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The Roles of Figures of Speech in the Process of Conceptual Change in the Physics Classroom

By

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Dedication

The work on this thesis is firstly dedicated to God in whom I live and move and have my being.

This work is also dedicated to my husband who encouraged me and supported me in many ways all throughout my Masters degree.

This work is also dedicated to my family and my community who always encouraged me to pursue higher education and supported me financially throughout my educational years.

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The Roles of Figures of Speech in the Process of Conceptual Change in the Physics Classroom

Dahlia Sawma Yaacoub

ABSTRACT

This study investigates the role of figures of speech, mainly metaphors, analogies, and personifications in the process of conceptual change in the physics classroom. The objectives of this study are as follows: (1) documenting the views of teachers on the role of figures of speech and humor in teaching physics concepts, (2) examining students' views on the influence of figures of speech on their understanding of physics concepts, (3) observing how students interact with the use of figures of speech and humor in the physics classroom, and (4) investigating the relation between the roles of figures of speech and humor on a motivational and cognitive level. A mixed-method approach was used to conduct this research. Interviews were conducted with physics teachers; questionnaires were distributed to students, and a non-participant observation was carried out during a period of 4 months. A thematic approach was used to analyze the data which provided in-depth knowledge of how teachers and students viewed the roles of figures of speech in teaching physics. Teachers viewed figures of speech as a

tool that helps them transmit abstract physics concepts to students in a simpler and concrete way as well as it helps deal with student misconceptions. The study suggests several ways to overcome the drawbacks and make the most of the positive aspects. Questionnaires revealed that the majority of students understand physics concepts better when the teacher uses tools such as figures of speech to explain them. The research highlighted the effective role of teachers in discerning when to use the figure of speech and how to overcome its drawbacks when applicable. Non-participant observations enlisted several examples of figures of speech used and the positive responses of students towards them. This study makes an important contribution to using language tools in teaching physics concepts. It highlights the urgent need for all stakeholders to work collaboratively to include figures of speech in the physics curriculum as tools to enhance the process of conceptual change in the physics classroom.

Keywords: Figures of speech, Teachers, Students, Physics classroom, Conceptual change, Humor, and Humorous figures of speech.

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Chapter One

Introduction

Introduction

In the past few decades, educators have been exhibiting an increasing reliance on technology in the classroom, believing that it can be enough for conveying the required message to students. However, several studies have demonstrated the need for teachers to use various methods in order to ensure the effectiveness of the conceptual change process. According to Erneling (2010), technology alone cannot create the cultural context which needs to be built around teachers and strategies used in the classroom. Examples include teachers being flexible, able to react to specific classroom needs, and teachers needing to express themselves in ways that students relate to, such as through figures of speech. Wellington and Osbourne (2001) show that language is a crucial element of science, and hence should be taken seriously into consideration. It is sometimes because of a weakness in the language of science that students can misunderstand a concept. They also suggest practical strategies that can help overcome this barrier through pupil-teacher dialogue, scientific inquiry, awareness on the importance of talking, argumentation and discussion in the science classroom, as well as presenting ideas that require further research among others. If dialogue in the science classroom has such an essential role in the process of learning then what role would figures of speech and humor play throughout the process of conceptual change?

This study explores **the role of figures of speech in the process of conceptual change specifically in the Physics classroom**.

Schweingruber, Duschl and Shouse (2007) assert that students are in need of several symbolic, creative tools such as analogical reasoning and thought experiments that permit them to refine prior concepts. Niebert, Marsch, and Treagust (2012) argue that teaching and learning science without analogies and metaphors is impossible. For example, atoms are compared to solar systems. Lemke (1990), whose work mostly focuses on science through the medium of language, shows by conducting a study on secondary science students that they tend to be more motivated when teachers use figures of speech such as metaphors, personifications, humorous comments and rhetorical questions. In fact, their use has been observed since the past century. For this reason a minor section of this study will go beyond studying the roles of figures of speech to studying humor that figures of speech consequently induce in the physics classroom: Its role on a motivational and cognitive level in enhancing the process of conceptual change.

Kipnis (2005), for example, mentions that the use of analogy in the 18th century was noteworthy in how it helped interpret concepts in Physics from one branch to another. Furthermore, figures of speech have proven to be effective even outside the classroom. Gentner and Holyoak and Kokinkov (2000) claim that even scientists use metaphors for theory building. Jeppson, Haglund, Amin and Stromdahl (2012) assert that the prevalence of implicit conceptual metaphors in our everyday language affects our scientific literacy and understanding. Moreover, Harisson (2000) states that studying

metaphors is an attractive field for researchers since it offers effective learning experiences for students.

1. The aim of this study

This research seeks to document teachers' and students' views towards the role that figures of speech play in the process of conceptual change specifically in the physics classroom.

The specific objectives for this research are the following:

a) To explore the views of teachers on the role of figures of speech and humor in teaching physics concepts
b) To examine the views that students have about the influence of figures of speech on their understanding of physics concepts
c) To describe how students interact with the use of figures of speech and humor in the physics classroom
d) To investigate the relation between the roles of figures of speech and humor on a motivational and cognitive level.

2. Research Questions

In this study I will attempt to answer the following questions

a) What is the role of figures of speech in the process of conceptual change in the physics classroom?
   i. From the perspective of teachers
   ii. From the perspective of students

iii. From the non-participant classroom observations

b) What are some figures of speech used in the classroom? How do they help students grasp physics concepts better?

i. From the perspective of teachers

ii. From the non-participant classroom observations

c) What are the drawbacks of figures of speech in understanding physics concepts? How do teachers overcome them?

i. From the perspective of teachers

ii. From the perspective of students

iii. From the non-participant classroom observations

d) How is humor related to figures of speech? Does it enhance the process of conceptual change in a physics classroom?

i. From the perspective of teachers

ii. From the perspective of students

iii. From the non-participant classroom observations

3. Operational Definitions

a) Figures of speech: In this study, I am interested in figures of speech used in the Physics classroom to explain a physics concept, such as similes, personifications, metaphors, analogies, understatements, puns, irony and others. In other words, figures of speech are expressions used by the teacher to relate a physics concept to an object or a person in order to make it simpler for students

to understand. For example: Electrons are like ping pong balls in a tube and then the teacher continues to relate the similarities.

b) Conceptual Change: Conceptual change is the evolution and refinement of physics concepts learned by students in the physics classroom, as well as the rectification of misconceptions. In this study, conceptual change will be measured by the response of students to figures of speech used to explain certain physics concepts. The students' responses to the teacher's questions throughout the lesson indicate the success of the process of conceptual change that is taking place. For example the teacher can ask the students before explaining: "Who did not understand?" Then he can re-explain using figures of speech and ask again those students questions to check for understanding. Students' verbal responses such as completing the teachers' sentences or nonverbal reactions such as nodding can be indicators of understanding.

4. Overview of the thesis

This thesis consists of six chapters. In Chapter 1, I provide the introduction, the context and the aim for conducting this study. Chapter 2,reviews the literature which is related to the main topic of the thesis and the important key words in the title. This literature will lead us through the study. Chapter 3 describes the methodology used, justifies the instruments used, and describes the participants, the research sites, and the data analysis procedures. In Chapter 4, I present the findings on the teachers' and students' views towards the role of figures of speech (a small section will include the topic of humor), and findings from non- participant observations about

the role of figures of speech in the process of conceptual change in the physics classroom. I will also include findings about the drawbacks of figures of speech and ways to overcome them through instruction. Finally a small section will comprise findings about the role of humor, whether positive or negative, in the process of conceptual change in the physics classroom. Findings from each instrument are also categorized into different themes and the teachers' direct quotes from the interview give a clearer picture as to some of their opinions. Excerpts from transcribed non-participant observations will give examples of figures of speech used in the physics classroom and the role they play in the process of conceptual change. Chapter 5 discusses and analyzes the relevance of the research findings and how figures of speech play a role in the process of conceptual change in the physics classroom. The final chapter in this study is Chapter 6 which provides some suggestions for the relevant stakeholders, recommendations for further research and the conclusion.

Conclusion

Chapter one introduced the researched topic, listed the research questions and defined words that are fundamentally at the core of my study. In addition to that, it clarified the aim of my study giving an overview of what's ahead.

Chapter two includes a summary of the literature related to my study. It reveals the background on which my study rests.

Chapter Two

Literature Review

Introduction

This section includes a review of the literature related to my study. Some of the literature is directly related whereas others are indirectly related. Before reviewing some of the research conducted on the topic, I was interested in finding various definitions of figures of speech and conceptual change, mentioned in different studies. Since this topic is very recent, the definitions varied from one study to another. Due to this variety in definitions, I chose the simplest ones to specify the scope of my study. The literature review also includes studies about the uses and misuses of figures of speech in teaching a physics concept and about the role of teachers in transmitting a physics concept and specifically in overcoming the drawbacks of figures of speech making the best of their use. I also included a section about the sense of humor in the classroom. This chapter helps define terms. It provides the appropriate background for my study.

Definitions

1. Figures of speech

   One of the essential figures of speech used by teachers is the metaphor: The etymology of the word 'metaphor' is defined by Schon (1987) as originating from the Greek word 'metaphora' which means to carry across. According to Levin and Wagner (2006) metaphors are mostly used to transfer the meaning from one content

area to another facilitating the acquisition of complex or new concepts. Similarly, Cameron (2002) states that a metaphor links two completely different domains in a comprehensible way. Cameron (2002) names the concept that needs to be learnt ‘the Topic’ and the figure of speech that explains it ‘the Vehicle’. Consequently, she claims that in order for students to understand the concept in the light of the metaphor, they must be able to bridge the gap between the two. She also reveals that recent studies show that metaphors play a role both in linguistic and conceptual stages. Science textbooks also use pictures as 'explanatory metaphors' for children. For example, an immune system may be depicted as an army of white blood cells fighting the enemy which is the germ.

The reviewed literature suggests that there are several factors that affect the processing of metaphors by learners. According to Cameron (2002), some metaphors are easily interpreted due to their frequent use whereas other novel ones require more effort.

Gallant (1981) studies figures of speech such as personifications, and states that they can be dangerous if not properly used in the right context. These figures of speech sometimes mislead students into thinking that objects are alive the same way humans are. Moreover, Kallery and Psillos (2004) highlight that animism is the tendency that children have to treat objects as living and conscious whereas anthropomorphism is the inclination to attribute life, reasoning, feelings, etc., to nonhuman beings. Finally teleology is the inclination to attribute a purpose behind the presence of objects and non human beings (Kallery & Psillos, 2004). Hence,

figures of speech, if misused or not well explained can provide students with good conditions to nurture such tendencies.

In addition to personifications and metaphors, analogies are an essential figure of speech used by teachers in the classroom: Amin, Jeppson, Haglund, and Stromdahl (2012) stress the difference between metaphors and analogies, stating that a metaphor is a general term that explains one thing in terms of another such as attribute-based similarity, comparison, and mapping relations whereas an analogy is more specifically directed from one domain to another. For example, Kipnis (2005) specifically shows how Huygens used an analogy in comparing light waves to the ripple effect in water waves. There are two types of analogies used in education: Explicit and implicit. Jeppson, et al., (2012) analyzed educational textbooks to study the role of explicit and implicit metaphors in teaching the abstract and challenging concept of entropy and the second law of thermodynamics. They concluded that the range of explicit and implicit metaphors chosen to explain a specific physics concept should be consistent with one another and that multiple metaphors should be used to explain such difficult concepts in order to tackle them from different angles.

The importance of using analogies in teaching is highlighted by Clement (2009), who considers analogical mapping to be at the core of the process of conceptual change.

2. Conceptual change

Conceptual change is the process through which concepts and relationships between them change particularly throughout an individual's life or generally

throughout history. According to Shtulman (2009), conceptual change is a slow process that is difficult to complete. Vosniadou (1999) also defines conceptual change as the restructuring of preconceptions that is necessary for the learning process. Thagard (1992) claimed that conceptual change can occur by either instruction or experience, therefore the instructor must develop guidelines to lead the students through the process. ÇİLa and ÇEPNİ (2012) conducted a study that showed that the conceptual change approach is the most effective in teaching students since its objective is to increase students' awareness of alternative concepts and induce dissatisfaction with prior knowledge. Vosniadou and Brewer (1992) hypothesized that prior knowledge is made up of several interconnected observations, beliefs, and presuppositions that eventually constitute a relatively coherent explanatory framework. However, some of these presuppositions are harder to change than others. Vosniadou, Ioannides, Dimitrakopoulou, and Papademetriou (2001) agree with previous literature that by the time students enter elementary school, they have already acquired a few concepts about the physical world due to their experience, however they are different from the ones they will learn in the science classroom. Schweingruber et al. (2007) assert that throughout educational years, from K-8 through intermediate classes, children build on prior knowledge that they have already attained through their observation and experience of the natural world. Some of this prior knowledge evolves into misconceptions that can either be stepping stones to deeper knowledge or barriers preventing them from understanding true concepts. Hence the process of conceptual change plays a major role in making use of this prior knowledge, or changing it to allow children

to access present concepts. Schweingruber et al., (2007) list different forms of conceptual change: elaborating on an existing concept, restructuring a network of concepts and adding new levels of explanation. Depending on the difficulty involved teachers should modify their teaching to attain optimal learning.

Jeppson et al. (2012) define conceptual metaphors as relations between abstract concepts and concrete domains that we use implicitly in our everyday and scientific language. For example: When we say: "I fell in love" treating love as a container in which we fall in and out of, is a conceptual metaphor that we use implicitly. The study conducted by Jeppson et al. (2012) highlights the roles of these metaphors in solving scientific problems. They conducted a study on two PhD chemistry students solving problems on entropy and found out that conceptual metaphors if well prepared can simplify problem solving in science, since they are usually linked with one another in a way that eventually leads to qualitative and quantitative reasoning. Conceptual metaphors act as a cognitive resource and contribute to the understanding of scientific phenomena and to the iterative process of conceptual change. Hewson and Hennesey (1992) claimed that for a concept to be comprehensible, students must not only know what the concept means but also go further into being able to re explain it in their own words. Students must believe that this is how phenomena in the world occur and they must be able to link it to previous knowledge about how other objects behave in similar situations in order for the concept to be plausible. Finally, for the concept to be fruitful it must be both intelligible and plausible. It must consequently aid students in solving problems and to have a better explanation of what happens around them.

Treagust and Duit (2014) highlight the idea that the affective aspect that includes student motivation also needs to be developed in science teaching because it plays a major role in the process of conceptual change. Zembylas (2005) goes a step further arguing that it is necessary to develop harmony between the cognitive and emotional dimensions of learning that views emotions as of equal significance as cognitive outcomes rather than just means to attaining them.

Von Aufschnaiter and Rogge (2010) in their research on conceptual change suppose that students enter a science classroom with prior misconceptions. As they are being accompanied through their school years, their conceptions evolve into scientific concepts. Accordingly, some misconceptions are an outcome of students' daily experiences. Some of the wrong assumptions are:

a) Metals are colder than wood is a result of the sensory experience: usually they *feel* colder.
b) Students' everyday experience with cycling, pushing objects, and similar activities is, indeed, that they have to exert a (constant) force to get a steady speed for any linear motion.

The findings of this study by Von Aufschnaiter and Rogge (2010) conclude that instruction should focus on missing conceptions rather than on misconceptions. On the basis of their findings they have argued that conceptual knowledge is a result and not an initiator of learning activities.

Uses of Figures of Speech

According to Cameron (2002), metaphors might appear in the learning of formalized concepts. Firstly, when concepts are metaphorically structured, students need to learn the metaphors in order to understand the corresponding theories. Secondly, students use metaphors that they informally construct in order to understand those concepts. Finally, metaphors can be used by teachers to enhance conceptual change. Levin and Wagner (2006) have conducted several studies to explore students' perspective concerning the use of metaphors. The studies suggest that cognitive and discursive insights into metaphors play a crucial role in the acquisition of concepts. Moreover, Levin and Wagner (2006) claim that metaphors constitute an indispensible factor of communication because they help students and teachers to express ideas that they cannot easily communicate, allowing them to transfer complex concepts in simple ways while providing richness to the content discussed. A similar argument is also expressed by Kipnis (2005) who shows how analogies may lead to an exponential improvement in students' understanding of science concepts through critical thinking and creativity. Amin (2009) emphasizes that metaphors help concretize abstract concepts and aid in the scientific understanding of energy and several other physics concepts. His work shows that the way we implicitly use metaphors in our language reflects our understanding of scientific concepts and simplifies the process of conceptual change. For example energy has always been perceived as a noun but metaphors guided students into understanding it as a causal agent, ingredient, output or bi product of processes. Venville and Treagust (1996) studied the role of analogies as motivators in explaining a biological concept. Analogies used, such as relating a heart to a bucket and pump, provided the proper ground for conceptual change.

Along with a recurrent emphasis on the importance of the use of metaphors and analogies in science teaching, several studies make a case for the importance of stories and narratives in conceptual development and change. Hutchison and Padgett II (2010) show how stories stay organized in the students' minds, and are more easily retrieved from memory than fragmented concepts learnt. Their study claims that the use of both analogies and narratives can enhance the process of knowledge construction through facilitating reception, transmission, storage and retrieval of information. The study also lists two ways of using analogies in the classroom: On one hand, students can learn to create their own analogies and to clarify their own concepts as well as the concepts of others in a group setting; and on the other hand, the teacher can use them to explain more difficult concepts.

In summary, a corpus of research literature provides cogent arguments for the use of metaphors, analogies and narratives in science teaching. Wiser and Amin (2001) specify that there are topics in science in which metaphors and analogies are very essential to explain, such as heat. Niebert et al., (2012) state that the good use of metaphors and analogies helps in recognizing the imaginative structure of scientific theories and students' experiences. Lemke (1990) argues that personification, whether animism, anthropomorphism or teleology, can be very useful in teaching science; however, both teachers and students should be aware to use them properly.

Misuses of Figures of Speech

Cameron (2002) emphasizes the risk that some learners might not notice the use of metaphors. At other times, they might have little knowledge about the concepts

interpreted in the metaphor and may not be able to make the necessary relational connections. Kipnis (2005) claims that analogies may lead to several hypotheses and stresses the need for testing and verification before using such figures of speech. Hutchison and Padgett II (2010) state that while analogies can facilitate learning they can also lead to several misconceptions, and therefore teachers should ensure that their use will improve the organization of ideas and the retrieval of information. Brookes and Etkina (2007) agree that if misused, analogies can lead students to misinterpreting them and thus forming misconceptions instead of resolving them.

A small-scale exploratory study on animism and anthropomorphism performed by Kallery and Psillos (2004) concludes that these two methods can cause cognitive problems in children and may even lead to severe emotional problems in particular cases. The teachers on which the study was conducted claimed that they consciously used these methods to transfer knowledge due to their technical weakness in the particular scientific field they were teaching and in the pedagogical content (Kallery & Psillos, 2004). This study also shows that younger students are more susceptible to confusion being caused by figures of speech, and to misconceptions due to their inability to distinguish between fact and fiction. However, regardless of students' age, the choice of the figure of speech is a crucial factor affecting the effectiveness of conveying the message. Niebert, et al., (2012) claim that students will fail to understand a new concept that is being taught if the metaphor used is too complex and state that conceptual metaphors constructed by teachers can sometimes lead to misconceptions among students if they are too difficult to imagine.

Role of teachers

The importance of the use of figures of speech implies that teachers hold a significant responsibility in the conceptual change process. Indeed, teachers play an essential role as they are the ultimate contributors in getting the information through to students. As mediators in the conceptual change process, the responsibility of choosing the appropriate figure of speech, explaining it properly, minimizing its misuse and ensuring it has successfully conveyed the message, finally rests with them. Duit and Treagust (2003) agree that research on students' and teachers' views and roles in effective teaching and learning science has evolved into a very important field of science education research during the past decades.

Unfortunately, Anderson (2007),in his recent overview of research about science learning, claims that there is a large gap between all the recent studies taking place about improving conceptual change leading to more effective teaching and learning strategies, and what is actually being put into practice. Moreover Anderson and Helms (2001) also pointed out that the main reason underlying this tardiness in the evolution of science education is the lack of engagement of teachers in research taking place in this field. Duit (2007) agrees that science teachers in general have narrow views of teaching and learning science with respect to all the research occurring. In their analysis on middle school physics teaching in Germany and Switzerland, Duit, Widodo and Wodzinski (2007), highlighted that most teachers lack awareness about main ideas in the process of conceptual change. Their views towards learning are not coherent with recent research conducted about teaching and learning. In their teacher professional development, West and Staub (2003) claimed that it is essential to encourage teachers to

familiarize with the recent research and to help develop their views concerning this matter.

Mercer (2008) focuses on the indispensable role of spoken dialogue in the process of conceptual change. In his study, he refers to transcribed conversations among students and between students and teachers. Mercer (2008) concludes that talk and social interactions have such a crucial role in the process of conceptual change that they cannot be ignored anymore. According to Mercer (2008) we express our views and attempt to persuade other people to share our conceptual understandings through dialogue. We also tend to believe that one of the most important ways of changing someone's mind is to talk with them, hence revealing the importance of dialogue in the process of conceptual change. A research by Alexander (2006) goes further to show the importance of students' talk with an expert, which is a teacher in this case in the process of conceptual change. Mortimer and Scott (2003) show in their focus on student-teacher conversations how dialogue between these too may lead to a conceptual shift and a refinement of student's understanding of ideas.

Numerous researchers have asserted this role of teachers. According to Cameron (2002), teachers must provide students with similes in order to make metaphor use more explicit when students are faced with confusion. The study emphasizes that teachers must carefully select metaphors making sure that they can easily be interpreted by students and are clearly related to the concept to be acquired. Moreover, it stresses the importance that concepts to be learnt be developed in the class and that the metaphors be explicitly stated as such before they are used and put in context. Cameron (2002) adds that teachers are able to assess whether there is a need for more than one analogy

or for visual images to enhance students' conceptual connections. Aubusson, Harrison, and Ritchie (2006) also admit that even though explicit metaphors and analogies are effective teaching tools they can sometimes be misused. Hence, to overcome the limitations of analogy use, teachers must support the concept with more than one analogy when needed and should make sure that explicit metaphors used are consistent with the ones implicitly mentioned. Jeppson, et al. (2012) consent that it is the role of the teacher to apply multiple analogies when teaching students a scientific concept in order to give them a full picture of the concept. In addition to that, they affirm that teachers should be aware of when and how to use metaphors since students might tend to understand them literally. McCandless (2012) also claims that the use of one metaphor can be unfair since it reveals one aspect of the information being conveyed, and stresses that teachers should mediate between the metaphor and the student through written and oral discourse to lead students into developing clear scientific concepts. Lemke (1990) also agrees that it is very important that teachers start implementing more ‘humanized’ ways of expression in the science classroom. Chi (1993) argues that some scientific concepts are harder than others since they are under the ontological category 'processes’ rather than ‘matter’. However, students tend to put most concepts under "matter" as a category due to their simplistic view. According to Chi (1993), this is when teachers should use specific instruction tools such as analogies, in order to place each concept to its corresponding category; then as a result, students will find it easier to understand Physics concepts such as heat, electrical current and light. Schweingruber et al. (2007) highlight that models in physics are used to help students visualize a concept, object or process that are usually at a scale that is impossible to directly see or

manipulate. These models sometimes act as demonstrating metaphors or analogies. The range of difficulty in students' understanding of these models depends on the complexity of how they are related. However teachers should clarify that these are just models and not real representations.

