Analogies in Physics Teaching: Experiences of Trinidadian Physics Teachers

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Abstract

Analogies have been widely used as tools for teaching difficult science concepts. The purposeful use of appropriate analogies can facilitate analogical thinking and help students develop the necessary transfer skills required for lifelong learning. Analogical thinking facilitates the development of higher order thinking skills among students. In this study the experiences of Trinidadian physics teachers on the importance of analogies as an instructional tool and the extent of its usage in physics teaching and learning were explored. Quantitative and qualitative methodologies were employed in this study. The findings revealed that, in general, Trinidadian physics teachers do in fact use analogies in their pedagogical practice but that the analogies used are mostly simplistic and with illustrative character. Some teachers use analogies deliberately to help students build new knowledge by transferring and applying prior knowledge and skills to new learning situations.

Key words: analogies, science teaching

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Introduction

Analogies in the Constructivist Paradigm

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***.** Holyoak (2012) posited that an analogy is an inductive mechanism based on structured comparisons of mental representations such that an analogy is a comparison through which a new idea, thing or process is contrasted to another idea, thing or process that is quite different. The aim when using analogies is to explain a new idea, thing or process by comparing it to something that is already known.

According to Holyoak (2012), analogical reasoning is a complex process involving retrieval and use of structured knowledge from long-term memory to interrogate new constructs by searching for similarities between what is already known and what is new with the intention of generating new inferences. Constructivist models of learning are built on the premise that connecting newly presented information with existing knowledge is essential in the promotion of meaningful learning (Limon, 2001). Duit, Roth, Komorek and Wilbers (2001) suggest that new conceptual frames are developed when transferring structures from familiar to new domains. Development of new conceptual frameworks in this way can be easily achieved by the purposeful use of analogies which facilitates connections between the familiar and the unfamiliar.

Richland and Simms (2015) have suggested that analogical reasoning is a cognitive skill that underpins many 21st century competencies and one which is essential for the development of the critical 21st century skills set students require for knowledge creation, knowledge sharing, social development and economic growth. Analogical reasoning requires a type of scrutiny involving memories and prior experiences in an effort to solve problem or critique solutions and to explain or interpret situations (Richland & Simms, 2015). It is a key feature of the learning process as framed within a constructivist perspective: every learning process includes a search for similarities between what is already known and the new (Maharaj-Sharma, 2012; Wittrock & Alesandrini, 1990). Analogical thinking and analogical reasoning through the effective use of relevant analogies have the potential to bring prior knowledge to bear on the acquisition of new information, new skills and understandings (Vosniadou, 1988) and in that regard, analogies can play a key role in the realignment of students' conceptual frameworks (Duit, Roth, Komorek & Wilbers, 2001).

Analogies and Physics Teaching

The study of science and physics in particular, provides for us an avenue through which we can understand the fundamental laws of nature, numerous everyday science concepts as well as many complex and abstract scientific techniques and processes. Physics in particular is often branded as a science of abstractions which are not easily understood unless related to everyday experiences (Otero, Pollock & Finkelstein, 2010). Physics teachers, and by extension science teachers in general, therefore frequently use analogies to explain scientific concepts, processes and behaviors to students (James & Scharmann, 2007). According to Poincare in his 1913 book entitled 'The Value of Science', scientists conceptualize analogies which can be placed somewhere along a spectrum ranging from 'primitive analogies' to 'mathematical analogies'. 'Primitive analogies' focus on sense-related aspects of similarities between the analogue and the target, while 'mathematical analogies' go beyond to compare structure-function relations, patterns and processes. A 'primitive analogy' is merely a brief comparison; it utilizes imagination but lacks critical thought. 'Mathematical analogies' are a form of reasoning that involves representative and interrogative thinking (Cruz-Hastenreiter, 2015).

