Perspectives and Practice (pp. 8-38). New York, NY: Teachers College Press.

Gentner, D. (1983). Structure-mapping: a theoretical framework for analogy. *Cognitive Science*, 7: 155-170.

Glynn S. M. (2007). Methods and strategies: the teaching-with-analogies model, *Sci. Child*., 44(8), 52–55.

Glynn, S. M, & Duit, R. (1995). Learning science meaningfully: Constructing conceptual models. In S.M. Glynn & R. Duit (Eds.), Learning science in the schools: Research reforming practice (pp 3-33). New Jersey: Lawrence Erlbaum Associates.

Guerra-Ramos, M. T. (2011). Analogies as tools for meaning making in elementary science education: How do they work in classroom settings? *Eurasia Journal of Mathematics, Science & Technology Education,* 7(1): 29-39.

Haglund, J. (2013). Collaborative and self-generated analogies in science education. *Studies in science Education,* 49(1): 35-68.

Haglund, J., Jeppsson, F., & Andersson, J. (2012). Young children's analogical reasoning in science domains. *Science Education*, 96(4): 725-756.

Harrison, A.G. & Coll, R.K. (2008). Using analogies in middle and secondary science classrooms. United Kingdom: SAGE Ltd.

James, M. & Scharmann, L (2007). Using analogies to improve the teaching performance of pre-service teachers. *Journal of Research in Science Teaching*, 44(4), 565-585.

Kalssen, S. (2006). A theoretical framework for contextual science teaching. *Interchange*, 37(1-2): 31-62.

Loughran, J., Mulhall, P., & Berry, A. (2008). Exploring pedagogical content knowledge in science teacher education. *International Journal of Science Education*, 30(10): 1301-1320.

Maharaj-Sharma, R. (2011). An examination of the types and usefulness of analogies generated by upper primary school students – A case study. *Journal of Science Teachers Association of Nigeria*, 46(2): 8-20.

Mascolo, M.F. (2009). Beyond students-centered and teacher-centered pedagogy: Teaching and learning as guided participation. *Pedagogy and Human Sciences*, 1(1): pp. 3-27.

Merriam, S. B. (1988). *Case study research in education: A qualitative approach*. San Francisco: Jossey-Bass.

Minner, D., Levy, A., & Century, J. (2009). Inquiry-based science instruction – What is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching,* 47(4): 474-496.

Orgill M.K., & Bodner G. (2004). What research tells us about using analogies to teach chemistry? *Chem Educ Res Pract* 5: 15–32.

Richland, L.E., & Simms, N. (2015). Analogy, higher order thinking and education. *Cognitive Science*, 692): 177-192.

Tregidgo, D., & Ratcliffe, M. (2000). The use of modelling for improving pupils' learning about cells. *School Science Review*, 81: 53-59.

Treagust D. F., Duit R., Lindauer I. & Joslin P., (1989). Teachers' use of analogies in their regular teaching routines. *Research in Science Education*, 19, 291–299.

Wellington, J. (2015). Educational Research: Contemporary issues and practical approaches (2nd edition). New York: Bloomsbury Academic.