According to Carey (2000) individual concepts can be linked together to build complex representational structures, such as propositions and theories. In order to do so, Carey (2000) suggests that the culture of the classroom must be changed: Teachers should be able to detect the children's prior knowledge so that they are able to classify them according to their level of understanding. Carey (2000) adds that teachers' awareness of the process of conceptual change, consequently allows them to realize that they should go beyond mere academic curricula to recent methods such as modeling techniques of case analyses and analogical reasoning. The bulk of science classroom culture should include the engagement of students in scientific discussions, allowing them to explain new concepts they learnt. Unlike previous terms and definitions used in literature Sinatra and Pintrich (2003), came up with a new term which is "intentional conceptual change" where they believe that teachers should intentionally initiate metacognitive processes where the children reflect on their own thoughts and motivational processes that catalyze a change in prior knowledge. According to a study conducted by Duit (2009), teachers and educators should design instruction suitable for conceptual change that includes:

1. Emphasizing phenomenon-based concepts because these are easier to grasp for students and provide a basis for further conceptualization.
2. Documenting students' misconceptions about the topic to be taught.

3. Preparing additional information to help students in concept acquisition.
4. Coming up with examples and problems to lead students into re-discovering conceptions established before.

Several studies have suggested different ways for teachers to use metaphors and analogies in their classrooms. According to Yip (2004), following the use of figures of speech in the classroom, teachers can direct students towards further knowledge construction through asking questions that help to test their knowledge. In addition to that, teachers in the study conducted by Kallery and Psillos (2004) claim that if a personification is supported by teachers' content and pedagogical knowledge, and if the teacher clarifies to older students that a personification is being used, it could be a good teaching aid. Gentner, Rattermann and Forbus (1993) stress in their study that analogies and narratives are not facts but rather just representations of the facts. For this reason, it is the role of teachers to make sure that students are able to relate the analogs and target concepts.

Hutchison and Padgett II (2010) conclude: "An analogy or a narrative is only as powerful as its creator is capable of making it clearly capture the facts" (p.4).

Humor

Figures of speech used by teachers in the classroom at many times result in introducing humor to the classroom. The idea of relating ‘serious’, ‘difficult’ and dry physics concepts to humans through personifications or to other objects through analogies or metaphors can be perceived as funny to students. These funny moments can sometimes be conducive to a learning environment and at other times be distracting. Duit and

Treagust (2003) show that cognitive and affective issues are interrelated, so humor can provide the conditions for students to understand concepts better. In a study based on surveys distributed upon language students and teachers, Askildson (2005) confirmed that humor seemed to play a crucial role in language instruction and learning, where it facilitated language acquisition by overcoming affective barriers. Even though one cannot deny the negative effects of humor when used excessively or when constantly directed towards a specific student in the classroom, this pilot study by Askildson (2005) greatly confirm the benefits.

Several empirical studies conducted by Parrot (1994), Derniere (1995), and Hillman (1995) have shown the influence that the use of humor can have in creating a positive learning environment. However educators must be aware that humor is volatile. According to Manke (1998) and Kothoff (2006), humor is affected by context and culture so what may seem funny in a teaching environment might not be funny in another.

Students' views towards humor greatly affect the importance of their role in education. For this reason, St. Pierre (2001) and Wanzer and Frymier (1999) and of course many other empirical studies showed how teachers' use of humor in the classroom positively affect the rating of the teacher's effectiveness by the students. Neumann, Hood and Neumann (2009), conducted interviews with a sample of 38 students to study the effectiveness of humor in an undergraduate statistics course at university. The results showed that humor made teaching more entertaining, helped simplify content, avoided boredom through decreasing monotony, and provided a mental break for students. It also helped motivate students, increase their attention span, and induced a positive

learning environment. A minority of students who already understood this subject easily, claimed that humor used by teachers can sometimes be irrelevant or distracting.

Tamblyn (2003) came up with five reasons to use humor in the classroom: it decreases stress, it can act as an ice breaker and bring people together, it restores visual memory and relevancy, it involves emotions, it allows the brain to rest and make meaning out of the concepts learnt and finally maximizes attention span. In addition to that, Struthers (1994) agrees that humor in the classroom increases motivation. According to an essay written by Iyah, Gordon-Messer and Kosinski-Collins (2010), humor in the classroom motivates students and allows their engagement in classroom activities. Gorham and Christophel (1990) in their investigation of the importance of humor in the teacher's closeness to students agrees that humor can decrease stress and boredom and raise interest and motivation consequently humanizing the teacher's image. St. Pierre (2001) adds that humor helps students preserve concepts learnt and allows them to enjoy the lesson. Hillman (1995) from another perspective asserts that it increases creativity and encourages divergent thinking guiding students into thinking 'outside the box'.

However, Hillman (1995) warns that teachers should avoid using humor that is irrelevant to the material to be learnt, they should also be careful not to use humor excessively since this might lead to distractions. Goodman (1992) in his study on humor also mentions that one should avoid sarcasm that is directed towards the students. His study concludes that humor should be constructive rather than destructive.

Examples of Common Misconceptions and Figures of Speech

Schweingruber et al., (2007) mention that there are several physics misconceptions that students deal with throughout generations. For example students often associate forces with movement and fail to recognize forces acting on objects that are in equilibrium. In addition to that, they view forces as something that starts a motion rather than stops it (which is what makes it hard for them to recognize friction). Schweingruber et al., (2007) explain that students mistake forces for properties of objects rather than features of interaction between objects. There are many physics misconceptions that are acquired during childhood years and accompany students to adulthood due to inappropriate instruction. For example: Confusion between air pressure and gravity, momentum and force, current and voltage and many others. Grappling with several articles and books, I made a list of a few physics misconceptions and their clarification through the use of figures of speech.

1. One of the physics concepts that are uneasy to understand is the electron configuration. A paper by Hutchison and Padgett II (2010) tells us about a well developed analogy that helps students understand the functioning of electrons in an atom:

   The analogy relates an atom to the main building, atomic orbitals to apartments, and the principal quantum number corresponds to floor numbers. Electrons represent tenants in the building, henceforth, the electron configuration is the address for each tenant in the building, and energy levels are floors in the building where energy is rent. The higher floors require more occupants.

   The analogy goes further to describing Physics principles such as:

a) The *Aufbau principle:* renting out the ground floor before penthouse. That is the electrons fill the ground level before the other levels.

b) *Hund's rule:* when everyone gets his or her own room before getting a roommate. Electrons fill the levels before pairing up with other electrons.

c) The *Pauli exclusion principle:* stipulates that a roommate must be of opposite sex. That is electrons only pair up with other electrons that spin in the opposite direction.

As students are applying the Aufbau principle some of them usually tend to fill the upper sublevels before filling the ground level with electrons. Similarly, as they are applying Hund's rule they might have the tendency to pair up electrons before filling the rooms with electrons. The analogies stated above will help them retrieve principles and rules previously learnt, from their memory. They can also mix up by thinking that in the Pauli exclusion principle, electrons of same spins can occupy same suborbital but the analogy saying that the roommate must be of opposite sex reminds students that electrons must spin oppositely in order to be able to occupy the same suborbital (The roommates being the electrons and the room being the suborbital). This image helps understand these concepts better and avoid misconceptions in electron configurations.

2. Another physics concept that confuses students in grade 10, is the concept of the refraction of light i.e. why light changes direction when it passes from one transparent medium to another as a result of a change in speed. Students are confused whether the light speeds up or slows down when it passes from air to glass or vice versa. In order to avoid this misconception in a study conducted by Treagust,

Venville, Harrison and Tyson (1997) a teacher was asked to use an analogy to compare light to a pair of wheels (a toy car). The teacher through a demonstration showed how a toy car speeds up when it is rolled from a hard surface to a softer surface. Treagust et al., (1997) studied the students' acquisition of this concept using analogical worksheets followed by interviews. The students who were taught by the same teacher without using the analogy as a tool showed that the concept was intelligible but not plausible. The interviews conducted with the students showed that they were able to know that the light rays change speed when they pass through different densities but they failed to explain why, or to link it to prior knowledge. One of the excerpts of the students who were taught using the analogy, shows how the analogy reminded the student of the concept and helped her in relating it to other concepts consequently being able to use it in everyday life situations.

Treagust et al., (1997) show that at the beginning the student was not interested, then once the analogy was introduced she became dissatisfied with her previous answer to the question and was motivated to answer all the following questions shifting from unclear ideas to specific correct responses. Students understand new concepts better when they are linked with prior ideas of the world around them. The excerpt clearly shows how the student related the analogy with the refraction of light. After mentioning the analogy she was no longer convinced with her previous understanding of refraction and as a result she changed her drawing.

3. Carey (2000) includes another confusion that the students often face, which is related to density and mass. She suggests that the teacher can first use a visual model that acts as an analogy: A multibox that includes several boxes and each box

has a certain number of dots in it which is equal to the ones in other boxes. Then the students are asked to count the total number of dots in the multibox, which refers to the mass which is an extensive property (depends on size),whereas the number of dots per box refers to density which is an intensive property (does not depend on size).

4. Schweingruber et al., (2007) refer to recent studies that show how young preschool children who, according to Piaget, cannot usually distinguish between distance, speed and time are now able to do so due to symbolic forms that help them relate objects to scientific concepts. For example: comparing a clock that says 10 to one that says 20 seconds, a distance strip, and two animals that are known to be fast or slow are symbols used to highlight the difference between time, distance and speed respectively even at a very young age.
5. Wiser and Amin (2001), highlight that the main reason why students have a misconception about heat is ontological. The students think that heat is connected with hotness while the scientific concept of heat is the exchange of energy. Students find a difficulty in differentiating between heat and temperature. Their inability to view heat as extensive rather than an intensive property is related to their ontological attachment with the concept of heat as hotness and not energy since according to their point of view energy cannot be hot. A computer based model that uses analogical reasoning to show how energy is distributed in a piece of steel before and after equilibration is used to help students understand the concept. The model shows a hot object which has quick moving molecules "giving" some of its energy to slower moving molecules in the cold object. The teacher can support this

model with an analogy of someone having a lot of money giving money to one that has less money. In this case the one that has more energy gives to the one that has less. The word ‘gives’ can guide the students into a personification that helps them relate "quick molecules" to a ‘rich man’. The model showed the object with the letter E distributed all throughout it. Heat was linked to the number of E's in the model while as temperature to the crowdedness of E's. Model molecules were represented by moving circles, and springs symbolized forces between molecules. This study showed how computer models and metaconceptual teaching helped in inducing a conceptual change through category transfer from heat as a concept to heat as a process, from being an intensive to becoming an extensive property.

6. Jeppson et al. (2012) in their study on explicit and implicit metaphors discussed a few explicit metaphors that help students understand specific physics concepts, for example in entropy as disorder, thermodynamics processes are linked to movements along a path, and energetic exchange is linked to financial transactions.
7. The findings of a study by Christensen, Melzer, and Ogilvie (2009) revealed that the most common misconception among students in understanding entropy and the second law of thermodynamics is that the entropy of a system and its surrounding is conserved in spontaneous processes. This misconception is formed due to the confusion between entropy and energy which is conserved. The misconception that entropy is conserved consequently leads to difficulties in the role of entropy in the second law of thermodynamics. The metaphor that entropy is disorder has been used repetitively. However, a study by Brosseau and Viard (1992) deduced through analyzing interviews conducted among students that it led to misconceptions. This

analogy led students into thinking that if entropy is disorder then as volume increases, disorder should increase as a result, and entropy would increase too. Brosseau and Viard (1992) in this case say that more metaphors (such as entropy is freedom, spreading information, substance or monetary value) should be accompanied by the disorder metaphor to give students a more complete picture of what entropy really is. This metaphor of "entropy is freedom" was used explicitly used in Zumdahl (1998) and Young Freedman (2003) where it was followed by more explicit examples of metaphors such as a messy room, and a shuffled deck of cards.

8. Jeppson et al. (2012) also claim that heat is the process of transfer of the energy motion of particles. To clarify this claim, it was metaphorically related to substance -like entities that change place. Zumdahl (1998) used a metaphor to clarify that work performed and its outcome are like one substance (Work energy which is transformed into heat energy).Young and Freedman (2003) also used implicit metaphors treating heat and work as a substance, for example: an engine can absorb, discard or reject heat" as if it were a substance.
9. They even went further to relating energy exchange to financial transactions. Zumdahl (1998) claims that if you have 50$ and you give it away to a millionaire it will not make a difference but if you give it to a poor college student it will be of great significance. This was related to the transfer of energy through the flow of heat. Energy is also conceptualized as a possession: You give or take energy, as if it were something that you own. All these metaphors help in clarifying the concept of energy and how it is lost and gained.

10. Bowley and Sanchez (1999) related science to a house made up of building stones which are facts. He continues that if the facts where not well built it will just be a heap of stones. This metaphor guides students and teachers into building scientific knowledge using prior knowledge and not just memorizing concepts randomly.
11. In order to avoid confusion between electric current and voltage which is very common among grade 7 students, Padilla, Miaoulis and Cyr (2009) in their physics book use analogies to show the difference. Electric current is related to a flow of water whereas voltage is related to a difference in the height of a roller coaster ride that causes the roller coaster to move. So it's the voltage or the difference in potential that allows the current to flow if the path is complete. The difference in height is related to the potential difference between the positive and negative terminal of the battery, whereas the water flow is related to the current.
12. Padilla et al. (2009) also relate a closed circuit to a race track. If the race track is broken the cars cannot move. If the electric circuit is broken the current cannot flow either. However in this case, the teachers should avoid misconceptions emphasizing that in a race track, the cars will reach the broken place and stop whereas in an open circuit, the electrons will not move at all. Students may get confused between an electric circuit and a current.
13. Padilla et al., (2009) relate resistance of a circuit to water pipes. The wider the pipes the greater the water flow and consequently, the less the resistance of water flow. The same applies for the length of the pipes. However, the longer the pipes, the more the droplets will collide with the walls of the pipes, therefore the less the water will flow and the greater the resistance. The pipes are related to electric wires, the

water flow to the current and finally the resistance of water to the resistance of current. This will help students better understand the concept of resistance and avoid confusion when dealing with increase and decrease of resistance.

Conclusion

This literature review provided background about the topic. It clarified many words and definitions. It also emphasized the aim of this study. The literature also helped me design my methodology in a way that is valid but at the same time new and innovative. Chapter 3 describes the methodology I used to carry on this study.

Chapter Three

Methodology

Introduction

The main aim of this study is to investigate the role of figures of speech in the process of conceptual change in the physics classroom. The students' and teachers' views are taken into consideration through questionnaires and interviews respectively, in addition to a non-participant observation that examines the role of these figures of speech applied directly in the classroom. Moreover, this research study also includes a minor sub section that explores the link between humor and figures of speech used in the classroom, and how humor plays a role on a motivational and cognitive level in the process of conceptual change. In this chapter I provide a description of the methodology which will be followed in this study.

A mixed methods approach was employed in this study as it provided answers to the following research questions being investigated:

- What is the role of figures of speech in the process of conceptual change in the physics classroom?
- What are some figures of speech used in the classroom? How do they help students grasp physics concepts better?
- What are the drawbacks of figures of speech in understanding physics concepts? How do teachers overcome them?

- How is humor related to figures of speech? Does it enhance the process of conceptual change in a physics classroom?

In order to include the participants' views as a central part of this investigation, the data corpus included questionnaires distributed to physics students (See Appendix A) and audio recordings of interviews conducted with physics teachers. In addition to that, data also included a transcript of classroom observations conducted in a grade 10 physics classroom to investigate how the use of figures of speech affects the learning process of students.

1. Research Method

After reviewing the literature related to the research focus and delving into the research questions, I noticed that it is really difficult to conceptualize the process of conceptual change. Therefore I tried to find a method that can help me achieve this. As mentioned above, a mixed-methods approach was used to collect and analyze the data. According to Johnson and Onwuegbuzie (2004), a mixed- methods approach is the type of research where the researcher joins quantitative and qualitative research methods.

Three methods of data collection were used:

a) Questionnaires
b) Interviews
c) Non-participant observations

Firstly, I wanted to understand how students view figures of speech in the physics classroom. To do so, I developed the following guiding questions that were included in a questionnaire: Do you think that figures of speech help you better understand difficult concepts? Do they distract you from understanding the core concept? Or do they have no role at all in your learning process? These guiding questions led to designing a set of 20 declarative statements which made up the core of the questionnaire.

Secondly, I was interested in finding out physics teachers' view towards figures of speech and how they facilitate the communication of new concepts to students and help avoid common misconceptions. I also wanted the teachers to provide me with some examples of figures of speech that they use in the physics classroom.

Finally, I also observed a Physics classroom to further understand how teachers utilize figures of speech as well as to explore students' views and reactions to them during physics lessons. Therefore, the methodology and underlying methods adopted by this study were guided by the above mentioned research questions.

The following sections will address the data collection methods, and the data collection procedures as well as issues regarding validity, reliability and ethical considerations. Following this is a description of the population and samples, and finally the measures for data analysis used in this research will be explained.

a) Questionnaires are an easy way of collecting data concerning views of a certain population that require minimal effort. Cohen, Manion, and Morrisson (2007) agree that distributing questionnaires is a very essential method for collecting

data that can be conducted in the absence of the researcher. This data collection method simplifies the analysis of other data due to its short questions and rating scales. (See appendix A for a copy of the questionnaire). The questions in the first section of the questionnaire were mostly about age, gender, grade level, number of physics periods and were purposely written since answers could sometimes be affected by gender, age and level of difficulty of the subject. The response categories in Section B of the questionnaire were designed using a Likert-type scale which consisted of a series of declarative statements. In a Likert-type scale, participants are asked to choose one of the five options which are: 'strongly agree, ''agree,' 'undecided,' 'disagree,' and 'strongly disagree.' Recent studies, for example Chang (1994) and Canty-Mitchell & Zimet (2000) have proven that the Likert-type attitude scales are relatively reliable and valid instruments for the measurement of attitudes. I constructed all the statements on the Likert scale. The statements are based on the literature review and are developed based on the research questions.

Questionnaires were distributed among 95 students whose ages range between 12 and 18. The students were given the option not to disclose their names, for confidentiality purposes. However, the schools they study in, their gender, age and number of physics periods weekly attended were asked of them to help with the analysis. I distributed these questionnaires in a place that is frequently visited by teenagers from both genders and from different schools. I conducted a pilot study, by distributing these questionnaires among other students not included in this study. The pilot study helped me improve my questionnaire in a

way that makes it easy for teenage students to fill in. The questionnaire helped provide a quantitative aspect to my study. The questionnaires were statistically analyzed using Microsoft Excel worksheets and by cross-break tables that helped me get an overview on how students perceive the use of figures of speech in the classroom; i.e. if they help them understand physics concepts better and if they believe that figures of speech have helped them understand a concept that they had previously misunderstood. Table 1 below presents a description of the categorization of the areas of focus of the questionnaire items:

Table 1

Main areas of focus in students' questionnaire.

Areas of Focus	Item Number	Number of Items	Sample Item
Positive Role of Figures of speech	3, 4, 7, 8, 12, 15 Section: B	6	I understand physics concepts best when they are taught using analogies.
Negative Role of Figures of Speech	6, 9, 10, 11, 13, 14. Section: B	6	I remember the metaphor without remembering the concept learnt while studying alone.
Positive Role of Humor	16,17,18	3	I am more excited to learn a new physics concept when the teacher introduces humor in the classroom.

Negative Role of Humor	19	1	I am distracted when the teacher jokes in the science classroom.
Humor and Figure of Speech	20	1	The figures of speech the teacher uses make me laugh.

Another method of data collection that led me to delve deeper into my analysis is the interviews that were carried with physics teachers. The interviews included the view of teachers concerning the themes mentioned in the table above going a little bit further to discussing types of figures of speech used. In the section below I will be discussing in more detail the interviews that were held with teachers.

b) According to Mertler (2009) conducting interviews helps provide the best qualitative data. For this reason, I chose to use interviews in collecting data about teachers' views towards the roles of figures of speech in teaching physics. This helped me get a detailed record of types of figures of speech, their advantages in understanding a new concept or in clarifying a misconception, their drawbacks, how to overcome them and a subsection about humor. The interviews carried out with teachers are semi- structured interviews where some of the questions are preset while others came up spontaneously (see for instance Fraenkel & Wallen, 2008). Most of the questions are open-ended which provided teachers the opportunity to express freely their views as mentioned in

Desimone & Le Floch (2004). The semi-structured interview used in my research consists of 13 questions (See Appendix B).