Famous analogies in science frequently reveal and ability to make mental leaps. For example, the idea of envisaging heat as a fluid that can be contained in warm objects with the ability to flow from one object to another has been a powerful image throughout the history of physics teaching and is in fact still used today (Viennot, 1998). James Clerk Maxwell developed the theory of electromagnetism by drawing physical analogies between fluid dynamics and the electromagnetic phenomenon (Maxwell, 1865). These examples are attestations to the claim that analogies are not only an important cognitive mechanism in creative thinking, but that the analogical approach is a basis for problem solving and therefore forms a core component of everyday mental processing (Jonane, 2015).

Although analogies can be very helpful and useful in physics learning, they can also be the source of misconceptions leading to incorrect or impaired learning if they are not used properly or if the analogue/target relationship is unsound (Richland & Simms, 2015). Some authors warn that the use of analogies in science, including physics teaching, does not always produce the intended effects and this is especially true if students take an analogy too far and are unable to distinguish it from the content being learned (Aubusson, Treagust & Harrison, 2009; Dilber & Duzgun, 2008). Making it clear to students where an analogy breaks down is essential in guarding against this outcome (Brown & Salter, 2010). Research has shown that this is the aspect of analogy usage teachers most often neglect (Brown & Salter, 2010). Knowledge about the law of conservation of energy can help students remember the law of conservation of momentum. Both are laws of conservation. However, although the laws are similar, it is important to emphasize the differences between them. In the law of conservation of energy direct physical contact is not necessary to facilitate energy transfer, while in the law of conservation of momentum, bodies in collision or contact is the trigger for its consideration. Yet another distinction is that energy is a scalar quantity so that direction of flow or transfer of energy is not important, while momentum is a vector quantity and therefore directions of motion of objects before and after collision are critical (Lightman, 2000; Hofstadter & Sander, 2013).

Purpose of Study and Research Questions

Only few studies have been conducted in the Trinidad and Tobago context to examine the use of analogies in science teaching (Maharaj-Sharma, 2012; Maharaj-Sharma & Sharma 2015). These studies have looked at the types of analogies science teachers use and at science students' perceptions of analogies. They have not explored what are science teachers' views on the use of analogies in their classrooms and how helpful they perceive analogies to be in facilitating science learning for their students. Very little is known about teachers' comfort levels with analogy usage and what the main aspects of the analogies teachers use are. These are the concerns which motivated the current study. The purpose of this study therefore was: 1) to identify Trinidadian teachers' views on the use of analogies in physics teaching, and 2) to evaluate teachers' beliefs about the role of analogies in the promotion of higher order thinking among their students. In this study, physics teachers had the opportunity to consciously review, describe, analyze and evaluate their past and current practices with a view toward gaining insights to improve their future practice (Finlay, 2008) and in that regard, the following research questions were tailored to guide the approach adopted in this work:

- What are the views of physics teachers on the use of analogies?
- What are physics teachers' assessment of their students' levels of thinking in relation to the use of analogies?
- What are the main aspects of the usage of analogies in physics instruction?
- What type of analogies do physics teachers use?

This study is significant in that it will add to the only sparsely available body of literature on the use of analogies in science teaching and learning in Trinidad and Tobago. Examples, explanations, suggestions and considerations revealed in this work will provide science and especially physics teachers with increased resources, understandings and encouragement for analogy usage in their teaching. It will also present science teachers with an additional option in their pedagogical toolkit, from which to select when preparing science lessons.

Methodology

Research Tools and Data Analysis

In this research, both qualitative and quantitative approaches were adopted (Creswell, 2003). A questionnaire (Appendix 1) was administered to a group of trained physics teachers (Group 1) and group interviews were conducted with another group of in-service training physics teachers (Group 2) currently pursuing their Postgraduate Diploma in Education at the University of the West Indies (UWI), St. Augustine, Trinidad. The questionnaire was used to gather useful and relevant information about teachers' views on the use of analogies in their physics teaching. It was prepared and piloted with the most recently graduated group of trained physics teachers from UWI – none of whom were part of either Groups 1 or 2. After the piloting, some items were reworded and an additional question was added to solicit teachers' personal views regarding the use of analogies in their physics teaching/learning. The revised questionnaire was distributed to Group 1 via e-mail and they were asked to return the completed questionnaires in 1 week.

The questionnaire consisted of four parts. Part 1 collected demographic details of the physics teachers – gender, age, qualification, teaching experience and school type. Part 2, entitled 'Using analogies in physics teaching', contained 10 items to which teachers responded using a five-point Likert scale that ranged from agree to disagree. The first 3 items were aimed at eliciting from teachers the extent to which they use analogies in their teaching, their general views on analogy usage and whether their decision to use analogies are deliberate. The other items in Part 2 were aimed specifically at detecting teachers' views as it relates to their assessment of their students' levels of thinking when analogies are used. Part 3 of the questionnaire targeted aspects of analogy use teachers employed in their physics teaching. In the last Part of the questionnaire, teachers were invited to submit some examples of useful analogies and to describe their views and experience in terms of the usage of these analogies in their physics teaching.

In addition to the questionnaire, a group interview protocol (Appendix 2) was developed based on the phenomenological approach within a paradigm of critical constructivism (Goodman, 2008). The qualitative research interview sought to cover both factual and interpretative data in relation to the use of analogies by physics teachers in Trinidad (Kvale, 1996). The interview protocol included 8 open-ended questions which addressed the following areas:

- Extent of analogy usage (relevant topics, choice of analogue and decision to use analogy)
- Experience about the successful usage of analogies (Examples of analogies and outcomes of their use)
- Suggestions for effective implementation of analogies in physics class

- Beliefs in relation to analogies as a tool for promoting high order thinking in physics teaching and learning, and
- Self-evaluation (teachers' evaluation of their effectivity with the use of analogies)

The interview plan was piloted in a manner similar to the questionnaire and found to be targeted and unambiguous. Analysis of the data from the questionnaire and the interview transcripts was based on the principles of quantitative and qualitative methodology (Creswell, 2003). Quantitative data from part 2 of the questionnaire was processed by polling the answers and calculating their percentage. Content analysis was utilized for the qualitative data from Parts 3 and 4 of the questionnaire, as well as the interview transcripts. Appropriate textual units (phrases, sentences or entire text of written answer) conveying a theme or idea were identified for coding. Inductive coding in which similar textual units were clustered in groups was used to place related groups into broader categories. Rich descriptive text was used to describe the categories which emerged from the analysis. The interview data and questionnaire data were compared to determine if physics teachers with different levels of professional training had similar views on the use of analogies in physics teaching.

Sample and Procedures

The sample was divided into two segments. Group 1 comprised trained physics teachers (N=50; 40% male, 60% female) from Trinidadian schools. The age of participants ranged from 27 to 56 years and their pedagogical experience span from 4 to 25. Participation was voluntary. Prior to administration of the questionnaires, the teachers were informed about the aim of the study and were assured that their responses will be confidential, that their anonymity will be guaranteed and the data supplied will be used only for the purposes of the current work.

Independent of the questionnaire, three group interviews with five in-service training physics teachers each (Group 2) (N=15; 30% male, 70% female) were undertaken. The 15 teachers in Group 2, were pursuing a science education course as part of their in-service training at UWI. In this course participants gained information on a range of topics including the nature of analogies, the role of analogical thinking in scientific investigations and prior research about the use of analogies in science education. (The Group 1 teachers too would have had these experiences during their period of training).

The Group 2 teachers gathered in small groups to share their experiences, to illicit examples of analogies and to discuss the methods associated with their usage. Teachers were informed about the aim of the group discussion and demographic data were collected. They were invited through the interview protocol to discuss the advantages and disadvantages of the analogical approach and to offer examples of analogies they used in their physics teaching. In the latter part of the interview, teachers were asked about their views, experiences, beliefs and attitudes towards analogies as a tool for development of transfer skills among their students. The interview with each small group lasted approximately 40 minutes. All the interviews were audiotaped and transcribed to facilitate coding.