The Interviews were conducted with nine physics teachers from both genders and teaching in different schools ranging from novice to experienced teachers. They were interviewed about both the positive and negative aspects of the use of figures of speech. They were asked to give examples of figures of speech they have already used, why they used them and how did they help in the students' acquisition of new concepts and in the building of prior knowledge. Teachers were also questioned about the prevention of drawbacks of figures of speech. The final section of the interview included questions about the advantages and disadvantages of humor in teaching physics on a behavioral and cognitive level and how is this field linked with figures of speech. These interviews were analyzed qualitatively (Mertler, 2009). I highlighted themes that the interviewees mentioned that are similar to the themes mentioned in the questionnaires such as: Examples of figures of speech, positive roles of figures of speech, drawbacks of figures of speech, overcoming the drawbacks if possible and a subsection about humor and its relation with figures of speech (see for example Braun & Clarke, 2006).

c) Classroom Observations: I conducted non-participant classroom observations in a grade 10 physics classroom for the duration of around 4 months, for about 16 hours (See Denzin, N.K. & Lincoln, Y.S., 2011 and Creswell, J., 2007). I also sought to obtain prior approval from both the teacher and the school involved. I noted certain figures of speech used by the teachers and worked on tracking the

understanding of students. The teacher was asked to try to use more frequently figures of speech and ask the students questions so that I was able to note the effect of these figures of speech on the students' understanding. For example the teacher asked students questions such as: "Who understood the concept better after I gave the example? Who wants me to explain it more?" The teacher was also recommended to ask students about the concept learnt. Through the questions raised, I observed whether the students reused the figure of speech to re-explain the concept learnt, remembered the figure of speech and forgot the concept learnt or if it had no effect at all on the understanding of new concepts. I also observed the verbal responses of students after the teacher used the figure of speech to explain a concept such as: agreeing verbally with what the teacher is saying, asking further questions, answering the teachers' questions correctly or verbally expressing that they understood the concept better after the figure of speech was used. The teacher asked oral questions to the students throughout the lesson. This helped me record how students' concept development is influenced by the teachers' use of figures of speech. I also engaged in a few informal conversations with students after classes to collect more data on this matter. I coded the transcribed classroom observations and divided them into themes that were similar to the ones mentioned in the interviews such as: Examples of figures of speech used in the classroom, roles of figures of speech used, positive and negative responses of students, overcoming the drawbacks of figures of speech used and incidents when figures of speech were humorous and how this affected the learning environment in the classroom.

2. Accessing the school, teachers and students

The sampling method used is convenience sampling. I interviewed nine physics teachers whom I know from my professional background as a physics teacher. I met up with them outside the school premises. I also performed part of my study in a Catholic school located in Cornet Chehwan. This school was firstly founded as an all-boys school but eventually evolved to including both genders. This is where I conducted my non-participant classroom observations and held informal conversations with students. Since I work at the school, I followed the school policy on how to gain access to a grade 10 classroom: I visited the school rector explaining to him the aim of my study and asking him for permission to observe the classroom of one of my colleagues in high school. After I gained his permission, I also explained to the teacher whom I was observing the aim and duration of my study. As for the questionnaires they were distributed in a youth camp done for students whose age range is between 12 and 18. I also collected around one hundred questionnaires. I could have distributed the questionnaire in the same school, but I preferred to have students from at least three different schools fill this questionnaire, in order to obtain different perspectives. I asked the camp leaders to sign a consent allowing me to conduct my study.

3. Limitations

a) Questionnaires: There are several limitations concerning using a questionnaire as a tool for collecting data: Firstly, we cannot tell whether the population is

responding truthfully to the questions or if they are not taking it seriously (see for instance Cohen et al., 2007). Secondly, we can never know whether the respondent wanted to clarify his answer or specify certain conditions. This stops the participants from providing the researcher with a fuller picture. An extra section where the participants could have written their additional thoughts or remarks would have helped. However, disregarding the limitations, this method of data collection seemed to be effective since it helped collect data from around 100 students in a short period of time and it provided a quantitative aspect for my study. This method also provided an easy way for young students to be able to express their views concerning the role of figures of speech in their understanding of physics concepts.

b) Interviews: Interviews can be time consuming (see for instance Grinnell & Unrau, 2008) and that is one of their major disadvantages. They require a lot of effort such as: travelling long distances, re-scheduling several interviews due to the time constraint of participants, or unavailability. I can recall several times when I had to wait 2 months before I could obtain an appointment from the teacher. One of the interviews required a 2 hour drive Even though interviews may require a lot of effort, I was keen on using them in my study because they provided the bulk of my qualitative data.

c) Non- Participant Observations: There are two major limitations that I dealt with as I collected data from observations. Firstly, observations consume a lot of time as mentioned in Guest, G., Namey, E.E., & Mitchell, M.L. (2013) and Mack, N., Woodsong, C., MacQueen, K.M., Guest, G., & Namey, E., (2005). Especially

that I am a full time physics teacher in a school, I found it challenging to find a free period when I could observe another teacher. That is why my class observations do not show consecutive physics periods bur rather independent once a week observations. It also took a lot of time to transcribe them. The second limitation is that, it was hard to note all the events occurring in the classroom: The figures of speech used, all reactions by students and so on. Even though it may not be exhaustive, however it is sufficient to collect data about the subject I'm researching.

d) Research Quality

Quality in educational research is crucial throughout the process. There are several ways to maintain it. I personally considered the following in my study: triangulation, validity and reliability, trustworthiness and ethical considerations.

i. Triangulation: According to Mertler (2009), Eisenhart (2006) and Cohen et al. (2007), relying on one source of data collection might make your study biased, therefore it is only logical that several sources will increase the validity, reliability and trustworthiness of the study, particularly if it was a mixed methods approach. The data in this study were gathered from: questionnaires administered to students, interviews with teachers, and non participant observations. These three methods led to triangulating the data collected. The triangulation method helps prove that the data collected is consistent, even though it is collected from several sources.

ii. Validity and Reliability: Validity is an important aspect of research quality that should be attained most of the time. The study that I am conducting is valid since according to Johnson and Christensen (2000), it is plausible, credible, trustworthy, and therefore defensible. This study includes all responses given by teachers and students without bias. This method includes several different views on the subject I'm researching. The validity of this research is addressed through honesty, depth and thick detailed description and richness of data since my study is mostly qualitative (see for instance Cohen et al., 2007 and Creswell, 2007). However because it includes several methods of collecting data, it can include a range of different views.

iii. Reliability is a consequence of validity (see for instance Lincoln and Guba, 1985). Since validity is attained in this study, then it is assumed that reliability is acquired too as a result, as in any qualitative research. The research must also be unbiased and lacking mistakes for it to be valid and consequently trustworthy.

iv. Trustworthiness: In a qualitative study, for the research to be trustworthy, it has to be credible, accurate and dependable. Trustworthiness can never be disregarded since if the research facts are not trustworthy then the whole study is suspicious (see Lincoln & Guba, 1985).

v. Ethical considerations: Before going out into the field, I obtained the approval of the IRB office to carry on with my study. I took an online course about ethical considerations and I sat for a test and eventually received a certificate proving that I succeeded in this course. Afterwards, I sent the

proposal, interviews, and questionnaires to the IRB office to test for flaws in ethical considerations, such as obtaining consents, respecting privacy, maintaining confidentiality. The participants should be voluntarily participating in this study and should be fully informed of and understand the nature of my research. I made sure all my participants whether teachers or students are aware of the study that they are choosing to be part of. Participants were allowed to ask questions or clarify about any issue that has to do with my study.

vi. Pilot Study: I distributed the questionnaire among around 23 graduate students taking an English education class at an American medium University in Lebanon. Most of the comments received by these students were English grammatical mistakes and improvements in the format. One of the comments included that the statements should be simpler for young students to understand, another one suggested to add the definitions of analogies, personifications, and metaphors at the beginning of the survey and so on. I took most of the comments that were given into consideration, and this helped improve my study.

Conclusion

In conclusion, my study is mostly a qualitative research that includes several methods of collecting data such as interviews, non-participant observations, and questionnaires that helped me collect a wide range of data for my study. Nonetheless, validity and reliability issues were taken seriously in order to be able to attain trustworthiness. Most importantly, the IRB office approved my study which provided assurance over ethical

considerations, especially after all participants were informed of this research and their rights and privacy were respected. This chapter also enlisted the limitations of my study and identified the quality of my research discussing ethical considerations, triangulation, validity and reliability. Chapter 4 builds on the methodology chapter. It lists the results and findings of my study after carrying on with the methodology.

Chapter Four

Results and Findings

Introduction

This chapter presents the findings derived from the different methods of data collection used for the study. The major aim of this research was to examine the role of figures of speech in the process of conceptual change in the physics classroom. The views of teachers and students were greatly taken into consideration. In addition to that, data was collected from a non-participant observation of a grade 10 physics classroom to support my study. Studying the drawbacks of figures of speech and how teachers overcome them was another objective. Finally, a section about humor was included. Given the aims of this research, both teachers' and students' views played a pivotal role in the analysis of the data. Data obtained from the interviews, questionnaire and non-participant observations were categorized into themes. This provided a rich source of information on the role of figures of speech in teaching and learning physics. The data collected are available as tables in the appendices and organized into categories and themes depending on the method of data collection.

1. Teacher Interviews

   In order to analyze the teachers' interviews, I first transcribed the audio taped interviews. Transcribed recordings were reviewed by me and cross-checked by my advisor. The analysis of the interview responses was based on what was spoken by

the participants. This was done to ensure the validity of the data. Data was organized into tables which can be found in the appendices: The first table includes the views of physics teachers on the role of figures of speech, examples of figures of speech, and a few notes. The second table describes the drawbacks of figures of speech, overcoming them and whether figures of speech are usually prepared beforehand. Finally, the third table includes data about the role of humor, examples of humor, overcoming its drawbacks and finally its relation with figures of speech. The Interviews were used to answer the following research questions, specifically from the teachers' views:

- What is the role of figures of speech in the process of conceptual change in the physics classroom?
- What are some figures of speech used in the classroom? How do they help students grasp physics concepts better?
- What are the drawbacks of figures of speech in understanding physics concepts? How do teachers overcome them?
- How is humor related to figures of speech? Does it enhance the process of conceptual change in a physics classroom?

The data collected from the interviews is organized according to five major themes: Roles and examples of figures of speech, overcoming drawbacks of figures of speech, roles and examples of humor, overcoming drawbacks of humor and finally the relations between figures of speech and humor. It is important to note that all data included in these five sections reflect only the teachers' views concerning these topics.

a) Roles and examples of figures of speech

Referring to the tables in Appendix C, one can note that all teachers agreed that the figures of speech have a crucial role in the process of conceptual change in the physics classroom. For example, teacher 1 (grade 9) stated that figures of speech relate new concepts to prior knowledge and relate physics formulas to formulas learnt previously helping weak students realize that all sciences are interdisciplinary. Teacher 1 also added that figures of speech are most effective when a teacher wants to start a new concept or treat misconceptions. Some of the examples that s/he gave were as follows: Relating electric potential difference to gravitational potential difference causing water to flow from a high level to a low level and relating potential difference to students moving from a crowded room to a less crowded room. The teacher also used verbs to describe concepts and objects that are usually used to describe human behavior. Teacher 2 (Grade7-8) gave an example to show how students reuse figures of speech learnt, to re-explain a concept since s/he claimed that figures of speech are very important to them and the students memorize them. The example states that after teacher 2 related electron orbits to planets, s/he asked the students a question and one of the students replied: 'It's like the solar system you explained for us'. In addition to these two teachers, teacher 3 (grade 12) stated that figures of speech allow students to understand Physics concepts better **not always but when needed only**. S/he added that they make a concept easier and clearer to understand and help change a misconception. S/he affirmed that figures of speech are most effective when there is a misconception or when the students

didn't catch the idea, confirming that students sometimes reuse the figures of speech to explain a concept acquired during peer coaching activities. Teacher 3 also mentioned that the figure of speech and the concept are so much related, that students can't remember one and forget the other. "They stick together in their minds" s/he said. Moreover, teacher 6 (grade 12)listed the following roles stating that figures of speech are used when the idea is not grasped immediately and when the idea is still unclear in the students' minds, even if they know how to apply it when solving exercises. S/he said that they also help students grasp the concept more easily and they relate Physics concepts to other Mathematical concepts that help shape the students' logic, and to other Physics concepts ensuring that they are gaining understanding of the whole Physics program. The example given was the following: Relating electrical resonance to mechanical resonance or pendulum to rotational oscillations. S/he claimed figures of speech can be used as a tool for initial understanding and s/he explained that students reuse the figure of speech to explain a concept to an absent student but they do not use it when s/he asks them a question since they know s/he's interested in their understanding rather than in the figure of speech itself. Teacher 6 also added that s/he uses figures of speech in the humanities sections more than in the scientific sections because scientific sections take lab sessions and can imagine abstract concepts better. Another example that teacher 6 gave was relating potential energy and the reference to people depositing their money in the same bank. Finally teacher 9 (grade 10) stated that figures of speech are most effective when they help students understand an abstract concept because

they relate it to something concrete, to a concept in real life, or to something they already know. S/he explained further saying that when students are learning a concept that is related to an old one, they can build the new concept on prior knowledge, whereas when s/he is teaching students a totally new concept, then s/he should be creating a new section in their minds that acts as prior knowledge. So the figure of speech used helps them construct the new concept in their minds. S/he added that figures of speech help in changing a misconception or when there's a difficult concept to be learnt. Some of the examples s/he gave were as follows: S/he related a generator to a bank that distributes money to people who spend it in shops relating the shops to passive dipoles that spend electricity. S/he related x and y axes to pockets on which diagonal forces are projected, and s/he linked the force being a vector quantity to a situation where one is trying to place a delivery order and explaining to the delivery man where the house is (the importance of the four characteristics of a vector). Teacher 9 concluded that even students who have graduated sometimes remind him/her of figures of speech s/he used in their class several years ago. All 9 teachers agreed that figures of speech have an essential role in changing misconceptions and in the explanation of a new concept. They all concurred that figures of speech clarify, simplify and concretize an abstract concept linking it to concepts they already know. They also agreed that students reuse the figure of speech to re explain the concept learnt when needed. All teachers except teacher 2 claimed that they use all types of figures of speech whereas teacher 2 claimed the s/he prefers to use personifications since they are easier to relate to oneself.

b) Drawbacks of figures of speech

Interviews held showed that all teachers agreed that there are very few drawbacks concerning the use of figures of speech in the process of conceptual change in teaching physics concepts. For example teacher 1 (grade 9), teacher 7 (grade 9 till 12), and teacher 9 (grade 10), stated that figures of speech sometimes only target one aspect of the concept leading the student to either an incomplete or a distorted understanding of the whole concept. However, these teachers indicated that there are methods to overcome this drawback, for example: teacher 1 and teacher 7 agreed that experience allows the teacher to be alert of upcoming potential misunderstandings and to warn students beforehand. Teacher 9 suggested chunking the concept into parts and using a figure of speech to explain only one part, s/he added that different figures of speech could be then used to explain the whole concept.

Another disadvantage noted by teacher 2 (grade7-8) is that sometimes the language is a drawback since physics is taught in English in her case, which is not the student's native language, hence concluding that figures of speech in English can sometimes be a hindrance in understanding a physics concept. However, teacher 2 noted that this drawback could be overcome by showing students pictures or concrete models that help them visualize the relation of the concept with the figure of speech. Teacher 3 (grade 12) and teacher 4 (grade 8) also noted that sometimes figures of speech do not relate with what is being explained and this leads to confusion among students. Both teachers agreed that the only solution to this drawback is experience in discerning the right place and

the right time to use the figure of speech. In addition to that, teacher 4 suggested that asking the students questions about the concept taught making sure that they understood it could be helpful. Teacher 5 (university students)proposed that it's better not to use figures of speech at all if one is not sure of their advantage in a particular situation. Moreover, teacher 6 (grade 12) claimed that sometimes students don't grasp the similarities between the figure of speech used and the concept to be explained and this confuses them. At other times, the figure of speech is clear in the teacher's mind but not in the student's. Teacher 6 added that figures of speech are not always his/her first resort in explaining a concept especially in scientific classes since s/he is concerned with forming the students' minds in a way to help them think in abstract terms. Teacher 6 included that the teacher should be confident enough to back down from attempting to use a figure of speech and noticing when it's not helping. S/he also claimed that the teacher should be cautious and should use figures of speech wisely. Finally, teacher 7 also mentioned that students could get confused between imagery and reality, and that the teacher must be alert and careful to remind students that this is not the reality but part of a bigger picture.

It is also important to note that teacher 1 and teacher 6 stated that they do not prepare figures of speech beforehand, that they believed that they come spontaneously with experience depending on what the students ask year after year and where they form misconceptions. Teacher 2, teacher 8 and teacher 9 highlighted the importance of preparing the figures of speech beforehand. However, teacher 2 added that sometimes figures of speech are triggered on the

spot depending on students' questions. Teacher 3, teacher 4 and teacher 7 claimed that one should do both, prepare the figures of speech beforehand when needed, making the correct links and avoiding drawbacks, and sometimes come up with figures of speech spontaneously upon the students' needs. Middle school teachers noted that American textbooks they use include figures of speech that can be helpful whereas High school teachers who use Lebanese books noted that their books do not include figures of speech, hence forcing them to come up with their own.

c) Role and examples of humor

All Physics teachers agreed that humor has a very important role on a motivational, behavioral and cognitive level in teaching Physics concepts. For example teacher 1 (grade 9) stated that humor helps students to understand a concept, to learn common misconceptions, that it motivates students, increases their attention span, helps them remember a new concept learnt, allows time to pass quickly and finally allows them to be closer to the teacher thus having implications on cognitive, affective, social, and behavioral levels. Some of the examples of humor mentioned by teacher 1 are as follows: Sometimes s/he explains something in a way and then she surprises them by telling them it's not true and then re-explains it in the correct way. Teacher 3 added that s/he uses humor to change the atmosphere when students have two consecutive physics periods since s/he believes that it gives them rest, prepares them for the concepts to come, and helps them relate concepts learnt with figures of speech that make them laugh. An example that teacher 3 provided us with is when s/he teaches the

students the right hand rule in electromagnetism relating the direction of the current, magnetic force and magnetic field to a hand taking the shape of a gun making students laugh every time they use the right hand rule in an exercise. Teacher 7 (grades 9 till 12) for example stated that through jokes s/he can carry the message across, and that students remember the concept if the joke is related to it. S/he also mentioned that humor relieves stress, helps students build a good relationship with the teacher, puts them at ease and motivates them. Finally teacher 9 (grade 10) highlighted that humor is crucial in classroom management especially that physics is considered by students to be a difficult and "dry" subject. S/he also included that humor catches the attention of students, makes them laugh, gives them a break allowing their brains to rest, refreshing them and motivating them for the rest of the period. S/he also mentioned that when s/he uses humor in explaining a concept, it helps students recall the concept in a better way because it's easier for them to remember a concept accompanied by a joke than a concept alone. S/he ended by saying that humor helps students in constructing the schema of the concept learnt in their minds and retrieving information. The example used to support his/her argument was the following: when explaining Newton's third law s/he gives the example of a human being running and then hitting an elephant. She mentioned that students laugh a lot at this example.

d) Avoiding drawbacks of Humor

All teachers agreed that humor, while having many advantages, has also some mostly behavioral disadvantages that can be overcome by classroom

management techniques. Teacher 2 (grade 7-8) for example suggested using humor depending on the group and the mood of the students, since some students take advantage. S/he also added that s/he mostly works on maintaining respect, teaching them that every place has its rules. Teacher 4 (grade 8) suggested that simply telling the students: 'Ok. It's enough, we laughed now let's go back to learning.' It could help in keeping the classroom under control. Teacher 5 (university students) added that keeping the time in which humor is being used concise, could help in maintaining a learning environment. Teacher 6 (grade 12) mentioned that s/he personally tells them at the beginning of the year that s/he sets the joking rhythm in the classroom. When students are joking and s/he wants them to stop she smiles and waits for them to stop. S/he also noted that if students know that she loves, cares for and respects them, s/he allows herself to joke, and then s/he would know that when s/he looks at them they will stop joking. However, s/he stated that before reaching that stage s/he prefers not to joke. Teacher 9 (grade 10) also agreed with teacher 6 that it is important for the teacher to be caring and loving because this makes all the difference since according to him/her students would feel it and consequently humor would have a minimal negative impact. S/he also mentioned that teachers should be delicate in using humor specifically sarcasm making sure it's not related to any sensitive topic. Finally s/he claimed that teachers should have a feel of what's happening in the classroom noticing if any one of the students is being defensive or is hurt so that s/he would talk to the student personally at the end of the period.

e) Relation between figures of speech and humor

All teachers who answered the interview question on the relation between figures of speech and humor agreed that at many times they are related. Some of the teachers provided a reason, for example teacher 2 (grade 7-8) claimed that figures of speech make students see things in a comic way and in new ways that make them laugh, teacher 4 (grade 8) stated the students laugh at some figures of speech used since they are not used to imagining the concept in a new way and teacher 6 (grade 12) mentioned that students find it funny to relate two different things in this way especially when the figure of speech is related to the concept learnt in an intelligent way, the students' minds enjoy it and you would see their eyes lighting up. Moreover, teacher 7 (grade 9 till 12) claimed that sometimes figures of speech are related to humor especially when they are linked to physical gestures or noises made during class. Finally, teacher 9 (grade 10) affirmed that figures of speech are related to humor especially when the teacher relates an object to human traits allowing the students to imagine it, and consequently, making them laugh.

2. Feedback from student questionnaires

Student questionnaires were distributed among 95 school students whose ages range between 12 and 18. All students returned the questionnaire. A number of statements about the views of students towards figures of speech were filled according to a 5 point Likert rating scale. The responses to the statements and questions concerned the following research questions:

- What is the role of figures of speech in the process of conceptual change in the physics classroom?
- What are the drawbacks of figures of speech in understanding physics concepts? How do teachers overcome them?
- How is humor related to figures of speech? Does it enhance the process of conceptual change in a physics classroom?

Data collected from these questionnaires was categorized into five major themes as listed below:

a) Positive role of figures of speech
b) Negative role of figures of speech
c) Positive role of humor
d) Negative role of humor
e) Humor and figures of speech

The questionnaire revealed the following findings:

a) Positive role of figures of speech

Concerning the positive role of figures of speech, participants had an overwhelmingly favorable view: Over 73% answered in agreement to the questions related to the positive role of figures of speech (either 'Agree' or 'Strongly Agree'), while only less than 10% answered unfavorably (either 'Disagree' or 'Strongly Disagree') and 16% remained undecided.

For example, 73% of participants indicated that they understand physics concepts better when they are taught using figures of speech, while only 8%

indicated otherwise. In answer to another question, 77% of participants stated that they understand the behavior of objects and particles and their interactions best when they are related to human behavior and interactions, while only 5% stated the contrary. Moreover, 79% of participants indicated that they sometimes remember certain science concepts just because of the good analogy the teacher used while teaching it, a statement that was refuted by less than 8% of the total participants. Furthermore, the use of figures of speech was deemed necessary, as 59% of participants viewed that their use is essential in their understanding of certain concepts, while 17% viewed otherwise.