Results and Discussion

The results of the study will be presented in four sections according to the research questions and, where possible, compared with the results of prior research. Firstly, a summary and analysis of the empirical data representing teachers' views on using analogies will be presented. Next, findings about teachers' assessment of their students' levels of thinking in relation to analogy usage will be presented. In the section which follows, the various aspects of analogies teachers use in physics instruction will be discussed and finally examples and types of analogies physics teachers use will be presented. Table 1 summarizes the empirical data from Part 2 of the questionnaire.

Table 1

Physics Teachers' Views on the Use of Analogies in Physics Teaching (N=50)

	Item	**%**				
		A	**SA**	**N**	**SD**	**D**
1	I make deliberate decisions to use analogies in my physics lessons	20	42	7	19	12
2	I use analogies in my physics teaching frequently	28	30	4	31	7
3	I believe using analogies is a good way to get students engaged in physics	60	30	5	0	0
4	The use of analogies helps to develop students' imagination	25	18	12	32	13
5	Analogy are helpful aids in the understanding of abstract concepts and processes which are difficult to perceive	48	26	5	14	7
6	Analogy sometimes diverts attention from the main concept or misleads students	10	35	15	24	16
7	If the teachers use analogy in an explanation, students reiterate it in their answers or discussions	40	33	0	8	19
8	Purposeful use of analogies develops the ability to apply knowledge to new situations	55	45	0	0	0
9	Learning with analogies requires mental meta-cognition, because it involves imagining one thing as another	72	19	5	2	2
10	At the end of secondary education, most students have developed the skill of analogical reasoning	0	8	14	60	12

Note: A – Agree; SA – Somewhat Agree; N – Neutral or no answer; SD – Somewhat Disagree; D - Disagree

Teachers' Views on Using Analogies

The data show that the majority of the teachers in this work (62%) make deliberate decisions to use analogies in their physics teaching and that 58% of the teachers use analogies frequently in their teaching. When probed to explain further what frequent use meant, teachers' responses revealed that frequent use was interpreted to mean the use of analogies in at least 50%

of the lessons they taught. These findings are consistent with that of Cruz-Hastenreiter (2015) which reported that teachers' use of analogies in their teaching activities is deliberate two-thirds of the times and that on average, teachers use analogies in half of the lessons they teach. What is noteworthy in this work is that almost one-third of the teachers (31%) do not make deliberate attempts to use analogies in their physics teaching. Maharaj-Sharma and Sharma (2015) have reported that teachers' reluctance to use analogies in their teaching may be linked to the fact that in their own learning experiences analogies were not used or that they do not feel they are creative enough to craft useful analogies. That having been said, it may be that the teachers who constitute this one-third do in fact use analogies, but not deliberately so, but that determination is beyond the scope of this work. It might be a worthy exercise to explore this supposition in subsequent work.

Responses from the questionnaire are consistent with the interview responses on the issue of deliberate use and frequency of use of analogies by physics teachers and this coherence suggests that trained as well as in-training physics teachers recognize the pedagogical soundness of analogies and are in fact using analogies in their physics teaching. During the interviews, teachers expressed both positive and negative opinions in relation to the use of analogies which, in general, correspond to the data presented in Table 1. The interviewed teachers recognized that the main factors to consider while preparing a lesson include: where an analogy will be used, students' familiarity with analogies selected for use, students' background knowledge and their ability to compare and transfer features from one object to another. Treagust, Harrison and Venville (1998) point to similar factors: the degree of difficulty of the topics, the degree of novelty, prior knowledge of the students and familiarity with the analogy as considerations that must be borne in mind when using analogies in classroom instruction.