It should be noted that the participants who agreed to the positive role of figures of speech are almost equally distributed among males and females. Moreover, of the participants who agreed to this positive role, 15% on average are in Middle School and 85% are in High School, which is in line with the overall distribution of the participants (15% of whom are in Middle School and 85% are in High School). Furthermore, an average of 61% of the participants who held a positive view of the role of the figures of speech are in English schools, while 40% are in French schools, which is in line with the overall distribution of the participants (60% of whom are in English schools and 40% are in French schools).

b) Negative role of figures of speech

On the negative role of figures of speech, participants held a less favorable view: Over 54% answered in disagreement to the questions related to the negative role of figures of speech (either 'Disagree' or 'Strongly Disagree'), compared to 21%

who answered favorably (either ‘Agree’ or ‘Strongly Agree’) and 22% remained undecided. It can be noted that an average of 64% of the participants who disagreed to the negative role of figures of speech are in English schools while 36% are in French schools, which is in line with the overall distribution of participants.

For example, 59% of participants stated that they did not find the use of figures of speech to be confusing during physics lessons, while 16% did. It is worth noting that of these 59%, only 60% are in High School, a percentage that is fairly lower than the overall distribution, given that 85% of all participants are High School students.

Moreover, 68% of participants indicated that they were not bored when the teacher starts using figures of speech to explain an idea, while 19% indicated that they did and 22% were undecided. It was noted that of these 68%, only 18% had previously indicated that they find difficulty in understanding physics concepts, a percentage that is fairly lower than the total percentage of students who admitted to facing difficulties in understanding physics, which is 27%.

In another question, when asked whether they recall misunderstanding a concept because of an analogy used to explain it, 41% of participants disagreed compared to 23% who agreed and 33% remained undecided.

Furthermore, 58% of participants replied unfavorably when asked whether they find it difficult to relate the behavior of objects and particles to human beings, while 22% agreed and 19% were undecided.

c) Positive role of humor

When surveyed about the role of humor, the participants held a significantly positive view: Over 76% answered in agreement to the questions related to the positive role of humor (either 'Agree' or 'Strongly Agree'), while only less than 10% answered unfavorably (either 'Disagree' or 'Strongly Disagree') and 11% remained undecided.

For example, over 84% of participants indicated that they are more excited to learn a new physics concept when the teacher introduces humor in the classroom, while less than 7% indicated otherwise and 7% were undecided.

Moreover, 70% of participants stated that an anecdote about a certain physics concept helps them understand it better, while 10% disagreed to this statement and 15% remained undecided.

Another example illustrates the positive role of humor when correcting exams in class: 74% of participants indicated that they understand concepts better when the teacher makes friendly anonymous jokes about mistakes on physics tests, while 13% indicated otherwise and 12% were undecided.

It can be noted that the distribution of the participants who agreed to the positive role of humor is in line with the overall participants' distribution in terms of gender, English or French schools and Middle or High schools.

d) Negative role of humor

On the negative role of humor, participants held a much less favorable view: Over 70% answered in disagreement when asked about the negative role of humor (either 'Disagree' or 'Strongly Disagree'), compared to 18% who answered favorably (either 'Agree' or 'Strongly Agree') and 9% were undecided.

For example, 70.5% of participants stated that they are not distracted when the teacher jokes in the science classroom, while less than 18% stated that they are, and 9.5% remained undecided.

According to the questionnaire results, the distribution of participants who disagreed to the role of humor is in line with the overall participants' distribution in terms of gender and Middle or High schools. However, the proportion of Middle school students who held a negative view towards humor, which stands at 7%, was fairly lower than the overall proportion of Middle school students (15%).

e) Figures of Speech and Humor

When asked about the relationship between figures of speech and humor, the participants did not display a significantly clear inclination: When asked whether the figures of speech used by the teacher makes them laugh, 45% of participants held a positive view (either 'Agree' or 'Strongly Agree'), while 25% indicated otherwise (either 'Disagree' or 'Strongly Disagree') and 28% were undecided.

It can be noted that while the distribution of participants who agreed to the relationship between figures of speech and humor was in line with the overall participants' distribution in terms of gender, however the proportions of Middle or High School students as well as the proportions of English or French schools were fairly different:

Only 7% of participants who agreed to the relationship between humor and figures of speech are in Middle School, which is lower than the overall proportion of Middle School students (15%). Similarly, only 28% of participants who agreed to this relationship are in French schools, which is lower than the overall proportion of French school students (40%).

3. Non-participant observations

In order to analyze non-participant observations, I first transcribed conversations occurring between teachers and students in the classroom. I highlighted figures of speech that were used and the responses of students towards these figures of speech on a behavioral, motivational and cognitive level. I also highlighted all humor instances, and the responses of students to humor on the behavioral, motivational and cognitive levels and how teachers overcame any drawbacks when applicable. I also went beyond that by highlighting humorous figures of speech that teachers used to explain a concept and how they impacted students' understanding and behavior. The observations were organized in three tables: The first one dealing with figures of speech, the second one with humor, and a third one with humorous figures of speech. The tables include examples of each, the roles of each, responses

of students whether positive or negative and how teachers overcame the drawbacks when visible. These non-participant observations also targeted the bulk of the research questions just as the interviews did, however not from the view of the teacher, but rather from the view of the non-participant observer. A lot of data was collected about humor, however I only mentioned part of it in the tables since the core of my study is about figures of speech. All the tables and the logbook from which the tables were designed are attached in the appendices.

a) Roles and examples of figures of speech

Non-participant observations showed that the role of figures of speech in teaching physics is mostly cognitive and sometimes motivational. Figures of speech help students understand physics concepts better. For example, in the excerpt below the teacher relates generators to factories and passive dipoles to shops, which helps students understand the role of generators. In this case the role of the figure of speech is mostly cognitive.

Excerpt 1

T: Generators are like factories that produce energy. Part of this energy is useful to the receiver and the other part is lost as heat in the internal resistance of receivers and resistors. (He continues and adds that energy is distributed in circuits partly as heat)

S: If the heat spent could ever be more than the energy produced by the generator?

T: If my factory produces 100 Pepsi cans, can they sell more than 100?

After the teacher explained generators using this figure of speech, he asked the students who understood the concept better after relating factories to generators, and 16 out of 28 students raised their hands. One of the students mentioned to me after class in an informal conversation that the figure of speech made the idea more logical and clear. He added that before the factory example was given, he was confused. In addition to that, the student who asked the question as shown in the excerpt nodded and claimed that s/he understood the concept after the teacher answered his/her question using the figure of speech. More than that, later this week, the teacher asked a student to re-explain to another student who was absent in the previous period, the concept of generators; the student first explained the concept and went further giving the figure of speech the teacher used.

Another example is also shown in the excerpt below when the teacher related an atom with excess electrons to a rich man and the one that has fewer electrons to a poor man through a personification. This helped students memorize the concept better hence rendering its role mostly cognitive, even though it has a motivational factor since they can relate it to a daily life situation.

Excerpt 2

S: Amount of electrons lost is equal to the amount of electrons gained.

T: Ok. So the person that has more money will give to the person that has less money. The one that has excess electrons should give the one that has less.

Ss: Yes! Yes! (agreeing in an interested way)

T: If they both have excess, they repel.

Students showed a positive response by agreeing out loud and a student answered a question correctly later, related to the concept. All students solved the exercises that followed correctly.

Another excerpt that shows the role of figures of speech, both on the cognitive and motivational levels is when the teacher related opposite forces to a game of football or basketball, then later on, to a man who paid a certain amount of money and wants his balance to go back to 0.

Excerpt 3

S: Two forces should be equal and opposite to each other and they cancel.

T: If Munich scored 1-0, what should Real Madrid do to become equal to Munich?

S: Score a goal in Munich.

T: True. Forget about football. Let's talk about basketball!

S: (Came up with a similar basketball example)

T: If someone paid 100$. When will his balance reach equilibrium?

Ss: (say along with the teacher) earns 100$

T: When the sum of forces is equal to 0 N. If one force is 10 N, another person comes from the other side and exerts 10 N. Opposite and equal forces.

Ss: (Agree)

In the excerpt above the major role of the figure of speech is to teach students how opposite forces interact so its role is mostly cognitive. However, since football, basketball and money are interesting topics to grade 10 students, the example also has a motivational role which is revealed by the students' responses when they started coming up with examples, agreeing with the teacher and answering the teacher's questions correctly.

Finally, the last excerpt is the following:

Excerpt 4

T: For every action there's an equal and opposite reaction

T: Carl, If I take your eraser, what would you feel?

S: I'm sad I want it back

T: If I took your watch (the teacher takes his watch)

S: I will be angry

T: (Pushes Carl mildly)

S: I want to push you back

T: So for every action there is an equal and opposite reaction.

Finally in this last example, the teacher related Newton's third law to normal human interactions that help students understand the law better and relate to it through the personification used. No other student responses were shown.

b) Roles, examples and overcoming drawbacks of humor

This section of my findings shows how humor can play an important role on a behavioral, motivational, and cognitive level, paving the way for conceptual change in the physics classroom. Several excerpts are enlisted in the table documented in Appendix C, however I will mention only three excerpts in this section since the main focus of my study is on the roles of figures of speech.

Excerpt 5

A student was chatting with his friend in the back while the teacher was explaining. The teacher stopped the class and said while laughing: " Joe, thanks for sharing all this information with us."

This excerpt shows the teacher's sarcasm towards the behavior of one of the students. The teacher's sarcasm made the student laugh along with the rest of the class. At the same time the teacher sent a message to students that when he's explaining a concept, he's also aware of who is paying attention to the explanation. The student who was talking stopped and started paying attention to the teacher's explanation. The purpose of humor in this excerpt is behavioral. However, in order to manage laughter, the teacher directly continued the lesson. Another excerpt that reveals the role of humor is the following:

Excerpt 6

T: If my hand had electricity and I touched Mr. Zoghbi (one of the students) in the back, he will be charged. What is happening when we are charging by friction? (The teacher draws the image of Mr. Zoghbi on the board. The image showed the electron distribution)

T: (asks Mr. Zoghbi)Were you annoyed before the ruler was rubbed on your hair? Stand up. Tell them how you were feeling.

S: I was restful.

T: Mr. Zoghbi was restful and if the ruler could speak it would've said that she's happy too.

This excerpt shows how the teacher started with a funny anecdote before explaining a concept. The idea of drawing a student on the board was funny. The questions asked to the student were humorous. This anecdote has a cognitive role because it introduced a new concept which is charging by friction, and at the same time it's motivational because it's funny. The other students were looking at the student involved in the anecdote and at the board and were laughing. It caught their attention that there's an image of a friend of theirs in the physics problem. The situation was very comic and the students were laughing really hard, so was the student involved. In order to control the laughter, the

teacher directly related the funny anecdote to some new exercises that he came up with.

The third excerpt reveals the motivational role of humor in the classroom through a very short excerpt.

Excerpt 7

T: If we know Newton's first law and Newton's third law and we agree that these are the only ones, then we definitely have counting problems.

By this statement the teacher was introducing another law which is called Newton's second law of motion. This kind of sarcasm made students laugh motivating them to pay attention to the law that the teacher was about to explain.

The table shows that the techniques mostly used by teachers to overcome the drawbacks of humor are always related to limiting the time of laughter either through starting a new idea or through giving them a specific time limit for joking or through reminding them that the time for joking has passed and now they should go back to the lesson.

c) Figures of speech that are humorous

This section of my findings includes examples of figures of speech that are also humorous. However, it is important to highlight that most of the figures of speech used by the teacher whom I observed were humorous due to the way he presented them. This section includes the greatest range of examples; however I

will only mention a few excerpts. The rest are found in the table attached in the appendices. This section mentions examples of figures of speech that are humorous, their role and some positive and negative responses of students towards these figures of speech. For example:

Excerpt 8

T (explaining one of the exercises): The proton and the electron will stay together because the force of attraction is greater than the force pulling them down. If I stick a magnet on the fridge, the magnet will stick to the fridge. If I hold the fridge and start moving(made funny physical gestures as if he's holding a heavy fridge), will the magnet fall? No! because the magnet's force of attraction is greater than the weight of the magnet.

The teacher in this excerpt was explaining an exercise relating the interaction between something that is unseen (protons and electrons) to something that is seen which is the fridge and the magnet. Only 7 students knew how to solve the exercises before the teacher related it to the fridge and the magnet whereas 16 students raised their hand saying that the figure of speech given by the teacher clarified the exercise. Students were listening and laughing at the figure of speech the teacher gave, because he presented it in a comic way. The figure of speech clarified the concept at a cognitive level whereas the funny way of demonstrating it motivated students to pay attention to the concept taught.

Another example that shows the role of humorous figures of speech is the following:

Excerpt 9:

T: A person calls for a delivery, he tells the guy I want to order a burger. The delivery guy asks him where is his house. The person says 3km. It's not enough.

T: The same way the vector stands for something much more than the magnitude. If the delivery man asks me where's my house and I tell him 3km; 3km is only one aspect of several other factors. You can go up to Dhour Choueir 3km or go down 3 km towards the sea or to go 3 km towards Zaarour. Most of you have the tendency like that guy who's ordering the delivery to say that your home is 3km away because you are just referring to the vector as a magnitude but it's much more than that.

The teacher in this excerpt relates giving directions to a delivery guy, to the mathematical concept of vectors. He highlights a common misconception of dealing with only one characteristic of vectors: magnitude, as if it were the only one. This humorous figure of speech has a cognitive role since it targets a misconception and clarifies it, however at the same time it has a motivational role since the way the teacher presents it in the form of an anecdote makes it funny and attractive to students.

Students had several positive responses towards this humorous figure of speech: First of all, eleven students raised their hands when the teacher asked them who thinks that they understood the concept better after the figure of speech was given. Secondly, the students were laughing and listening to the teacher. They were also engaged in a conversation with the teacher and in several classroom

activities: some of them pushed the table with the teacher demonstrating forces, others engaged in detective role play; some gave examples and answered the teacher's questions. The teacher finally gave the students an exercise and the students were able to draw the forces correctly.

Another excerpt that reveals the cognitive and motivational role of humorous figures of speech is the following:

Excerpt 10:

T: I love when forces are collinear. Always before I sleep I look at pictures of collinear vectors.(students laughing)

T: I want to create two pairs of collinear vectors.

T: If I'm holding 3 objects with my hand. (He holds three things in one hand). And I want to hold bags. Where do I put the objects?

S: You throw them

S: Do you have pockets?

T: Yes

S: You put them in your pockets.

T: Exactly I put the keys in one pocket, the cell phone in the other and the bottle in the other one.

T: How do I put them?

S: Depending on a certain size?

T: Depending on a certain strategy: for example I put the keys in the right pocket and the cell phone in the left pocket in order not to scratch it.

T:Now that's what we're going to do with the forces. Divide them into 2 axes (the two pockets): The x- axes and the y-axes. W is divided into Wx and Wy. Wy and N cancel, since the object is not flying vertically. If Wx is greater than T it will slide down. So when we see the forces we distribute them among 2 axes: the x-axis and the y-axis.

T: If we have diagonal forces, what do we do?

S: We divide them among two pockets.

In this example the teacher is relating projecting forces unto x-axes and y- axes to holding many things at the same time and having to put them in two pockets in a strategic way. The teacher started explaining by a joke and students were laughing intensely. Students all over the classroom answered the teacher's questions abruptly and they were very attentive. The student at the end of the excerpt answers the teacher's question using the analogy that the teacher previously used. The students were assigned homework about projecting vectors along the axes and they all solved it correctly. A week later, the students were solving an exercise about an object sliding on an inclined plane, and the teacher asked the student: "What do we do with the weight?" The student answered him: " We divide it into pockets: Wy and Wx. " The joke at the beginning of the

excerpt changed the atmosphere of the explanation to something funny and enjoyable.

The last excerpt I will mention in this section is the following:

Excerpt 11

T: There is a love story between….

S: (interrupts blurting out two names)

T: any two masses

T: Really? (shows interest sarcastically)

T: There is a love story between any 2 masses. This is a fact.

T: What is love?

S: Attraction

T: Only?

S: commitment

T: Commitment?

S: sacrifice

S: connecting

T: Connecting!!! Ouf! Ouf! Ouf!

S: Honesty

S: According to Paolo Choello: " Love simply is."

S: Respect

T: What factors increase or decrease love? Remember these are masses. Please I don't want anyone to say we get Mars a rose.

T: What are the components.

S: Mass

T: Mass. Will Mars be loved more if it ate maamoul? Salim will love me more if I ate maamoul (Lebanese dessert)?

S: If there's a distance love decreases

T: That's what you think?

S: As distance increases, attraction decreases

T: Excellent. Another component. (Continues conversation)

T: FA/B =FB/A= Gmm/d2 affected by mass and indirect relationship with distance. This is Newton's law of gravitational attraction.

In this excerpt the teacher is relating gravitational attraction to love between two people. He personifies gravitational attraction making it something tangible to students. This figure has a cognitive role since it helps students relate factors that affect love to factors that affect gravitational attraction. Students were paying attention all throughout the example. They were laughing, concentrating

even though they knew from the beginning that this lesson is not included in the final exam and they will not be tested on it. They were all raising their hands to answer the teacher's questions. In the physics period just after this one the teacher asked the students who understood gravitational attraction better after the analogy, and 15/26 students raised their hands.

Most excerpts included positive responses by students towards the use of humorous figures of speech and only two negative responses were mentioned: One is related to classroom management when all students were talking at the same time not giving the student who was supposed to answer the teacher's question a chance to speak and the other case is when one of the students remembered the figure of speech but was not able to remember the concept.

Figures of speech in most excerpts had a cognitive role, humor in most excerpts had a behavioral, motivational and cognitive role whereas humorous figures of speech had mostly a cognitive and motivational role. All three together work like the strands of a rope to enhance the process of conceptual change in the physics classroom.

In addition to the data in the tables, informal conversations with students showed that students understand better when the teacher uses figures of speech because the idea becomes clearer in their mind. A student in an informal conversation claimed that she understands better when the teacher uses figures of speech since they help her link the concepts to what is actually happening and because she takes a short break from numerical values. She also added that she

believes students do use figures of speech to re-explain a concept they learnt however sometimes they don't because they think that the teacher and the student they are explaining the concept to, are interested in the final answer rather than the analogy that links it. The student also claimed that if students had enough time to explain for another student something, like in the recess, then they would've definitely used the figure of speech since it's the best link to help the student understand a new concept. She also mentioned that sense of humor creates a nice atmosphere in the classroom. She claimed that she did not consider the jokes to be offensive yet wondered whether all other students would agree with this claim. She also added that she never felt specifically in this class that the jokes were hurtful but rather funny and motivating. She concluded saying that sense of humor and funny stories make the session less boring and not completely serious while figures of speech help her understand the theory better. She then added that she believes that figures of speech have no negative aspects; however sense of humor if used in excess can sometimes make the class less serious and hard to concentrate in, not mentioning that they might sometimes be hurtful. Another student sitting next to us agreed that he believes figures of speech really help in understanding new concepts since they take it into a real life level. He said that it's much better than just being theoretical, since the concept becomes more tangible. He also said that sense of humor helps them refresh, and he added that it never had a negative effect.

Informal conversations held with the students supported the data found in the tables.

Conclusion

For the purpose of this study, it was important to categorize the data depending on the method of data collection. Data collected through interviews was divided among five categories: Roles and examples of figures of speech, drawbacks of figures of speech, roles and examples of humor, avoiding drawbacks of humor and the relation between figures of speech and humor. Similarly, data collected from questionnaires was also divided into 5 categories: Positive role of figures of speech, negative role of figures of speech, positive role of humor, negative role of humor and finally humor and figures of speech. Finally data collected from observations was divided into 3 categories: Roles and examples of figures of speech, roles and examples of humor and finally roles and examples of humorous figures of speech. Each category included both positive and negative student responses. Further, these areas assisted in addressing the three research questions in this study. Teachers' personal knowledge of the use of figures of speech and humor was collected through semi-structured interviews, whereas students' views towards the role of figures of speech and humor was collected though questionnaires and finally excerpts of non-participant observations highlighted the role of both figures of speech and humor in the process of conceptual change. Furthermore, teachers expressed that figures of speech play an important role in teaching a new physics concept and in changing common misconceptions. Secondly, teachers' responses suggested that if the drawbacks of humor were well- managed, humor can help students de-stress allowing their brains to rest and be more receptive for upcoming concepts to be learnt. Finally, teachers also suggested that humorous figures of speech can play the role of both figures of speech and humor together. Most students also agreed on the

importance of figures of speech and humor in the classroom. Non- participant classroom observations also showed how these two play a major role in the process of conceptual change in the physics classroom. In this chapter, I presented the findings derived from the data collection methods used during this study. The use of the various methods of data collection provided a rich source of data about the roles of figures of speech and humor in the process of conceptual change in the physics classroom. The following chapter analyzes and discusses the findings based on the data organized in this chapter and draws some implications that they might have on teaching techniques in the physics classroom.

Chapter Five

Discussion

Introduction

In Chapter four, I presented the findings obtained from the three instruments used for data collection: teacher semi-structured interviews, student questionnaires, and non-participant observations. In this chapter I will provide an evaluation and discussion of the findings related to the role of figures of speech in the process of conceptual change in the physics classroom with a minor section about the role of humor.

These areas reflect the intent of the following research questions:

1. What is the role of figures of speech in the process of conceptual change in the physics classroom?
    a) From the perspective of teachers
    b) From the perspective of students
    c) From the non-participant classroom observations
2. What are some figures of speech used in the classroom? How do they help students grasp physics concepts better?
    a) From the perspective of teachers
    b) From the non-participant classroom observations
3. What are the drawbacks of figures of speech in understanding physics concepts? How do teachers overcome them?
    a) From the perspective of teachers

b) From the perspective of students

c) From the non-participant classroom observations

4. How is humor related to figures of speech? Does it enhance the process of conceptual change in a physics classroom?

   a) From the perspective of teachers

   b) From the perspective of students

   c) From the non-participant classroom observations

This discussion addresses the major areas which are derived from the analysis of the findings. The following sections are relevant as they provide further insights into teachers' and students' views of figures of speech in the physics classroom and some direct implications of their views noted in a non-participant observation of a grade10 physics classroom. In this section every research question is answered depending on the findings in the previous chapter and is related to the literature review.

1. What is the role of figures of speech in the process of conceptual change in the physics classroom?

   Most of the findings collected from the interviews, questionnaires and non-participant observations concerning the role of figures of speech in the process of conceptual change in the physics classroom, agree with previous literature and go even further. For example, non-participant observations showed that figures of speech have both a cognitive and motivational role in the process of conceptual change. Since figures of speech are usually related to ideas that students already

know about and are interested in, they grab their attention and motivate them to listen to the teacher's explanation. Furthermore, they are usually used to explain an abstract, difficult, or new concept and hence have a cognitive role. Observations showed that students responded positively to the use of figures of speech either by answering the teacher's questions and solving exercises correctly, or by raising their hands when the teacher asked them if they understood the concept better, or by re explaining the concept using figures of speech to the teacher or to a friend who missed class. These findings concur with Cameron's results (2002) who claimed that students use metaphors that they informally construct in order to understand formal and difficult concepts and with Venville and Treagust's (1996) who identified figures of speech as motivators.

According to teachers in the semi-structured interviews, figures of speech make a concept easier and clearer for students to understand. A wide range of different roles of figures of speech was derived from the interviews conducted with physics teachers as follows: Figures of speech help students relate what they learn to real life experiences, overcome misconceptions, learn new concepts, relate new concepts to prior knowledge and retrieve information from their memory. Figures of speech also play a major role in the students' understanding of difficult concepts by relating them to familiar experiences or relating physics concepts to other physics or mathematical concepts that they are already familiar with. Teachers also agree that figures of speech simplify the theory, help students imagine and visualize an abstract concept, help them differentiate between two similar concepts and concretize abstract concepts. More than that, figures of speech make the class more

interesting and help teachers communicate ideas to students. All these roles stated in the interviews agree with Levin and Wagner (2006) who also studied the views of teachers concerning the role of figures of speech and concluded that they have a crucial role in the acquisition of concepts, and are an indispensible tool for classroom communication that helps both students and teachers communicate their ideas clearly. Amin (2009) also stated that metaphors concretize abstract concepts and Hutchison and Padget II (2010) confirmed that figures of speech simplify the process of retrieval of concepts from the memory. The interviews also showed that teachers use figures of speech to differentiate between concepts that seem similar but are totally different such as vector and scalar quantities, mass and weight, voltage and current and many others. Wiser and Amin (2001) also highlight this role of figures of speech in their study on heat and temperature. My findings go further than the literature, when one of the teachers mentioned that figures of speech create a new section in students' minds when they are learning a new concept of which they have no prior knowledge. According to this teacher, this new section acts as prior knowledge on which the student can construct new knowledge. Finally questionnaires also proved that figures of speech have an important role in the students' understanding of a physics concept, in changing misconceptions and in retrieving a physics concept from their memory.

2. What are some figures of speech used in the classroom? How do they help students grasp physics concepts better?

The tables that organize the data collected from the observations and the interviews include several examples of figures of speech: both humorous and not humorous. These figures of speech appeared to have several roles in the process of conceptual change in the physics classroom. Some of the roles are motivational while most of the others are cognitive and some are both. Some of these examples are similar to the ones listed in the literature while others are not. For example in one of the excerpts, as the teacher was introducing an exercise, he referred to a circuit including several electrical appliances to a 'bouquet of appliances' motivating students to solve the exercise making it seem simpler. Another example is when the teacher referred to the physics exercise as a puzzle, relating a difficult exercise to something interesting to students. Similarly Bowley and Sanchez (1999) related science to a house made of building stones which are facts. In one of the excerpts on humorous figures of speech the teacher also related a physics fact to an appetizer or a soup. All these examples act as motivators, they have no cognitive role, but they motivate students to listen and keep them interested.

In many of the examples mentioned in both the interviews and observations, energy was treated as a possession which agrees with Zumdahl (1998) who explained that this analogy helps clarify the concept of energy. For example, during observations a generator was related to a factory that produces energy, or to a bank that distributes money (the money being the energy). In one of the interviews, potential energy was related to money being saved by people in a bank, and finally some teachers mentioned in the interviews and it was observed in the classroom that teachers use verbs that treat energy as a possession, such as: *removed and spent*.

Moreover, some other findings agree with Kallery and Psillos (2004) who claimed that personifications are a good teaching aid. For example: relating atoms with excess electrons to a rich man and atoms with less electrons to a poor man, relating Newton's third law to normal human interactions, relating gravitational attraction to a love story between two people, relating elements to generous or selfish people when trying to explain bonding between metals and non-metals, and finally relating positive and negative charges to a rich and a poor man respectively. All these personifications have a crucial cognitive role since they help students memorize the concepts more easily and help them relate new concepts to what they already know.

Other figures of speech mentioned deal with forces and movement such as: relating forces to other vector quantities to emphasize the vector aspect of forces, relating opposite forces to a game of football or basketball or to a man who paid a certain amount of money and wants his account to balance again, relating an object flying in space at constant speed to a student thrown out in space, and relating force projections among axes to dividing objects among two pockets. All these examples on forces clarify the concept of adding and subtracting forces as vectors and relating forces to motion clarifying the misconception mentioned in Shweingruber et al., (2007).

Some of the examples mentioned in the findings clarified misconceptions about physics principles such as in Hutchison and Padget II (2010), others dealt with confusion between two similar concepts such as electric current and voltage, pressure and force and many others. This agreed with previous literature for example: Wiser and Amin (2001) used figures of speech to help students distinguish

between temperature and heat, Young and Freedman(2003) related exchange of heat to financial transactions as mentioned in one of the examples previously, Shweingruber, et al., (2007) distinguished between concepts of distance, speed and time and Padilla et al. (2009) related voltage to a roller coaster ride and current to water to distinguish the difference between the two concepts. More than that, Carey (2000) dealt with confusion between density and mass. Some examples mentioned in the interviews clarified the concept of refraction as light bending from one transparent medium to another which is similar to the study conducted by Treagust et al., (2007) who also clarified refraction by raising dissatisfaction with prior knowledge. Jeppson et al., (2012) claimed that figures of speech help students understand physics concepts better as mentioned in many of the interviews and as clarified in several examples: relating interactions between planets to interaction between magnets, relating the buoyant force to someone holding another person up while floating, relating love to gravitational attraction and many others. Most of the teachers in the interviews agreed with Chi (1993) that some scientific concepts are more difficult than others and need specific tools such as analogies to be taught correctly such as heat, electrical current and light.

3. What are the drawbacks of figures of speech in understanding physics concepts? How do teachers overcome them?

In addition to the major role that figures of speech play in transmitting a physics concept, my findings revealed very few drawbacks, which according to teachers can be easily overcome. For example, the only drawback mentioned in the observations is that sometimes students remember the figure of speech clearly, but the concept

taught vaguely. This finding does not relate with the literature. However, semi structured interviews with the teachers listed several drawbacks, some of which agree with the literature and others that go further. For example one of the drawbacks mentioned is the complexity of the figures of speech sometimes used that leads students to confusion which agrees with Niebert et al.,(2012). At other times figures of speech might not fit in the subject as mentioned in the interviews or might not be noticed by students as Cameron (2002) states. Teachers also mentioned that students' difficulty in understanding the figures of speech used is often due to a weaknesses in the language of instruction, or in grasping the similarity between the figure of speech and the concept taught or due to the vagueness of the figure of speech given which agrees with Cameron (2002) and Kallery and Psillos (2004). Findings also show that if not properly explained, figures of speech can lead to misconceptions as mentioned in Hutchison and Padget II (2010) and Etkina (2007). Kallery and Psillos (2004) also agree with my findings that sometimes students mistake the image implied in the figures of speech used with reality. Finally, questionnaires reveal that very few students acknowledge the drawbacks of figures of speech. However, findings agree with the literature that younger students (middle school students) can get more confused with figures of speech used, than older students (Kallery & Psillos, 2004). Finally some of the ways of overcoming those drawbacks agree with the literature: Teachers should use multiple analogies when teaching a scientific concept in order to target all aspects of the concept as Jeppson et al., (2012) claim. Another teacher mentioned that the use of models can help overcome the problem of misunderstanding the figure of speech whether due to

difficulty in language or in understanding its complexity which agrees with Schweingruber et al., (2007). Findings also reveal that the teachers' experience and knowledge plays a very important role in overcoming these drawbacks, since it is through experience that they decide when they need to use a figure of speech, when they need to avoid using one, or when they need to back down. Some teachers mentioned that emphasizing the role of the figure of speech to students before using it can help students to differentiate between imagery and reality. It is important to note that questionnaires and observations do not include many findings about overcoming the drawbacks of figures of speech.

4. How is humor related to figures of speech? Does it enhance the process of conceptual change in a physics classroom?

Many of the figures of speech used in the physics classroom are humorous for several reasons: Some include exaggeration; others emphasize an incorrect concept in a funny way, and at other times relate something that is unseen to something that is seen, inducing humor. Moreover, anecdotes used to narrate the story behind the physics theory make the students laugh. In addition to that, personifications which relate the interaction between objects to interactions between teachers and students induce laughter and keep the students engaged in classroom activities. Most teachers in the interviews agreed that figures of speech and humor are related since they help students visualize things in a comic way, change the atmosphere, make the students imagine concepts in ways that they never did before, sometimes relating it to a physical gesture the teacher used, or a noise that the teacher made. Indeed, relating objects to human traits through personifications can be very funny. These kinds of

humorous figures of speech motivate students to pay attention, and at the same time help them relate concepts to things they already know, thus achieving their cognitive aim. The findings mentioned above agree with Duit and Treagust (2003) that cognitive and affective issues are interrelated, so humor can provide the conditions for students to understand concepts better. Findings mentioned in the observations and interviews show that humor helps increase the affinity between teachers and students which agrees with St. Pierre (2001) and Wanzer and Frymier (1999). Results also agreed with Neumann et al., (2009) that humor makes teaching more entertaining, helps simplify content and avoid boredom, allows time to pass quickly, relieves stress and provides a mental break for students increasing their motivation. Findings also reveal that humor in figures of speech used allows student engagement in classroom activities, increases their attention span, and induces a positive learning environment agreeing with the following studies conducted by Tamblyn (2003), Struthers (1994), Iyahet al., (2010), and Gorham and Christophel (1990). St Pierre (2001) adds that humor helps students preserve concepts learnt and allows them to enjoy the lesson. However, the teacher during non-participant observations used a lot of sarcastic humor, not accompanied with figures of speech, mostly when referring to a bad behavior. However according to Goodman(1992)teachers should avoid this kind of humor. The findings list several drawbacks of humor; however the positive effects on the learning environment far outweigh the drawbacks as mentioned in Askildson (2005). The drawbacks mentioned were mostly related to classroom management which can be dealt with using classroom management techniques.

Conclusion

The discussion focused on areas of the findings which are significant to the research questions that guide this study. The findings reaffirmed much of the literature that was mentioned in the first chapter and delved deeper into discussing more topics such as humorous figures of speech. The discussion went beyond the findings motivating teachers into delving more deeply in the study of figures of speech in physics education, encouraging them to take decisions such as preparing their figures of speech beforehand, noting which figures of speech are effective, getting textbooks that include figures of speech and many others. Hence, this discussion also raised awareness among teachers to realize the complex relationship between figures of speech and humorous figures of speech in the process of conceptual change. In addition to that it revealed the social use of humor in the physics classroom.

Overall, the discussion revealed that despite some drawbacks concerning the use of figures of speech and humor in the physics classroom, their positives far outweigh the negatives.

In the following chapter, I present the suggestions for future research to address the issues which have emerged as a result of my findings. I also address the limitations of this current study and include recommendations for further action about the use of figures of speech in teaching a physics concept.

Chapter Six

Conclusion

Introduction

The role of figures of speech in the process of conceptual change is a topic that has been previously raised in the field of education. However, studying this topic in a physics classroom is recent. Figures of speech which are usually related to the field of descriptive language mentioned in a dry physics classroom are new. However, in this study, figures of speech have proved to have a greatly influential role in the process of conceptual change in the physics classroom, especially when the figures of speech are humorous. Overall, most physics teachers showed to have positive views towards the role of figures of speech and suggest that with good preparation and experience, they can play a very important role in physics education. Students through the questionnaires also expressed that figures of speech help them understand physics concepts better. Non-participant observations, showed through excerpts how figures of speech enhanced the process of conceptual change among students.

In this final chapter, I will first provide some suggestions which I believe may assist teachers in enhancing their pedagogical practices in the physics classroom. I also believe that these suggestions may assist teachers in making the best out of these educational tools. Also presented in this chapter are suggestions to the stakeholders who are responsible for overseeing the physics curriculum. These suggestions are intended to assist all stakeholders in making informed decisions about physics education.

This chapter also highlights some areas for further research which may lead to other studies on the roles of figures of speech in teaching physics. The chapter concludes with a summary of this study.

Suggestions for teachers and students

1. Teachers must enroll in workshops that raise awareness about the importance of figures of speech and humor in the physics classroom.
2. Students and teachers should master the language of instruction in order to avoid misconceptions.
3. Teachers should note effective figures of speech used in the classroom.
4. Teachers should prepare the lesson with the figures of speech used when needed to avoid any missing links.
5. Teachers should keep track of ineffective figures of speech to avoid misconceptions and optimize learning efficiency.
6. Teachers should chunk the physics concept into parts and support it with several figures of speech to cover the concept as a whole when needed.
7. Teachers should read textbooks that include several figures of speech used to teach physics concepts and tested pedagogically.
8. Teachers should make it clear to students when using a figure of speech.
9. Feedback from students should be collected every time a teacher uses a figure of speech in order to evaluate its effectiveness from a student's perspective.
10. Teachers should also make use of technological tools that help model the figure of speech used and show the links with the concept to students.

Suggestions for the Ministry of Education

1. The Ministry of Education (M.O.E), in collaboration with curriculum analysts should provide training to raise awareness on the importance of figures of speech in teaching physics.
2. The M.O.E should provide teachers with preparation textbooks that include well developed figures of speech.
3. The M.O.E should add to the curriculum a section that teaches students how to deal with figures of speech used in the physics classroom.

Future Research

Several limitations of this present study should be kept in mind. One potential limitation is that some students may have filled the questionnaire haphazardly just for the sake of filling it. Though I personally explained the difficult words in the questionnaire in Arabic (their native language) before distributing the questionnaire, some students especially the French educated ones might have not understood it fully. Further, I had no way of measuring or ensuring the sincerity and honesty of the students' views through the questionnaires. Therefore, the use of the questionnaire may not have provided an accurate idea of the students' views towards the role of figures of speech and humor. As a result, future research can use another method such as pre-tests post tests to measure students' achievement. Taking into consideration the limitations above, I believe that the methodology used was the most appropriate for this study. Most importantly, the data collected provided interesting information about teachers' and

students' views towards the role of figures of speech in the physics classroom on one hand. On the other hand, the non-participant observation was helpful in studying teacher practices and students' responses to figures of speech in the physics classroom. However if non-participant observations were carried out in more classes, there would have been a wider range of data. Many important issues have emerged from this study, which are worth being considered for future research. First, it would be interesting to study the effect of figures of speech on cognitive achievement through pre and post testing. Secondly further study should be conducted on the role of questions and inquiry in the process of conceptual change. Thirdly, including a minor section on humor revealed to me a larger field that requires further research.

Conclusion

Language is at the center of communication and communication is the basis of every classroom: Teachers communicate ideas, they ask the students questions and students answer their questions and provide feedback. Figures of speech are at the heart of communication. Often as we are explaining something to someone we find ourselves saying words such as: *for example, like,* and *as*. The purpose of this study was to investigate the role of figures of speech in the process of conceptual change in the physics classroom. In so doing, I have discussed the views of students and teachers towards the role of figures of speech in the physics classroom. This included the positive roles, drawbacks and overcoming the drawbacks. Non-participant observations carried out in a grade 10 physics classroom also supported my study. Another section of my study dealt with the relation between figures of speech and humor and overcoming

the drawbacks of humor. The study revealed that figures of speech together with humor play a major role on a cognitive, motivational, and behavioral level, enhancing the process of conceptual change of understanding difficult, new, or incomplete physics concepts. The study also showed a few drawbacks that are mostly related to classroom management or lack of clarity in teacher instructions that can be easily overcome with proper training. Findings also revealed that humor allows the mind to rest, followed by a figure speech that leads the students to imagine the concept and build on prior knowledge, hence the importance of humorous figures of speech. Teacher awareness, training and openness to upcoming research in this field are necessary to overcome the drawbacks and to benefit from the indispensible role of figures of speech in the process of conceptual change in the physics classroom.

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Appendix A: Questionnaire

This is a research project and for this project you will be asked to complete a short questionnaire. This questionnaire aims to collect data about your attitude towards the role of figures of speech in your understanding of physics concepts in the classroom.

The information you provide will be used to enhance and improve physics teaching techniques. Your answers will not be released to anyone and will remain anonymous. Your name will not be written on the questionnaire or be kept in any other records. All responses you provide for this study will remain confidential. When the results of the study are reported, you will not be identified by name or any other information that could be used to infer your identity. Only researchers will have access to view any data collected during this research. Your participation is voluntary and you may withdraw from this research any time you wish or skip any question you don't feel like answering. Your refusal to participate will not result in any penalty or loss of benefits to which you are otherwise entitled to. The research intends to abide by all commonly acknowledged ethical codes. You agree to participate in this research project by filling the following questionnaire. If you have any questions, please contact me Dahlia Sawma on 03/928040. Thank you for your time.

Section A: General Information

All information provided will be treated in the strictest confidence. No one, other than the researcher, will have access to the information on this questionnaire. Thank you.

1. Name: …….
2. Sex: Male □ Female □
3. Nationality: ……
4. How old are you? □14□15 □ 16 □17 □18
5. Which school do you attend?……

6. Which grade are you in?……

7. What is the number of students in your class?……

8. How many periods of physics do you have per week?……

Section B: Questionnaire (addressed to students whose age is ranging between 14-18 years)

Read each of the statements carefully and indicate your response by putting a tick **(√)**in the box that matches your perception of learning Physics.

SA: Strongly Agree **A**: Agree **U:** Undecided **D:** Disagree **SD:** Strongly Disagree

Part1: Figures of Speech
Types of Figures of Speech

Metaphor: The comparison of one thing to another without the use of the word like. Example: An electric current is a river.
Analogy: A similarity between like characteristics of two things. Example: electrons are to an electric current as water droplets are to a river.
Personification: The attribution of human nature or character to animals or inanimate objects or notions. **Example:** A generator **generously gives** electricity.

Table 2: Student Questionnaire

		SA	A	U	D	SD
1.	In general, I find it hard or difficult to understand new physics concepts.					
2.	I understand physics concepts best when they are taught using the active board.					
3.	I understand new physics concepts best when they are taught using analogies.					
4.	I understand the behavior of objects and particles and their interactions best when they are related to human behavior and interactions.					
5.	My teachers use metaphors and analogies to teach new physics concepts.					
6.	I think that metaphors and analogies in physics lessons are confusing.					
7.	I sometimes remember certain science concepts just because of the good analogy the teacher used while teaching it.					
8.	The metaphors my teacher uses in class help me remember concepts.					
9.	I remember the metaphor without remembering the concept learnt while studying alone.					
10.	I get bored when my teacher starts relating objects to other things in					

	order to explain an idea.					
11.	I recall misunderstanding a concept because of an analogy used to explain it.					
12.	My teacher's use of metaphors and analogies has helped me understand better concepts I already knew.					
13.	I find it difficult to relate the behavior of objects and particles to human beings.					
14.	My teacher's use of personification to explain physics concepts often confuses me.					
15.	I believe the use of figures of speech is essential in my understanding of certain concepts.					
16.	I am more excited to learn a new physics concept when the teacher introduces humor in the classroom.					
17.	An anecdote about a certain physics concept helps me understand it better.					
18.	When my teacher makes friendly anonymous jokes about mistakes on physics tests, I understand these concepts better					
19.	I am distracted when the teacher jokes in the science classroom.					
20.	The figures of speech the teacher uses make me laugh.					

Appendix B: Interview Questions

This is a research project and for this project you will be asked to answer the following interview questions. This interview aims to collect data about your attitude towards the role of figures of speech in teaching physics concepts.

The information you provide will be used to enhance and improve the teaching of physics concepts.

Your answers will not be released to anyone and your identity will remain anonymous If you choose to. All responses you provide for this study will remain confidential. ***When the results of the study are reported, you will not be identified by name or any other information that could be used to infer your identity if you choose to.*** *Only researchers will have access to view any data collected during this research. Your participation is voluntary and you may withdraw from this research any time you wish or skip any question you don't feel like answering.Your refusal to participate will not result in any penalty or loss of benefits to which you are otherwise entitled to.*

The research intends to abide by all commonly acknowledged ethical codes. You agree to participate in this research project by answering the interview questions. If you have any questions, you may contact me, Dahlia Sawma on 03/ 928040. . Thank you for your time.
If you have any questions about your rights as a participant in this study, or you want to talk to someone outside the research, please contact the:
IRB Office,
Lebanese American University
3rd Floor, Dorm A, Byblos Campus
Tel: 00 961 1 786456 ext. (2332)

1. Do you use figures of speech in the classroom when teaching? Why or why not?
2. How do you believe the use of figures of speech helps students learn new concepts? Can you provide an example?
3. How do you believe that figures of speech can help in the change of a misconception? Can you provide an example?
4. Can you please give us an example of a specific figure of speech that you usually use in your classroom and how did it help in teaching a specific concept?
5. When do you think the use of figures of speech is most effective?
6. What are the drawbacks of the use of figures of speech in teaching a concept?
7. How can you avoid or prevent these drawbacks?
8. Do students reuse the figures of speech you use in your classroom to re explain a concept they acquired? Can you recall an instance when this happened? Or can you please provide an example?
9. Which type of figure of speech (simile, metaphor or personification) do you believe is the most effective in teaching? Explain why.

10. Do you usually introduce humor into your classroom? Why or why not?Can you recall an example or a situation?
11. How is this conducive to a learning environment? How does it help students learn new concepts?
12. In your opinion, are figures of speech sometimes related to humor? If yes, how?
13. In your opinion, what are the drawbacks of using humor in the classroom? What are the advantages?(on behavioral levels, regarding subject-matter, etc).