Teachers' Assessment of their Students' Levels of Thinking

The teachers agree (60%) or somewhat agree (30%) that analogies can help students become actively engaged in physics learning. Several other studies highlight the potential of analogies in teaching and learning of science, primarily of concepts with a high degree of complexity (Glynn, 2008; Harrison & Treagust, 2006). A large number of teachers (57%) responded 'disagree' or 'somewhat disagree' or 'no answer' when asked about the potential of analogies to help develop students' imagination. Such a large number of teachers holding this view suggests that either these teachers have little experience with analogies, may not know how to effectively use analogies or may not be confident about using this pedagogical approach in general. A similar trend in teachers' responses was obtained when asked about their views on the usefulness of analogies in aiding students' understandings of abstract concepts and processes in physics.

Analogy usage does not always yield a positive effect. Aubusson, Treagust and Harrison (2009) as well as Dilber and Duzgun, (2008) reported that analogies can sometimes divert students' attention. The result is that some students only remember the analogy and not the content under study while others focus on extraneous aspects of the analogy and draw spurious conclusions about the target concept. In contrast though, Cruz-Hastenreiter (2015), showed how analogies allowed for insights and highlighted students' misconceptions. In this work as well, teachers admit that if analogies are not effectively used they can mislead students but the percentage of teachers who felt strongly about this was slightly lower than that reported by Dilber and Duzgun (2008).

A large percent of the physics teachers in this work (73%), said that students are likely to recall and repeat an analogy long after they were taught a concept or a process using analogies. In examination responses for example, students would often provide the analogy in their explanations instead of explaining the science concept or process. In spite of this teachers agree unanimously that the purposeful use of analogies develop students' ability to apply knowledge and transfer skills to new situations. Similar conclusions were drawn by Harrison and Coll (2008) in which they reported that when analogies are effectively used they readily engage students' interest and clarify difficult abstract ideas. Aubusson et al. (2009) also reported that concrete analogies facilitate understanding of abstract concepts by pointing to similarities between objects or events in the students' world and the phenomenon being taught. Making this distinction clear to students is critical in getting them to the point where they can recognize that the analogue is only a conceptual tool used to achieve the concept or process of the designated target (Brown and Salter, 2010).

Overall, the participants believed that learning by analogies is a skill that students need to develop. It is a mental construct that is strengthened when relevant analogies are effectively used. Students cannot do it on their own, teachers must be the critical facilitators of the process (Holyoak, 2012). Ninety-one percent (91%) of the teachers in this work agree or somewhat agree that teachers have an integral role to play in guiding students and ensuring that meaningful learning occurs when analogies are used. High level thinking can be cultivated through the use of analogies in physics teaching, but the approach must be consistent, focused, structured and relevant at all times. This, the physics teachers in this work admit is rarely the case in the Trinidad context and the result is that most students do not develop high order thinking skills or analogical reasoning skills by the time they exit secondary schooling - 72% of the teachers in this work are of this view.

Aspects of Analogy Use

Analysis of the group interview transcripts revealed four distinct themes in relation to analogy use by the participants. These four aspects, as well as the desired aim in each case, as articulated by the teachers are presented in Table 2.

Table 2

Dimensions of the Usage of Analogies: Physics Teachers' Views

Dimension of Analogy Usage	Desired Aim from Usage
Development of initial understandings of concepts, ideas or processes	• To generate interest for learning new topics by activating students' experience • To build on prior knowledge and understanding relevant to the target concept • To organize students' thoughts about a concept or process
Visualization of an abstract concept	• To develop a picture or model of the abstract concept or process • To visualize indirectly perceivable objects or processes
Information transfer	• To provoke thought triggering memories

	• To refresh students' minds with information from real life
Memorization or rephrasing of terms	• To determine the meaning of physics terms (such as resistor or conduction etc.) • To stimulate certain operations