Appendix C: Summary of Interviews and Non-Participant Observations in Tables

Table 3: Examples of figures of speech in observations

Examples of figures of speech	**Role**	**Positive student responses**	**Negative student responses**
T: Finding E' and R' is like a puzzle.	Relating a difficult exercise to something interesting to students. (Motivational)		
T: A bouquet of appliances	Relating electrical appliances connected together such as: a resistor, a generator and a receiver to a bouquet of flowers. (Motivational)		
T:Generators are like factories that produce energy. Part of this energy is useful to the receiver and the other part is lost as heat in the internal resistance of receivers and resistors. He continues and adds that energy is distributed in circuits partly as useful and partly as heat. S: If the heat spent could every be more than the energy produced by the generator. T**:** If my factory produces 100 Pepsi cans can they sell more than a 100?	Relating generators to factories. (Cognitive)	16 out of 28 students raised their hands when the teacher asked them who understood the concept better after relating generators to factories. One of the students said that the figure of speech made the idea more logical and clear. He said that before the factory example he was confused. The student who asked the question nodded and said that she understood. A week later, the teacher asked a student to explain to another student that was absent in the previous period the concept of generators. The student first explained the concept then she gave the example of the figure of speech, giving more importance to the concept itself.	She mentioned the figure of speech secondly after the concept.
T:Like we can divide 2 sides of an equation to get x in 2x=4 we can also multiply both sides of Pouillet's law by I and we get an equation that describes power.	Relating a physics concept to a mathematical concept. (Cognitive) Building on prior knowledge.		

Table 3: Examples of figures of speech in observations

Examples of figures of speech	**Role**	**Positive student responses**	**Negative student responses**
T: If I **removed** RI^2 and if it **spent** all the energy on nice men and ladies like you.	Treating the formula as an object and energy as money. Relating energy to a previous analogy. (Cognitive)		
T: The vector u has the following characteristics: the origin, **the line of action which is the line holding the force**, the direction; every line of action has two directions, and the fourth is the magnitude.	Helps students visualize the line of action, relating it to a human holding something. (Cognitive)		
S: Amount of electrons lost is equal to the amount of electrons gained. T: Ok. **So the person that has more money will give to the person that has less money. The one that has excess electrons should give the one that has less.** Ss: Yes! Yes! (agreeing in an interested way) T: If they both have excess, they repel.	Relating atoms with excess electrons to a rich man and the ones that have fewer electrons to a poor man. (Personifications) This will help them memorize the concept. (Cognitive and motivational)	Ss: (agreeing showing interest with the analogy) Yes! Yes! (verbal) A student answered a relevant question that clarifies the explanation. Students solved the exercises correctly.	
T:We have two identical objects, same shape, same motor and identically charged. T (relates them): **You have 2 cell phones, one is charged and one is not.** Both are identical, same shape but one is charged the other is not.	Relating objects in an exercise to cell phones; something that students relate to.(Cognitive)	The students were looking at him. Then he continued to solve the exercise with the students. The students understood it after this small introduction because they answered his questions correctly afterwards and because they solved a similar exercise.	

Table 3: Examples of figures of speech in observations

Examples of figures of speech	**Role**	**Positive student responses**	**Negative student responses**
S: Two forces should be equal and opposite to each other and they cancel. T: **If Munich scored 1-0, what should Real Madrid do to become equal To Munich?** **S: Score a goal in Munich**. T: True. Forget about Football. Let's talk about Baskeball! S: (came up with a similar basketball example) T: **If someone paid 100$. When will his balance reach equilibrium?** Ss: (say along with the teacher) earns 100$ T: When sum of forces = 0N. If one force is 10 N,another person comes from the other side and exerts 10N. Opposite and equal forces. Ss: agree	Relating opposite forces to a game of football or basketball. Then later on relating it to a man who paid a certain amount of money and wants his balance to go back to 0. (Cognitive and motivational)	Students were coming up with examples, agreeing with the teacher, and answering the teachers' questions correctly.	
T: **I represent my displacement by a vector AB**	Relating a vector (drawing)to displacement. (Cognitive)		
T**: If I'm at rest I will stay at rest, I need a force to move me. If I'm in motion and the sum of forces cancel .** How did I start moving we're not interested but as I am moving , I will remain moving.	Relating the object in Newton's first law to one's own motion. Trying to make it simpler.(Personification-Cognitive)		

Table 3: Examples of figures of speech in observations

Examples of figures of speech	**Role**	**Positive student responses**	**Negative student responses**
T: For every action there's an equal and opposite reaction **T: Carl, If I take your eraser, what would you feel?** **S:I'm sad I want it back** **T: If I took your watch (the teacher takes his watch)** **S: I'll be angry** **T: (Pushes Carl mildly)** **S: I want to push you back** T: So for every action there is an equal and opposite reaction.	Relating Newton's Third law to normal human interactions.		
T: (Draws a brain representing the brain of the students and divides it into two parts, left and right hemisphere) **Your brain is divided into 2 hemispheres, left and right: URM and UARM**: URM which has only one formula $x= vt + x_o$ .What does U.A.R.M have?	A figure of speech that shows them how to organize the information they learnt. Used for clarity and organization. (Cognitive)	Students were alert and answered the questions correctly.	
T: Why is the magnitude of T'2 equal to T2 S: **And T1 I got it from T'2**	Relating T2 which is a force to a place where you can get things from. (Cognitive)		
S: Why does the big planet attract the small planet? T: Newton's third law T: If I'm in a room **with 0 gravity and 2 magnets,** they'll move closer to each other and meet at midpoint unless one magnet is stronger than the other. If there was a fridge it will be affected by the fridge. Same for earth sun and moon.	Relating interaction between planets to the interaction between magnets.	Students started coming up with new examples after the teacher gave this example.	.

Table 4: Examples of humor in observations

Humor	**Types and Roles**	**Overcoming drawbacks**	**Positive student responses**	**Negative student responses**
T: Who can give me an example of a receiver? (Looks at student but the student remains silent) T: OK. Can anyone give me another example? S: (read from the book) The motor is a receiver. T: Wow! You have very good reading skills!	Sarcasm towards student behavior. (Behavioral)		Students giggled including the student targeted. Laughter in the classroom.	Shyness
T:The motor in English, the moteur in French, the matir in Arabic that's what Aboul Zouz calls it, takes electrical energy and transforms it into electrical energy.	Sarcasm towards Lebanese pronunciation of the word motor. Showing contrasts between different languages. Teaching the students the correct way of saying it. (Cognitive and motivational)	The teacher repeated the definition again several times making sure that after all the fun, the students were listening again and paying attention.	Students were all laughing because of the joke.They listened carefully to the definition. Students were taking notes about the motor definition.	
T (after giving examples about receivers) apologized for mentioning only boy toys since he had no exposure to girl toys when he was a kid.	Sarcasm towards himself. Joking about a concept he just explained. (Motivational)		Laughter	
T: If you want to show off, go to the middle school and tell them an electrolytic cell is an accumulator. (articulated the word electrolytic cell in a funny way).	Articulating words in a funny way and joking before defining electrolytic cell. (Motivational)		Ss: We know it from chemistry (Most of them responded at the same time which shows that they are paying attention)	
T: if you have a phone charger that can charge your phone in 2 minutes or one that can charge it in a week, of course the one that can charge it with a few minutes is more efficient. T: To compare which receiver is more efficient, we only look at the useful energy.	Sarcasm. Joking just before explaining a concept. (Cognitive)		Students giggled	

Table 4: Examples of humor in observations

Humor	**Types and Roles**	**Overcoming drawbacks**	**Positive student responses**	**Negative student responses**
A student was chatting with his friend in the back while the teacher was explaining.The teacher stopped the class and said (laughing): Joe, thanks for sharing all this important information with us.	Sarcasm. The role of this statement was to let the student pay attention to the explanation, in a funny way. (Behavioral)	He continued directly the lesson.	The students giggled including the student who was talking, then he looked at the teacher and started paying attention to the lesson.	
A student was solving something on the board. Another student said (loudly): It's wrong!!! T: Tawwel belak.(In English: Be patient). (pause) tawwalto? Now you want to say something to her? Something nice like sorry for example? T: Let us show Mrs. Dahlia that we are civilized. The game is that we act civilized. I am the head of the game who wants to play with me? The game ends on the 28th of June (last day of school). Ok now close your eyes and imagine you are civilized, listening to one another, no violence with each other, no chatting when the teacher is explaining something.	Sarcasm directed towards student behavior. Emphasis on being civilized. (Behavioral)		The students were laughing a lot.	

Table 4: Examples of humor in observations

Humor	**Types and Roles**	**Overcoming drawbacks**	**Positive student responses**	**Negative student responses**
T: Let's start!! Chapter 13! Pouillet's law (Some student were going to burst out laughing because of the name.) T: OK! I will give you a minute to joke about his name: Pouillet, poulet, djej, djeje, you name it. (The teacher left the class for a minute.) S: Shawarma! T (entering): I think you should write a book of jokes, and put your picture in the back of the book and your name on it and publish it!Claude Pouillet, a French physicist, 1861, he was sitting in his office and suddenly he felt something weird…(laughed) I'm kidding he didn't feel anything weird but he was a French physicist.	Allowing students to joke.Grabbing their attention. Allowing their minds to rest. (Motivational and cognitive)	Limited the time, leaving the class to give them a real break . Directly continued the lesson.	The students joked, they were laughing with the teacher. All the students were listening attentively and staring at the teacher waiting for what's next and there was silence. The students were motivated to know about Claude Pouillet. By the end of the period the teacher asked: "What did Pouillet do when he was in his office?"The student said, he felt something weird. Students were alert and awake building on prior knowledge and answering the teacher's questions. A week later the students still joked about Pouillet.	
S: (answering the teacher with a very low voice) T:I can't hear you. You know I am growing old I can't hear well anymore please raise your voice.(He's only 26)	Sarcasm directed towards himself. (Behavioral and Motivational). Encouraging the student to raise his voice when he answers a question.		Laughter in the classroom.	
The students upon the request of the teacher, did a play about Lavoisier in the classroom. The play was informative but at the same time, funny.	A funny play. (Cognitive and motivational)		Students were paying attention and laughing. They were able to answer all questions about Lavoisier. One of the students was taking notes about his life though they will not be tested on that later.	

Table 4: Examples of humor in observations

Humor	**Types and Roles**	**Overcoming drawbacks**	**Positive student responses**	**Negative student responses**
T: We can charge two objects through friction S: Aluminum T: Don't start wondering and thinking metaphysics. S: Adhesion? Cohesion? S: For every action there's an equal and opposite reaction. T: Who thinks that all of their friends are saying is Chinese. Tchin, Chin Sheen?!	Sarcasm towards students who are trying to make a concept seem harder. (Motivational) Reassuring students who are not understanding.	The teacher quickly moves to a new idea.	Laughter	
T:If my hand had electricity and I touched Mr. Zoghbi (a student) in the back he will be charged. What is happening when we are charging by friction? (The teacher draws an image of Mr. Zoghbi on the board. It shows the electron distribution) T (asks Mr. Zoghbi):Were you annoyed before the ruler was rubbed on your hair? Stand up. Tell them how youwere feeling. S: I was restful. T: Mr. Zoghbi was restful and if the ruler could speak it would've said that she's happy too.	Funny anecdote just before explaining a new concept. The image of the student on the board was funny. The questions asked were humorous. (Cognitive and motivational)	The teacher directly relates the funny example he gave to new exercises that he came up with.	The students were looking at the board and Mr. Zoghbi and laughing because it caught their attention that there' s an image of a friend of theirs in the Physics problem The situation was very comic and the students were laughing really hard so was the student involved in the joke.All of the students laughed really hard .	
The students upon the request of the teacher, did a play about Coulomb in the classroom. The play was informative but at the same time, funny. The students said that the name of Coulomb was written on the Eiffel tower. T(dreamy tone): Maybe someday we can ask the school to take us to a field trip to Paris and see Coulomb's name on the Eiffel tower and remember $F= k \|q1\| \|q2\| / d^2$.	A funny play. (Cognitive and motivational)	The teacher directly started asking the students questions about the play, so that they can take things seriously.	The students reminded the teacher that there's a play. The students were listening and laughing. They answered all questions asked by the teacher about Coulomb's law. They seemed interested.	

Table 4: Examples of humor in observations

Humor	**Types and Roles**	**Overcoming drawbacks**	**Positive student responses**	**Negative student responses**
T: Point object. What is a point object? S: An object that is a point? S: Center of gravity of object. T: Very good! A point that represents an object. When we are tired and bored from doing so (he drew a very detailed funny car on the board), we use the point to represent the car. S: But sir? The windows (The teacher drew windows) S: The echangeur! (Very detailed car parts) S: El madikhne (smoke pipe) T:I gave you some time to joke but I didn't expect you'd stay that long. Would anyone like to add an extra joke? Let them all out, better than keeping them repressed during the Physics period." T: hahahahah! Serge medikhne! very funny! you should write a book, smile put your picture in the back and write why you wrote the book.	The teacher was exaggerating the reason behind a point object in a way that is funny. The aim of the joke was for the students to understand why do we draw a point object instead of the whole object.(Cognitive) Sarcasm towards students'jokes. (Behavioral)	The teacher gave students limited time to joke, he joked with them. When he wanted the humor to stop he directly started asking the students serious questions.	The students were all included in the atmosphere. They joked and laughed.	
T: Next year you will study projectile. What is projectile? S: I don't know T:You don't know? Bang! Bang! T:If you want to throw a pebble and " djagglo" (In English: show off) on your friends. And you want to throw it the farthest, what is the best angle? S: 45 degrees S: Because it's not too high and it's not too low T: Good. The most important thing is that you don't throw it 90 degrees.	Teacher joking. (Introducing a new idea briefly) (Motivational and cognitive)	Started explaining directly.	Students answered the teacher's questions. Students laughed.	

Table 4: Examples of humor in observations

Humor	**Types and Roles**	**Overcoming drawbacks**	**Positive student responses**	**Negative student responses**
(students chatting and talking) T: Let's play a game. The rules of the game are that we should stop talking. I am the head of the game and you're the participants. *Students laugh and then become quiet*	The teacher was using sarcasm to tell the students to stop talking. And it worked. (Behavioral)	The teacher startedexplaining directly.	The students became quiet.	
T: If we know Newton's first law and Newton's third law and we agree that these are the only ones, then we definitely have counting problems.	Introducing sarcastically Newton's second law. (Motivational)		Students laugh.	
T: Did anyone ever throw the keys from the balcony all the way down for someone to catch? S: Yes T: You did?(Confused look) T: Don't try it, the speed will increase greatly, your hand will hurt, not much.(sarcastically)	Introducing the concept g=a by using funny examples. Nonverbal reactions and sarcasm.		Students laughed a lot because of the teacher's look.	

Table 5: Humorous figures of speech in observations

Figures of Speech that are humorous	**Role**	**Positive student responses**	**Negative student responses**
T: The generator gives electricity like the bank gives money. Or in this case, electricity that we need. Ok?" S:Ok T: The resistor receives money or electricity in this case to give heat. Whereas the receiver takes electricity to give useful energy and heat as lost thermal energy. For example imagine each one of those is a shop. If you want socks do you go to the grocery shop to get a sock? " Ss (mumble and laugh): No T: When you use a charger, you use it to charge your phone, and not to heat up **.** T: If you want to use a charger you use it to charge your phone and not to heat up. You don't buy a charger to heat you house for example. This shop charges your phone. However if you touch the charger sometimes it's hot due to lost thermal energy. So the charger is a receiver. It is a passive dipole that takes electricity to give useful energy and thermal energy. T: Did you understand the concept very well?	Re explaining a concept that is not understood Exaggeration to make the figure of speech more comic for students. (Cognitive and motivational)	The students answered the teachers' questions. The students laughed and mumbled. The students started filling in the blanks as the teacher was explaining which showed that they were motivated and that they understood. One student gave a correct example about how the heater acts as a resistor because it needs the thermal energy. Afterwards the teacher explained that when a phone heats up, we don't use it a heater. A student responded that it is a resistor. The students said that they understood the concept very well. A student recalled a week later what is a receiver. A student was asked about the generator and was able to explain it perfectly relating it to the figure of speech.	A week later two students were asked what is a generator, one was able to remember the figure of speech but was not able to state a correct and complete definition of the generator.
T: How can we charge objects? S: Friction S: Give it more electrons T: **How can you get a bouquet of electrons and start giving this one 2 electrons and this one 3 electrons?**	Emphasize a wrong concept.(Motivational and cognitive)	Students were laughing. The teacher asked a question directly after the humorous figure of speech and a student answered correctly.	

Table 5: Humorous figures of speech in observations

Figures of Speech that are humorous	**Role**	**Positive student responses**	**Negative student responses**
T (explaining one of the exercises): The proton and the electron will stay together because the force of attraction is greater than the force pulling them down. If I stick a magnet on the fridge, the magnet will stick to the fridge. If I hold the fridge and start moving (made funny physical gestures as if he's holding a heavy fridge), will the magnet fall? No! because the magnet's force of attraction is greater than the weight of the magnet.	Explaining an exercise. (Relating the interaction between something unseen such as protons and electrons to something seen that is the fridge and the magnet. (Cognitive/ Motivational)	7 students knew how to solve the exercise before the teacher related it to a fridge and a magnet.Whereas 16 students raised their hands to say that the figure of speech given by the teacher helped them in solving the exercise. Students were listening and laughing at the figure of speech the teacher gave, because he presented it in a comic way.	
The teacher asked one of the students to act as a detective of a crime scene. He told the student to get out of the class, then he planned several different crime scenes with another student. The detective would come in and try to find out how the crime scene occurred using forces and their characteristics.	The teacher related a crime scene to forces. (Cognitive and Motivational)	Students were helping the detective answer the teachers' questions. Students were laughing and they were alert awaiting what's going to happen. Many students were raising their hands trying to come up with suggestions.	
T: A person calls for a delivery, he tells the guy I want to order a burger. The delivery guy asks him where is his house.The person says 3km. It's not enough. T: The same way, the vector stands for something much more than the magnitude. T: If the delivery man asks me where's my house and I tell him 3km, 3 km is only one aspect of several other factors. You can go up to Dhour choueir 3 km or go down 3 km towards the sea or to go 3km towards Zaarour. Most of you have a tendency like that guy who's ordering the delivery to say that your home is 3 km away because you are just referring to the vector as a magnitude but it's much more than that.	The teacher relates giving directionsto a delivery guy, to the concept of vectors. He highlights a common misconception of dealing with only one characteristic of vectors: magnitude. (Cognitive and motivational)	11 students raised their hands when the teacher asked them who thinks he understood the concept better after the examples I gave. The students were laughing and listening to the teacher. They were engaged in the conversation and in the classroom activities. Some pushed the table with the teacher to demonstrate forces, others engaged in the detective role play, and some gave examples and answered the teachers' questions. The teacher finally gave an exercise and the students were able to draw the forces.	

Table 5: Humorous figures of speech in observations

Figures of Speech that are humorous	**Role**	**Positive student responses**	**Negative student responses**
T: Let's go back to Hansel and Gretel. As Hansel was walking, he threw pieces of bread . Then he walked a little bit faster. He drew pieces of bread spaced from each other, then a little bit closer to each other. Looking at the pieces of bread drawn on the board. Who wants to narrate the story of Hansel and Gretel? * The teacher asked a specific student to answer* S: Don't know T: I want an answer S: Hansel was walking then he saw a candy house and started walking faster towards it. T: Ndahash! khaffaf! then sar yimshe asra3. Wa2a3 minno pieces of bread add ma ndahash.	Relating the trajectory of Hansel and Gretel toacceleration. (Cognitive and Motivational)	All the students got excited and started inventing different scenarios for the story. The students were laughing. 7 out of 25 students raised their hand when the teacher asked them if they understood the concept better after the example. However the rest said that they had understood it from before.	The student who was asked first to narrate the story felt useless and said: That's enough. I'm going to sit. Many students were talking at the same time.
S: The object at rest has a tendency to stay at rest and an object in motion has a tendency to stay in motion unless a force acts on it. S:But sometimes it stops alone. T: Impossible S: But sometimes it does. T: There would be a force of friction that stopped it. T: Sum of forces equal 0 it means, U.R.M or at rest. It can be moving like a car that is neither speeding up nor slowing down. T: If Semaan and I (family name of a student) went through a rocket to Mars to say hi to his friends. And he was thrown out of the rocket in space, he will remain moving in space with the same speed. If he was initially moving he will remain moving S: Like the ice skating T: OK. If you want to ice skate in Mars, you will remain with the same speed. If you put your skates in a way that creates friction. It will stop.	Relating an object undergoing the first law of motion to a car moving at a constant speed, to a student that was throw out of a space rocket, and to ice skating. (Cognitive)	Students were laughing, engaging in the conversation with the teacher and taking notes.	

Table 5: Humorous figures of speech in observations

Figures of Speech that are humorous	**Role**	**Positive student responses**	**Negative student responses**
T: When is an object in equilibrium on earth S: When in URM S: When at rest T: This is in theory,**it's like the soup or the appetizer of what I'm going to start explaining now.**	Relating a concept to an appetizer or a soup. (Motivational)	Students laugh, some fix the way they are seated as if to pay attention.	
T: I love when forces are collinear. Always before I sleep I look at pictures of collinear vectors. T: I want to create two pairs of collinear vectors. T: If I'm holding 3 objects with my hand. (He holds three things in his one hand). And I want to hold bags. Where do I put the objects? S: You throw them S: Do you have pockets? T: Yes S: You put them **in your pockets.** T: Exactly I put the keys in one pocket, the cell phone in the other and the bottle in the other one. T: How do I put them? S: Depending on a certain size? T: Depending on a certain strategy: for example I put the keys in the right pocket and the cell phone in the left pocket in order not to scratch it. T:Now that's what we're going to do with the forces. **Divide them into 2 axes (the two pockets) el x- axes and the y-axes**.W is divided into Wx and Wy. Wy and N cancel, since the object is not flying vertically, If Wx is greater than T it will slide down. So when we see the forces we distribute them among 2 axes: el x-axis wel y-axis. T: If we have diagonal forces, what do we do? S: We divide them among two pockets.	Relating the projection of forces o n the x and y axes to distributing many objects among two pockets. (Cognitive)	After the teacher starts by joking the students laugh a lot. Students all over the class answer attentively the teachers' abrupt quick questions. The student in the end uses the figure of speech is saying: We divide them among two pockets. They had a homework for the next day about dividing vectors into x-axes and y-axes (pockets) that all the class did correctly without any exception. A week later in an exercise where an object is on an inclined plane, the teacher asked a student: "What do we do with the weight." The student answered: " We divide it into pockets: W_y and W_x." The rest of the students continued the problem correctly.	