During the discussion, it was revealed that there was a high degree of agreement among the teachers that analogies should be taught by methods that pique students' intuition and prompt them to apply their prior knowledge and reasoning skills to solve unfamiliar problems. Three collective insights on methods of analogy use emerged from teachers' interviews:

1. Analogies should be correct and accurately phrased. This is important to in order to prevent misconceptions of not directly perceived processes. They should not be too primitive, because primitive analogies do not catch students' attention and do not facilitate analogical reasoning.
2. Objects or physical processes must be mapped onto real life objects or processes as well as onto prior knowledge or skills. For students, it is easier to learn something new if it is compared with their prior knowledge or experiences. Analogies from real life are very helpful in creating associations which make it easier for students to understand new concepts.
3. Comparison between the analogue and the target object or process must be step-by-step. What teachers think might be clear and understandable, for instance, when analyzing the operation of a pump and a power source in electric circuits, may be far from clear and understandable for students. So, step-by-step analysis highlighting what is similar and what is not will go a long way in guarding against students developing misconceptions.

It is important, therefore, when aiming to promote analogical reasoning among students to explain the basic properties of the analogue to enable an analogical transfer that is correctly established between the analogue and the target. Description of the analogue and discussion of the analogical reasoning strategy can help students focus on key features for analogical transfer.

Types of Analogies

Approximately 80% of the teachers surveyed mentioned at least one analogy; 28% - mentioned two or three analogies. Overall, the teachers provided a total of 38 examples of analogy. Most of the analogies described were primitive in nature, focusing on physical objects and establishing superficial comparisons of structure between the analogue and the target for example an illustration of the similarities between the model of the atom and the solar system. Very few of the analogies described by the teachers were analyzed in depth to establish structure function relationships between the analogue and the target, though many had the potential for deeper analysis. Brown and Clement (1989) and well as Maharaj-Sharma (2012) emphasize that teachers more frequently use bridging analogies, analogies between well know structures, objects or processes and novel scientific phenomena and so in most instances their exploration and explanation of the analogies remain at the descriptive level. Nonetheless, these bridging analogies provide students with a platform from which to develop inference and to prompt conceptual change, when examining elements of similarity between the analogue and the target.

Many of the analogies (60%) described by the teachers are actually found in physics textbooks used in Trinidadian schools, such as the similarity between an electric current and the flow of automobile traffic. A few of the analogies however were innovative, for example, the metaphorical analogy of a broken bridge pictured as an open circuit. The physics teachers in this work cited a large number of analogies related to electricity and this may be because, as suggested by Dilber and Duzgun (2008) and Glynn (2008), electric current is a difficult concept for students to understand and teachers are always challenged to find ways to make this topic easier for students to grasp. During the group interview, the teachers shared their experience with teaching the concept of radioactive decay. One teacher offered the analogy where the unpredictable element of chance associated with each person who plays the lottery actually winning is similar to the random nature of particle disintegration in radioactive decay. In addition, the teachers advised that it is important to think carefully about the analogy strategy to ensure that when it is used a comfortable transit between the unknown and the new concept is created for students. Models and role-play can sometimes be very helpful in establishing this connection (Maharaj-Sharma, 2012). Based on the new popularity and the versatility of information and communication technologies, approximately half of the interviewed physics teachers indicated that they use a variety of animation analogies that are easy to create or user-friendly. Kim and Ryu (2001) have written about this and suggest that animation analogies are more effective than pictorial or verbal ones for developing students' understandings of difficult science concepts, particularly those associated with electricity.

Conclusion

In this study, the use of analogies as a tool for the development of high order thinking and analogical reasoning in physics teaching/learning was analyzed from an experiential point of view. Analogy as a teaching/learning tool has tremendous potential to promote analogical reasoning and high order thinking. The teacher, however, and his/her competence has a significant impact on the nature and extent of analogical thinking fostered in the physics classroom. According to this work, physics teachers' repertoire of analogies is primarily derived from textbooks; therefore authors of textbooks should be careful to include appropriate examples, information and tasks which promote analogical thinking.