Table 5: Humorous figures of speech in observations

Figures of Speech that are humorous	**Role**	**Positive student responses**	**Negative student responses**
T: That's why if I let an elephant or an object in freefall they both have the same acceleration. T: If we threw far far away Ralph… firstly then Atamian. (students laugh including Ralph and Atamian) T: They will be attracted in space. Same path, have two masses, and distances and there's attraction between them. Planets too. Perfect mass and perfect force to maintain the orbit of the earth around the sun and planets around the sun.	Relating the motion of two students thrown in space to the motion of planets. (Cognitive and motivational)	The students were laughing including the students who were included in the example. Positive atmosphere in the classroom. Some students asked relevant questions after that.	
T: There is a love story between…. S: (interrupts blurting out two names) T: any two masses T: Really? (shows interest sarcastically) T: There is a love story between any 2 masses. This is a fact. T: What is love?S: Attraction T: Only?S: commitmentT: Commitment?S: sacrificeS: connecting T: Connecting!!! Ouf!Ouf!Ouf!S: Honesty S: According to Paolo Choello: " Love simply is."S: Respect T: What factors increase or decrease love? Remember these are masses. Please I don't want anyone to say we get Mars a rose. T: What are the components. S: Mass T: Mass. Will Mars be loved more if it ate ma3moul? Salim will love me more if I ate ma3moul? S: If there's a distance love decreases T: That's what you think? S: As distance increases, attraction decreases T: Excellent. Another component. (Continues conversation) T: FA/B =FB/A= Gmm/d^2 affected by mass and indirect relationship with distance. This is Newton's law of gravitational attraction.	Relating gravitational attraction to love between two people. (Personification) It has a cognitive role.	Students were paying attention, laughing concentrating knowing that they will not be tested on this chapter in the final, which is usually uncommon. They were all raising their hands and engaging with the teachers' questions. In the next session the teacher asked the students who understood gravitational attraction better after the analogy, 15/26 students raised their hands.	

Table 6: Views of teachers concerning the roles of figures of speech through the interviews held

Teachers according to grades they teach	Roles of figures of speech	Examples for each Role	Notes and Remarks
Teacher 1: Grade 9	1. Help students **relate new conceptsto prior knowledge.** 2. Most effective when teachers want to start a new concept, remove misconceptions, and when building on prior knowledge. 3. Relate physics formulas to previous physics formulas especially when dealing with weak students to help them know that all sciences are interdisciplinary. 4. Several metaphors should be used to change a misconception.	1. Relating potential difference in electricity to gravitational potential energy causing water to flow from a high level to a low level. 2. Relating potential difference to students moving from a crowded room to a less crowded room. 3. Using verbs that are usually used to describe human behavior.	1. Potential difference is the difference in potential between the terminals of a dipole. 2. I use all types of figures of speech, as long as it can be related to something the students already know.
Teacher 2 : Grade7-8	1. Help students understand the concept based on their previous knowledge. 2. Help them learn new concepts because they relate them to their everyday life. 3. Change a misconception. 4. Most effective when students have the background to the ideas that the concepts are related to. 5. Students reuse figures of speech learnt to re explain a concept since they stay with them. 6. Personifications help students see, remember and visualize.	1. Relating electron orbits, to planets. They all move on a path. Relating orbits to the solar system and showing them how they never touch each other. They reuse this concept by answering: "It's like the solar system you explained for us". 2. Relating elements to people, some that are generous and like to give while others that don't, like non-metals, they would rather take. So they share and	1. Personifications are most effective since it's easier to relate to oneself. 2. This interview made me think about the use of humor and if it can really make a change and I believe if applied would create an idea

	7. Help improve the grades of good students, and get students that are not serious to be at least interested.	they take, relating it to bonding.	teaching atmosphere.

Table 6: Views of teachers concerning the roles of figures of speech through the interviews held

Teachers according to grades they teach	Roles of figures of speech	Examples	Notes and Remarks
Teacher 3: Grade 12	1. Let students understand **better when needed only**. 2. Make a concept easier and clearer to understand. 3. Help change a misconception 4. Figures of speech are most effective when there is a misconception or when the students didn't catch the idea. 5. Students sometimes reuse the figures of speech to explain a concept acquired during peer coaching activities. 6. The figure of speech and the concept are so much related, they can't remember one and forget the other. They stick together in their minds.	1. Relating an electric current to a flow of marbles through a pipe or a canalized system. Whenever you cut the pipe usually the flow stops The pipe is the circuit and the flow of marbles is the flow of electrons. 2. Most students think that the electric current flows slowly from one part to another. In reality it either flows through the whole circuit or it doesn't. The pipe example clarifies this misconception.	1. All figures of speech are important, we cannot prefer one over the other.
Teacher 4 : Grade 8	1. Help the students relate what they learnt to real life experiences. 2. Help them relate new concepts to something they have previously seen, or something they already know. 3. Changes misconceptions. 4. Helpful when the concept is hard for the students to understand just by explanation. So relating it to something else that is more familiar might help them understand.	1. Relating positive and negative charges to a rich and a poor man respectively. Two poor men cannot give each other, it's like negative charges repel. But a rich man can give a poor man, so opposite charges attract. 2. Light bends, magnetic poles push each other.(The verbs bends and pushes are usually used to refer to	1. All figures of speech are important. Uses mostly personifications. 2. Uses examples more than figures of speech. 3. A student that I teach in private lessons remembered the example about positive and negative charges and

	5. Students reuse analogies and examples that I give in class to re-explain the concept.	humans.)	explained it all.

Table 6: Views of teachers concerning the roles of figures of speech through the interviews held

Teachers according to grades they teach	Roles of figures of speech	Examples for each Role	Notes and Remarks
Teacher 5: University students	1. Help students understand new concepts because they help them see the idea that I am trying to explain in a concrete way. 2. Simplify the theory. 3. Help avoid misconceptions. 4. Effective when I am teaching something that is complicated. 5. Help them see clearly, imagine and understand the theory. 6. Students reuse the figures of speech to re-explain a concept. They remember it wholly and correctly.	1. Relating refraction of light as it passes from air to glass, to a student who is moving from an empty place to a crowded place. He slows down so does light. 2. Relating the buoyant force to someone who holding you up while floating on water.	1. I believe figures of speech can help everybody in every situation, not just in learning physics or science. It can help them to understand any concept even in life.
Teacher 6 : Grade 12	1. Used when the idea is not grasped immediately. 2. Used when the idea is still unclear in the students' minds, even if they know how to apply it in exercises. 3. Help the students grasp the concept more easily. 4. Relate Physics concepts to other Mathematical concepts shaping their logic. 5. Relate Physics concepts to other Physics concepts ensuring that students' understanding of the whole Physics curriculum. This helps in the formation of their mind. 6. Tools for initial understanding. Students reuse the figure of speech to explain a concept to an absent student but do not use them when I ask them a question in class, knowing that I'm interested in their understanding rather than the figure of speech.	1. Relating electrical resonance to mechanical resonance. Relating oscillations in pendulums to rotational oscillations. 2. Relating potential energy and the reference to a people putting their money in the same bank. The bank comes up with a policy that any account below 2000$ will be closed. So the ones that have 1800$ will add 200$ and so on. 3. The teacher says: "Let's call the Math teacher" instead of telling them let's solve mathematically.	1. There are tools others than figures of speech in case figures of speech did not work. 2. I use figures of speech in the humanities sections more than I use them in scientific sections because scientific sections take lab sessions and can imagine abstract concepts better. 3. There is a difference in comparing scientific formulas to mathematical

	7. Make the class more interesting. 8. Help students retrieve the concept from the memory. Students sometimes remember one word and then whole concept.	4. Relating a nucleus in an excited state to a classroom with boys and girls(protons and neutrons) where2 couples hold hands and walk out of the class creating a disturbance.	ones from using a figure of speech whereby the physics concept is compared to a non-scientific reality. 4. I use all figures of speech because all of them are useful, if need be I dance to make them imagine the concept.

Table 6: Views of teachers concerning the roles of figures of speech through the interviews held

Teachers according to grades they teach	Roles of figures of speech	Examples for each Role	Notes and Remarks
Teacher 7: Grade9-10-11-12.	1. Figures of speech help young students to understand difficult concept such as vectors. 2. Always useful especially when the concept is abstract and theoretical. 3. Help students realize that they haven't fully understood the concept yet. 4. Help the teacher know whether the student understood or not. 5. Help student at the beginning of a concept. Afterwards they remember the concept and forget the figure of speech. 6. Smart students reuse the figure of speech taught to re explain a concept. 7. Figures of speech make it easier for weak students that I teach private lessons to understand better. 8. Help students understand concepts that are above their ability of understanding. 9. Help communicate the idea to students.	1. Relating voltage to a difference in water level and electric current to the flow of electrons. 2. Strength contests "Kbeish" to explain Newton's third law of motion. 3. Relating a new Physics concept to a new person you've met. We cannot rely on outer appearance.	1. I use mostly analogies.
Teacher 8 Grade 7-8-9-	1. Make it easy for students to understand what I want myself to clarify and to point at. 2. Help them differentiate between two new concepts that seem similar, for example: Electric current and	1. Relating voltage to trapping water at a higher level in a dam or in a reservoir and the water flow due to this difference in	1. I choose figures of speech that they can relate to something they've seen in their daily life like water flowing down a reservoir to

10	voltage. 3. Help them differentiate between two concepts that they've learnt before and they classified as the same but are not such as: weight and mass. 4. Most effective when students keep finding a difficulty in understanding a new concept. 5. Students reuse them to re-explain a concept they learnt during oral recitations, private lessons and to their parents.	potential to the electric current. 2. An astronaut measuring the mass and not the weight of a meal he wants to eat. 3. Relating pressure to a man lying on a surface of nails and not being injured.	their taps rather than roller coasters as mentioned in their textbooks. 2. I use all types of figures of speech.

Table 6: Views of teachers concerning the roles of figures of speech through the interviews held

Teachers according to grades they teach	Roles of figures of speech	Examples	Notes and Remarks
Teacher 9 (the one I observed): Grade 10	1. Most effective when they help students understand an abstract concept because they relate it to something concrete. 2. Help the student relate the idea to a concept in real life. 3. When students are learning a concept that is related to an old one, we can build the new concept on prior knowledge. Whereas when we are teaching students a totally new concept, then we're creating a new section in their minds. So when we use the figure of speech it helps them create the basic layer for the concept. 4. When figures of speech relate a concept to something they already know, they help construct the new concept in their minds. 5. Help in the change of a misconception or when there's a difficult concept to be learnt. 6. Students reuse figures of speech used in the classroom to re explain a concept, while solving exercises and in private lessons.	1.Relating a generator (which is a totally new device(dipole)) to a bank in a city. People take money from the bank and they spend the money in different shops. The passive dipoles are related to shops that spend the electricity. 2.Students have a difficulty in understanding forces as vector quantities, the always represent them as scalar quantities. 2N is not enough to represent a force the same as saying to a delivery man that your house in 2 km away is not enough. The direction, line of action, and origin are required. 3.Relating the projection of forces on the x and y axes to wanting to hold several objects but can't so you start dividing them into 2 pockets using a strategy.	1. Depending on the type of the concept to be taught, I choose the figures of speech to be used. 2. I encourage teachers to use metaphors especially in our culture. I notice that students really relate to metaphors in a very interesting way especially in physics and Math because they are abstract concepts. When I meet with my students who have graduated and are at university now they remind me of some of the figures of speech I used in class. 3. Working with you on the observations this year was an eye opener for me to be using figures of speech in a more serious and prepared way in the upcoming years.

Table 7: Views of teachers concerning the drawbacks of figures of speech through the interviews held

Teachers according to the grades they teach	**Drawbacks of figures of speech**	**Overcoming drawbacks**	**Are figures of speech prepared beforehand**
Teacher 1 : Grade 9	1. When figures of speech explain only part of the concept, the student might not understand the whole concept. 2. Some students rewrite the concept learnt in the same way the teacher explained it. They don't justify their answer scientifically, but they use terms used in the figure of speech.	Experience. You get experience from previous years to know when to tell them to pay attention to what they could misunderstand.	1. They come with experience. I never prepare them beforehand. 2. I learn from year to year what students will ask. I know where they will form misconceptions.
Teacher 2: Grade7-8	1. The language is the drawback because we teach in English, and it's not their native language. Using figures of speech in English sometimes is a hindrance since some students don't understand the language properly. 2. No other drawbacks, have much more advantages.	1. Giving pictures, or models (concrete) to help them see it.	1.Most of the time I think of the figures of speech beforehand. 2.Many times I come up with the figures of speech on the spot, triggered by the students' questions about concepts they did not understand. 3.Textbooks used include figures of speech that are helpful.
Teacher 3 : Grade 12	1. Figures of speech sometimes don't fit in the subject.	1.They must be used at the right place and at the right time.	1. Sometimes we prepare them especially in the prerequisites. 2. Sometimes it comes to you when you're facing a problem in explaining a concept due to experience. 3. Metaphors are not available in secondary Lebanese textbooks they are mostly available in American books used in middle school.
Teacher 4: Grade 8	1. Sometimes the figures of speech used do not really relate to what is being explained.	1. Practice or experience is needed.	1. This teacher realized the importance of figures of speech in delivering a

	2. They might confuse students.	2. Ask students about the concept after explaining it to make sure they understood it.	concept due to students mentioning figures of speech during private lessons. Hence, I realized the importance of preparing them beforehand.

Table 7: Views of teachers concerning the drawbacks of figures of speech through the interviews held

Teachers according to the grades they teach	**Drawbacks of figures of speech**	**Overcoming drawbacks**	**Are figures of speech prepared beforehand**
Teacher 5: University Students	1. I sometimes prefer not to use them because I don't want the student to understand the concept in a wrong way and then I'll have to adjust it again.	1. When I feel they have drawbacks I prefer not to use them.	
Teacher 6 : Grade 12	1. Sometimes students don't grasp the similarities between the figure of speech used and the concept to be explained and this confuses them. 2. Sometimes the figure of speech is clear in the teacher's head but not in the students' heads. 3. In scientific classes my first resort in explaining a concept is not figures of speech because I am interested in forming their minds to think in abstract terms.	1. The teacher has to be confident enough to back down from attempting to use a figure of speech and noticing when it's not helping. 2. The teacher needs to be cautious and use figures of speech wisely.	1. I don't prepare them beforehand, I use them spontaneously. 2. Sometimes I know from experience which figures of speech were previously helpful and ask students to tell me if it helped them so that I can evaluate it.
Teacher 7: Grade9-10-11-12	1. Figures of speech when used alone give an incomplete explanation. Since they sometimes target one aspect of concept. 2. Figures of speech act as images and are not real.	1. Always remind them that it is a figure of speech and not the reality; a part of a bigger picture. 2. Experience: knowledge of some common misconceptions that can be targeted beforehand.	1. Textbooks used do include figures of speech and we also use videos and simulations. 2. Some figures of speech are spontaneous because some questions asked by students are spontaneous and unprepared. But others are prepared, read in textbooks or taken from other colleagues.

Table 7: Views of teachers concerning the drawbacks of figures of speech through the interviews held

Teachers according to the grades they teach	**Drawbacks of figures of speech**	**Overcoming drawbacks**	**Are figures of speech prepared beforehand**
Teacher 8 : Grade 12	1. Sometimes hinders students from linking the concept to their everyday life experiences because they keep linking it only to the figure of speech the teacher gave. 2. Sometimes students cannot explain the concept without the analogy.	1. I tell them that it's just an example or an analogy, once you understand it, forget about the analogy and understand the concept.	1. I prepare analogies before coming to class, when I know I'm going to start explaining a new difficult chapter. With experience, they will come without preparation but I encourage novice teachers to prepare them. 2. American textbooks in the middle school start each chapter with an example or a figure of speech whereas the Lebanese textbooks used in high school don't include figures of speech.
Teacher 9: Grade 10	1. Sometimes the figure of speech does not hit on all aspects of the concept, but targets only one part. Students will either have a distorted understanding of the concept or an incomplete understanding.	1. I chunk the concept into parts. And the figure of speech will be used to explain one part. 2. Using different figures of speech to relate to the whole concept.	1. It is better to prepare them. Usually most of the time they are spontaneous, but this year I prepared a few because you were observing my class. Next year I will be preparing them more cautiously. When figures of speech are prepared they help students understand more, and they are targeted with a deeper purpose. 2. Textbooks I use don't include figures of speech at all.

Table 8: Views of teachers concerning the role of humor in the interviews held

Teachers according to grades they teach	**Role of Humor**	**Examples**	**Avoiding Drawbacks**	**Relation between figures of speech and humor**
Teacher 1: Grade 9	1. Makes them understand a concept. 2. Makes them learn a common misconception. 3. Motivates students 4. Humans cannot concentrate for more than twenty minutes, so it gets back their attention. 5. If it is related to something a student did or said, it can help them remember a new concept learnt. 6. The students will like the teacher. 7. Lets the students feel that the period passed very quickly.	1. I explain something in a way that they all agree, then I surprise them by telling them that it's not true. 2. Lets them say wrong answers without commenting until everyone answers and then I tell them the correct answer.	1. Too much humor might disrupt the learning environment. 2. Controlling the class	1. Yes they are related.
Teacher 2: Grade7-8	1. Triggers more of your adrenaline which goes higher and it helps you assimilate more. 2. Makes students not forget new concepts at all.	No examples	1. I use humor depending on the group and the mood of the students. Since some students take advantage and will start playing. 2. I work on maintaining respect. 3. I like them to know that every place has its own situation. 4. Trial and error helps me learn which group I can implement humor with.	1. They are related because figures of speech help you see something in a comic way and in new ways.

Table 8: Views of teachers concerning the role of humor in the interviews held

Teachers according to grades they teach	**Role of Humor**	**Examples**	**Avoiding Drawbacks**	**Relation between figures of speech and humor**
Teacher 3: Grade 12	1. Usually if I have two consecutive physics periods, I use humor to change the atmosphere. 2. Gives them a small rest. 3. Prepares them for the concepts to come. 4. Helps them relate concepts learnt with figures of speech that made them laugh.	1.When teaching the students the right hand rule in electromagnetism you relate the direction of the current, force, and field to the shape of a gun with your hands.	1. Humor must be controllable or else avoid using it. 2. You must not allow students to take advantage. 3. You must always be in control even when you are using humor. 4. Sometimes I ask a student who is humming to sing in front of the whole class or say something aloud.	1. Yes they can be related just as the example states. The students like it and it changes the atmosphere.
Teacher 4: Grade 8	1. Breaks the tension. 2. Energizes students. 3. Prevents boredom, and keeps students involved. 4. Keeps them alert. 5. Creates contact between the teacher and the student.	1. While we were talking about conductors and insulators. I told them a story about a man who was shaking his leg because there was a stone in his shoe, and another man saw him and thought he was being electrocuted so he hit him with a wooden stick.The students laughed and learnt that wood is an insulator.	1. Try not to overdo humor, once or twice is enough or else they would want to start playing and stop taking it seriously. 2. Telling them: "Ok. It's enough, we laughed, now let's go back to learning."	1.Yes they are related. Because they can't imagine the concept otherwise. It makes them laugh.

Table 8: Views of teachers concerning the role of humor in the interviews held

Teachers according to grades they teach	Role of Humor	Examples	Avoiding Drawbacks	Relation between figures of speech and humor
Teacher 5: University students	1. Helps when students are tired from concentrating. 2. Helps students relax, so that they can listen again to what I'm teaching. 3. If the joke has to do with Physics it will be very helpful but personally I am not good at this. 4. It helps them to concentrate more, but not to learn.	No examples	1. Try not to use them all the time or else there will be disorder in the classroom. 2. Make the time when I'm using humor very concise, I don't spend a lot of time on it to keep the atmosphere serious. Then I continue explaining the session.	No answer
Teacher 6: Grade 12	1. Relaxes the atmosphere 2. Lets time pass quickly 3. It puts them at ease and in a receptive environment.	No examples	1. I tell them at the beginning of the year: "I am the one who sets the joking rhythm in the classroom, even though you are funnier than me." 2. Smile and wait for them till they finish when they continue joking. 3. In some classes I joke less. 4. If they know that I love, care and respect them, I can joke. Because then I can look at them and they will stop joking. If I haven't reached this stage, I don't joke.	1. They find it funny to relate two different things in this way. Especially when the figure of speech is constructed in an intelligent way. Sometimes their intelligence enjoys it and you can see their eyes lighting up.

Table 8: Views of teachers concerning the role of humor in the interviews held

Teachers according to grades they teach	**Role of Humor**	**Examples**	**Avoiding Drawbacks**	**Relation between figures of speech and humor**
Teacher 7: Grade 9-10-11-12	1. Through jokes I can carry the message across. 2. Helps them remember concepts in the test when the joke is related to a concept. 3. Relieves stress. 4. Helps build a good relationship with the teacher. 5. Puts them at ease and motivates them.	1. Telling them I was "amazed" by your answers in the exam to remind them of their mistakes later in a funny way. 2. When explaining refraction of a ray from a more refractive medium to a less refractive medium, I stamp my feet on the ground and tell them: "Surprise!" They remember this during the test and laugh.	1. Humor needs discernment depending on the group of students I'm teaching. 2. Time management 3. There should always be a certain distance between the teacher and the student.	1. Sometimes figures of speech are related to humor especially when they are linked to a physical gesture or a noise that I made during class.
Teacher 8: Grade 7-8-9-10	1. I use humor especially when the students are tired, especially in the afternoon. 2. Increases student's attentiveness since they will be waiting the upcoming joke. 3. Students will listen more, and will be more involved.	1. When explaining buoyancy, I draw a container on the board and tell them let’s pretend we drop an object into the container. I step aside and tell them it’s because I don’t want to be splashed by the water. 2. When I'm explaining mass and weight, I say imagine if everyone goes to Mars they will become thinner. 3. Sometimes when I want to pull the overhead projectors screen and I'm short I ask one of the students to do it and I say	1. We shouldn't use humor all the time, because some students take advantage of that.	1. Sometimes figures of speech are related to humor if they happen to be funny.

		usually I can do it but now I don't want to.		

Table 8: Views of teachers concerning the role of humor in the interviews held

Teachers according to grades they teach	Role of Humor	Examples	Avoiding Drawbacks	Relation between figures of speech and humor
Teacher 9: Grade10	1. Humor is crucial in classroom management especially that Physics is considered by most students to be a difficult and dry subject. 2. Humor catches their attention, makes them laugh, allows them to take a break, their brains would rest, they get refreshed and continue the period. 3. When I use humor in explaining a concept, they can really recall it in a better way, because it's easier for students to remember a joke than a concept alone. 4. Humor helps students in constructing the schema of the concept learnt in their minds and retrieving information.	1. When explaining Newton's third law: For every action there's an equal and opposite reaction, I relate it to a human being running and hit an elephant. (Students will laugh)	1. Teachers should be delicate in using humor. 2. If the teacher wants to use sarcasm, he should use it wisely and not relate it to any sensitive topic to avoid hurting someone. 3. Most importantly the teacher should be caring and loving and this makes all the difference, because students will know and feel it and humor will have a minimal negative impact. 4. Teachers should have a feel of what's happening in the class, if one of the students is being defensive the teacher can talk to the student on a personal basis after the class to understand and fix the problem.	1. Of course figures of speech are related to humor. For example relating an object to a human trait can sometimes be funny Students imagine the figure of speech which makes them laugh and understand the concept.