A majority of the teachers herein believe that purposeful use of appropriate analogies can be very helpful for teaching abstract physics concepts and processes. In selecting analogies for use in this way, the teachers herein strongly advise that the following three aspects of analogy be carefully considered:

- Analogy should be correct and accurately phrased
- Target objects or physical processes must be compared with real life objects or processes or prior knowledge or skills and
- There is a need to explicitly compare the elements of the analogue and the target object or process.

In summary therefore, the underlying intention is that the findings revealed here will not only be instructive for physics teachers or science teachers, but that it will serve as a critical point starting for teachers of other subjects to explore opportunities for analogy usage. This is important in the Trinidad context, if teachers and educators are to truly make the much required and long overdue pedagogical shift – away from traditional methods toward an embracement of contemporary approaches in teaching and learning. Finally, it is important to bear in mind that the findings herein relate to a small group of conveniently selected physics teachers who participated in this work willingly and because they all had some prior experience with analogy use in science/physics teaching. The results therefore may not be generalizable for all school contexts, all science/physics teachers or for all types of learners.

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Appendix 1

Analogies in Physics Teaching: Experiences of Trinidadian Physics Teachers

Questionnaire

Section 1 - Circle the appropriate response

Gender: male female

Age (yrs): 20-30 31-40 41-50 >50

Highest Qualifications: Primary Secondary Tertiary (Undergrad) Tertiary (Postgrad)

Teaching Experience (yrs): <5 5-10 11-15 16-20

School Type: Government Gov't-Assisted Private

Section 2 – Using Analogies in Physics Teaching

Please read each statement carefully and indicate the extent of your agreement to each one by checking one of the following: A – Agree; SA – Somewhat Agree; N – Neutral or no answer; SD – Somewhat Disagree; D - Disagree

	Item	**A**	**SA**	**N**	**SD**	**D**
1	I make deliberate decisions to use analogies in my physics lessons					
2	I use analogies in my physics teaching frequently					
3	I believe using analogies is a good way to get students engaged in physics					
4	The use of analogies helps to develop students' imagination					
5	Analogy are helpful aids in the understanding of abstract concepts and processes which are difficult to perceive					
6	Analogy sometimes diverts attention from the main concept or misleads students					
7	If the teachers use analogy in an explanation, students reiterate it in their answers or discussions					
8	Purposeful use of analogies develops the ability to apply knowledge to new situations					
9	Learning with analogies requires mental meta-cognition, because it involves imagining one thing as another					
10	At the end of secondary education, most students have developed the skill of analogical reasoning					

<u>Section 3 - Please read the following statements and check all those that apply to you.</u>

What are your intentions when deciding to use analogies to teach a science lesson?

- ☐ To help students develop understandings for new information
- ☐ To help students visualize abstract concepts/processes
- ☐ To facilitate information transfer between familiar ideas/knowledge and new ideas/knowledge
- ☐ To help students remember newly learned material

<u>Section 4 - Please provide 2 examples of analogies you use in your science/physics teaching.</u>

1.

2.

Based on your experiences using these analogies you have identified, how effective (in your view) would you say they are in promoting science learning and high order thinking among your students? Explain your view.

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Appendix 2

Analogies in Physics Teaching: Experiences of Trinidadian Physics Teachers

Interview Protocol

1. What guides your decision to use analogy/ies in a science/physics lesson?

2. What do you consider when selecting a particular analogy for use in a science lesson?

3. What are some science topics for which you use analogies?

4. What are some examples of analogies you use in science/physics teaching?

5. How effective are these analogies when used? Explain your response.

6. State one (1) thing you feel must be carefully considered for the effective implementation of any selected analogy.

7. How effective are analogies for promoting high order thinking among students? Explain fully.

8. When you use analogies in your teaching, do you think that they are effective in achieving the learning outcomes you intend?