Appendix D: Questionnaire Answers

Table 9: Questionnaire Answers Part 1

Ref	Sex	Nationality	Age	School	School French / English	Grade	Number of students in the class	Number of Weekly Physics periods
1	M	Lebanese	16	College Louise Wegman	French	10	20	4
2	M	Lebanese	16	Shweer Secondary School	English	9	31	2
3	M	Lebanese	16	Saint Joseph School	English	9	25	3
4	M	Lebanese	17	Notre Dame des Apotres (Rawda)	French	11	29	7
5	M	Lebanese	14	Champville	French	9	34	3
6	M	Lebanese	18	Saint Joseph School	English	12	29	6
7	M	Lebanese	17	Antoura	French	11	34	6
8	M	Lebanese	18	Saint Joseph School	English	12	29	5
9	F	Canadian / Lebanese	16	Saint Joseph School	English	11	31	3
10	F	Lebanese	16	Saint Joseph School	English	11	31	5
11	F	Lebanese	17	Saint Joseph School	English	12	29	5
12	F	Lebanese	17	Saint Joseph School	English	11	31	5
13	F	Lebanese	18	Saint Joseph School	English	12	29	5
14	F	Lebanese	17	Saint Joseph School	English	12	29	5
15	M	USA	17	Saint Joseph School	English	12	29	5
16	F	Lebanese	18	Saint Joseph School	English	12	29	5
17	F	Lebanese	17	Saint Joseph School	English	12	29	5
18	F	Lebanese	16	Saint Joseph School	English	11	31	5
19	M	Lebanese	17	Saint Joseph School	English	12	28	7
20	F	Lebanese	16	Saint Joseph School	English	11	30	5
21	F	Lebanese	16	Saint Joseph School	English	10	30	3
22	F	Lebanese	16	Saint Joseph School	English	10	30	3
23	F	Lebanese	17	Saint Joseph School	English	10	30	3
24	F	Lebanese	18	Saint Joseph School	English	12	29	5
25	F	Lebanese	18	Saint Joseph School	English	12	29	5
26	F	Lebanese	18	Saint Joseph School	English	12	38	4
27	F	Lebanese	17	Champville	French	12	24	1
28	F	Lebanese	18	Notre Dame des Apotres	French	12	33	6
29	F	Lebanese	17	Montana International College	English	12	5	5

Table 9: Questionnaire Answers Part 1

Ref	Sex	Nationality	Age	School	School French / English	Grade	Number of students in the class	Number of Weekly Physics periods
30	F	Emirati	18	Montana International College	English	12	5	5
31	M	Lebanese	17	Saint Joseph School	English	12	29	7
32	M	Lebanese	17	Saint Joseph School	English	12	29	5
33	F	Lebanese	18	Saint Joseph School	English	12	29	7
34	M	Lebanese	17	Saint Joseph School	English	12	29	5
35	M	Lebanese	16	Saint Joseph School	English	10	29	3
36	M	Lebanese	16	Saint Joseph School	English	10	29	3
37	M	Canadian	15	Saint Joseph School	English	10	29	3
38	F	USA	15	International College	English	10	21	3
39	F	Lebanese	14	Sainte Famille Fanar	French	9	30	2
40	M	Lebanese	15	Notre Dame des Apotres	French	10	33	4
41	F	Lebanese	16	Beirut Evangelical School	English	11	20	1
42	F	Lebanese	16	Beirut Evangelical School	English	11	20	1
43	M	Lebanese	17	Antoura - Saint Joseph	French	11	33	6
44	F	Lebanese	16	Saint Joseph School	English	11	23	
45	F	Canadian / Lebanese	15	Sainte Famille Fanar	French	10	24	4
46	F	Lebanese	16	Antoura - Saint Joseph	French	11	26	7
47	F	Lebanese	16	Saints-Coeurs Kfarhbab	French	11	26	2.5
48	M	Lebanese	18	Saint Joseph School	English	12	29	5
49	M	Lebanese	16	Antoura - Saint Joseph	French	10	33	4
50	M	Canadian	16	Saints-Coeurs Bikfaya	French	10	32	4
51	M	Lebanese	16	Antoura - Saint Joseph	French	10	33	4
52	M	Lebanese	16	Sainte Famille Fanar	French	10	33	4
53	F	Lebanese	16	Saint Joseph School	English	10	30	3
54	F	Lebanese	16	Saint Georges Zalka	French	11	21	1
55	F	Lebanese	15	Adventist School (ASB)	English	10	21	2
56	F	Lebanese	17	Freres Maristes Amshit	French	11	20	2
57	M	Lebanese	18	Saint Joseph School	English	12	28	9
58	M	lebanese	17	Saint Joseph School	English	12	29	5

Table 9: Questionnaire Answers Part 1

Ref	Sex	Nationality	Age	School	School French / English	Grade	Number of students in the class	Number of Weekly Physics periods
59	F	Lebanese	15	College National du Shouf	French	10	28	3
60	M	Lebanese	17	Saint Joseph School	English	12	28	7
61	F	Lebanese	15	Sainte Famille	French	10	32	3
62	F	Lebanese	16	Saint Joseph School	English	10	30	3
63	F	Lebanese	15	College Protestant Francais	French	10	22	3.5
64	M	Lebanese	15	Jamhour	French	10	30	3
65	F	Lebanese	18	Saint Joseph School	English	12	29	5
66	M	Lebanese	17	Lycee Nahr Ibrahim	French	12	28	5
67	F	Lebanese	18	Saint Joseph School	English	12	29	7
68	F	Lebanese	17	Saint Joseph School	English	12	28	7
69	F	Lebanese	17	Saint Joseph School	English	12	28	7
70	F	Lebanese	18	Saint Joseph School	English	12	30	5
71	M	Lebanese	18	Saint Joseph School	English	12	28	
72	F	Lebanese	18	Saint Joseph School	English	12	30	5
73	M	Lebanese	17	Saint Joseph School	English	12	28	7
74	M	Lebanese	17	Saint Joseph School	English	12	30	5
75	F	Lebanese	18	Saint Joseph School	English	12	29	5
76	F	Lebanese	12	Saint Joseph School	English	7	32	2
77	F	Lebanese	12	Sacre-Coeurs - Gemmayze	French	7	33	3
78	F	Lebanese	13	Jesus and Mary School	English	7	26	2
79	F	Lebanese	13	Jamhour	French	7	34	1.5
80	M	Lebanese	17	Champville	French	11	35	2
81	M	Lebanese	17	Jamhour	French	11	32	5
82	M	Lebanese	17	Valley International School	English	11	10	3.5
83	M	Lebanese	17	Sagesse Brasilia Baabda	French	11	31	5
84	M	Lebanese	17	College Metn El Chemaly	French	11	33	7
85	M	Lebanese	14	Saint Joseph School	English	9	26	3
86	M	Lebanese	14	Antoura - Saint Joseph	French	9	32	4
87	M	Lebanese	15	CPA	French	9	29	2

Table 9: Questionnaire Answers Part 1

Ref	Sex	Nationality	Age	School	School French / English	Grade	Number of students in the class	Number of Weekly Physics periods
88	M	Lebanese	17	Carmelites - Fanar	French	11	33	7
89	M	Egyptian	14	Jamhour	French	7	35	3
90	M	Lebanese	16	Sagesse Brasilia Baabda	French	10	26	4
91	M	Lebanese	17	Saint Coeur - Jdeide	French	11	25	6
92	M	Lebanese	14	Antoura - Saint Joseph	French	8	34	2
93	M	Lebanese	16	Saint Joseph School	English	11	30	5
94	M	Lebanese	15	Val Pere Jacques	French	9	32	2
95	M	Lebanese	14	Antoura - Saint Joseph	French	8	30	2

Table 10: Questionnaire Answers Part 2

Ref	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
1	SD	SD	A	SA	A	D	U	A	SD	SD	A	D	SD	SD	SA	A	SD	SD	SD	SD
2	A	U	SA	A	A	U	U	SD	D	SD	U	A	SD	D	A	U	A	A	SA	D
3	U	D	SA		SA	SD	U	A	SD	SD	A	A	U	U	SA	SA	A	U	SD	D
4	D	SA	U	SA	D	D	SA	SA	D	A	A	SA	D	D	D	SA	A	A	D	A
5	U	SA	U	A	A	A	SA	SA	U	SA	A	A	A	SD	SA	SA	A	SA	SA	SA
6	SA	A	SA	A	D	SD	A	A	A	U	A	D	A	U	SA	SA	A	SA	D	A
7	U	A																		
8	SD	D	A	U	A	D	A	A	D	D	D	A	D	D	D	D	A	A	D	SA
9	D	U	U	A	A	D	SA	SA	SD	SD	D	A	U	U	U	SA	A	D	D	U
10	U	A	A	A	U	D	A	A	A	U	D	U	D	U	D	SA		SA	SD	A
11	D	SD	A	A	U		A	U	D	A	A	A	U	U	D	A	A	U	D	U
12	A	U	A	A	A	D	SA	SA	D	D	D	A	D	U	A	SA	A	SA	SD	A
13	D	SD	U	A	A	U	A	A	U	D	U	A	D	U	D	SA	A	SA	D	SA
14	A	U	SA	SA	A	SD	SA	A	D	SD	U	A	SD	D	U	SA		SA	SD	U
15	SD	U	A	A	A	SD	U	SA	SD	D	D	D	SA	D	D	A	A	A	U	D
16	U	D	A	A	SD	D	A	A	D	D	D	SA	D	D	A	A	A	U	D	A
17	D	D	U	U	A	U	A	A	U	D	A	A	U	A	D	SA	SA	A	D	D
18	U	D	A	A	U	D	A	A	U	D	D	A	A	D	SA	A	U	D	D	D
19	D	U	A	D	A	D	D	A	D	U	SA	A	D	D	A	SA	A	A	SD	U
20	A	SD	A	D	SA	SD	A	A	D	D	D	SA	D	D	A	D	SA	A	SD	D
21	D	D	A	A	A	D	A	A	D	D	U	SA	SD	U	A	SA	U	U	SD	A
22	U	D	A	A	A	U	A	D	D	D		A	A	A	A	A	A	SA	A	SA
23	U	D	A	A	A	U	A	A	D	D	A	A	U	A	A	A	A	A	A	SA
24	U	U	SA	SA	D	D	SA	SA	D	D	D	SA	U	U	SA	SA	SA	SA	SD	U
25	A	SD	A	SA	D	SA	A	A	SA	U	U	U	A	D	SD	SA	SA	SA	SD	U
26	D	U	A	A	A	U	SA	SA	U	SD	U	A	D	U	U	A	A	SA	U	U
27	A	SA	SA	A	SA	D	SA	SA	U	D	A	SA	D	D	A	SA	A	SA	SD	A
28	A	U	SA	SA	A	D	A	SA	U	D	SD	A	D	D	A	SA	A	A	D	U
29	SA	SA	A	SA	A	A	SA	SA	U	U	A	SA	D	A	SA	SA	SA	A	SA	A
30	A	U	U	SA	A	U	SA	A	A	U	A	A	D	A	U	SA	A	A	SD	D
31	D	U	A	U	A	U	A	A	D	D	D	A	U	D	U	SA	A	A	SD	A
32	D	SD	SA	A	U	U	U	U	D	A	SD	U	U	U	SA	SA	SD	SA	SD	SA

Table 10: Questionnaire Answers Part 2

Ref	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
33	U	U	SA	A	D		SA	A	D	D	D	A	D	D	U	SA	A	A	D	U
34	D	U	A	A	U	U	U	U	D	SD	D	D	U	SD	SD	SD	U	U	A	SA
35	D	U	A	SA	A	D	A	A	U	SD	SD	D	U	SD	D	SA	A	U	SD	A
36	D	U	SA	A	A	D	SA	SA	A	SD	SD	SA	D	SD	A	SA	SA	SA	SD	A
37	D	U	A	SA	A	D	A	A	U	SD	U	A	D	D	A	SA	U	A	SD	A
38	A	A	D	A	D	A	D	A	D	D	A	SA	SD	SD	SA	D	A	A	A	SA
39	A	U	U	A	D	SA	A	A	U	SA	U	U	SA	U	A	U	U	SA	SD	SA
40	D	A	SA	U	SA	D	A	SA	U	D	U	A	D	A	A	SA	A	A	SA	D
41	SD	U	D	A	D	A	D	A	A	D	D	A	U	D	D	SA	A	A	D	A
42	SD	U	D	U	SD	D	A	A	U	U	A	A	D	D	A	SA	A	A	D	U
43	SD	D	SA	A	D	SD	A	U	D	SD	U	D	A	D	U	A	U	A	D	U
44	A	A	A	A	A	U	A	A	SA	A	A	D	A	D	A	A	A	SA	D	SA
45	D	A	D	A	SD	A	SD	SD	D	SA	U	A	SA	A	U	A	SA	SA	SD	U
46	D	U	A	A	A	D	SA	SA	U	D	A	A	D	D	A	SA	SA	SA	SD	SA
47	D	A	A	SA	SD	A	A	D	U	SD	U	U	SA	D	SA	SA	SA	A	D	SD
48	SD	A	A	A	A	U	D	U	A	A	A	U	U	A	U	A	A	U	A	U
49	A	U	A	SA	A	SD	A	A	U	SA	D	SA	U	A	D	SA	SA	SA	SD	A
50	D	A	A	A	A	D	SA	A	U	SD	U	A	D	U	A	SA	U	A	SD	D
51	D	SA	U	U	D	D	U	U	U	D	D	U	D	SD	A	U	D	D	D	SD
52	SD	D	A	U	D	D	A	U	A	D	A	D	U	D	D	SA	U	D	SD	D
53	D	U	A	U	SA	U	A	A	SD	D	SD	A	D	U	U					
54	U		SA	A	SA	SD	SA	A	U	SD	SD	SA	D	SD	A	SA	A	A	SD	U
55	SD	U	SA	A	SA	SD	A	A	U	D	U	SA	SD	SD	A	SA	A	A	SD	A
56	D	A	SA	SA	D	SD	SA	SA	D	SD	SD	SA	D	SD	SA	SA	SA	SA	SD	SA
57	SD	SD		SA	SA	SD	SA	SA	U	U	U	SA	D	D	SA	SA	SA	SA	SD	SA
58	U	U	A	SA	A	SD	SA	SA	A	D	D	A	U	D	SA	SA	SA	SA	SD	U
59	D		A	A	U	SA	U	D	SA	SA	SA	SD	SD	A	SD	U	SD	SA	D	SD
60	D	U	A	U	A	U	SA	U	U	SD	U	U	D	D	U	SA	A	SA	SD	SA
61	D	U	A	A	A	U	A	A	D	D	U	A	SD	U	A	SA	U	A	U	SD
62	D	D	U	A	A	D		A	D	D	U	A	D	D	A	SA	A	A	D	A
63	D	U	A	A	A	U	SA	SA	U	D	U	U	SD	U	A	SA	U	A	U	SD
64	D	U	A	A	A	U	A	A	D	D	U	A	D	D	U	A	A	D	A	U

Table 10: Questionnaire Answers Part 2

Ref	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
65	U	U	A	SA	U	D	SA	SA	A	D	D	SA	D	D	SA	SA	D	SA	D	U
66	SA	SA	SA	U	A	A	A	A	A	U	U	U	SA	A	U	A	A	U	SA	U
67	U	A	D	A	A	A	D	A	D	SD	D	SA	SA	U	A	SA	SA	U	SD	SA
68	A	SD	D	D	A	D	SA	A	D	D	D	A	D	A	U	SA	A	SA	SD	SA
69	A	D	U	A	SA	SD	SA	SA	A	SD	U	A	SD	D	A	SA	SA	SA	SD	SA
70	D	D	SA	A	A	SD	SA	A	D	SD	SD	SA	SD	SD	D	SA	SA	SA	SD	SA
71	A	U	U	A	A	D	A		D	D	U	A	U	A	A	SA	SA	SA	SD	A
72	U	A	SA	SA	U	SD	SA	SA	SA	SD	SD	SA	D	SD	SA	SA	SA	SA	SD	SA
73	A	U	SA	SA	A	D	A	U	SA		D	A	SA	SD		SA	A	SD	A	U
74	A	U	SA	SA	A	D	A	U	SA	A	D	A	SA	SD	U	SA	A	SD	SA	D
75	U	U	A	A	D	U	SA	A	U	D	U	U	SD	U	A	SA	A	SA	SD	U
76	SD	U	A	A	SA	SD	A	U	D	D	D	SA	SD	SD	U	A	SA	SA	D	SD
77	D	SA	U	U	SA	SD	U	D	A	A	D	U	SA	SD	U	A	D	SD	SA	D
78	D	SA	A	A	U	D	U	SA	A	A	U	A	D	SA	U	A	SA	SD	SA	SD
79	U	D	A	A	A	D	A	A	D	SD	SD	A	D	D	SA	SA	U	SA	SD	U
80	U	D	A	D	U	U	A	D	SD	D	U	D	SA	SA	U	SA	A	D	SD	SA
81	U	A	D	SD	D	U	D	U	SD	D	A	D	U	A	SA	SA	U	U	D	SA
82	D	SA	SA	SA	SA	SD	SA	SA	SA	SD	U	SA	SA	D	A	SA	A	SA	SD	A
83	U	A	A	A	A	SA	A	A	SA	D	U	U	A	U	A	SA	A	U	D	U
84	A	D	SA	SA	A	SD	A	A	A	D	D	U	SD	U	A	SA	A	A	D	U
85	A	D	SA	SA	A	D	SA	A	A	D	A	A	D	A	A	SA	A	A	U	U
86	SD	U	A	A	U	D	A	A	D	D	U	D	D	D	D	U	D	A	U	D
87	A	SA	SA	U	A	SD	SA	SA	SA	A	SD	A	A	SD	SA	D	SD	D	SA	D
88	D	U	A	U	A	U	A	A	D	D	D	U	U	D	A	A	U	A	D	D
89	A	SA	U	U	A	SD	SA	U	SD	A	U	A	SA	SA	A	U	D	A	A	U
90	D	A	U	A	U	D	A	A	D	U	D	A	D	D	A	SA	A	A	D	A
91	D	A	U	SA	A	D	SA	SA	U	SD	U	U	SD	D	U	SD	U	SA	U	A
92	A	SA	A	SA	A	SA	U	SA	SA	SA	SA	A	SD	SA	U	SA	SD	SA	SD	U
93	D	U	SA	U	A	SD	SA	A	SD	SD	SD	SA	SD	SD	A	A	A	A	SD	A
94	A	U	D	A	A	A	A	SA	SA	A	D	U	D	A	A	U	A	A	U	U
95	U	U	A	A	A	SA	SA	SA	U	A	U	SA	D	U	A	SA	A	SA	U	A

Table 11: Questionnaire Answers Part 3

Ref	Question	Category
Q1	In general, I find it hard or difficult to understand new physics concepts.	N/A
Q2	I understand physics concepts best when they are taught using the active board.	N/A
Q3	I understand new physics concepts best when they are taught using analogies.	Positive Role of Figures of Speech
Q4	I understand the behavior of objects and particles and their interactions best when they are related to human behavior and interactions.	Positive Role of Figures of Speech
Q5	My teachers use metaphors and analogies to teach new physics concepts.	N/A
Q6	I think that metaphors and analogies in physics lessons are confusing.	Negative Role of Figures of Speech
Q7	I sometimes remember certain science concepts just because of the good analogy the teacher used while teaching it.	Positive Role of Figures of Speech
Q8	The metaphors my teacher uses in class help me remember concepts.	Positive Role of Figures of Speech
Q9	Iremember the metaphor without remembering the concept learnt while studying alone.	Negative Role of Figures of Speech
Q10	I get bored when my teacher starts relating objects to other things in order to explain an idea.	Negative Role of Figures of Speech
Q11	I recall misunderstanding a concept because of an analogy used to explain it.	Negative Role of Figures of Speech
Q12	My teacher's use of metaphors and analogies helped me understand better concepts I already knew.	Positive Role of Figures of Speech
Q13	I find it difficult to relate the behavior of objects and particles to human beings.	Negative Role of Figures of Speech
Q14	My teacher's use of personification to explain physics concepts often confuses me.	Negative Role of Figures of Speech
Q15	I believe the use of figures of speech is essential in my understanding of certain concepts.	Positive Role of Figures of Speech
Q16	I am more excited to learn a new physics concept when the teacher introduces humor in the classroom.	Positive Role of Figures of Humor
Q17	An anecdote about a certain physics concept helps me understand it better.	Positive Role of Figures of Humor
Q18	When my teacher makes friendly anonymous jokes about mistakes on physics tests, I understand these concepts better	Positive Role of Figures of Humor
Q19	I am distracted when the teacher jokes in the science classroom.	Negative Role of Figures of Humor
Q20	The figures of speech the teacher uses make me laugh.	Humor and Figures of Speech

Table 12: Questionnaire Answers Part 4

Ref #	% of "Strongly Agree" answers	% of "Agree" answers	% of Undecided answers	% of "Disagree" answers	% of "Strongly Disagree" answers	% of Blank answers
Q1	3.16%	24.21%	22.11%	37.89%	12.63%	0.00%
Q2	12.63%	17.89%	41.05%	17.89%	8.42%	2.11%
Q3	26.32%	47.37%	15.79%	8.42%	0.00%	2.11%
Q4	25.26%	51.58%	15.79%	4.21%	1.05%	2.11%
Q5	12.63%	54.74%	12.63%	14.74%	4.21%	1.05%
Q6	6.32%	9.47%	22.11%	35.79%	23.16%	3.16%
Q7	34.74%	44.21%	11.58%	6.32%	1.05%	2.11%
Q8	28.42%	48.42%	13.68%	5.26%	2.11%	2.11%
Q9	11.58%	15.79%	27.37%	34.74%	9.47%	1.05%
Q10	6.32%	12.63%	10.53%	43.16%	25.26%	2.11%
Q11	3.16%	20.00%	33.68%	28.42%	12.63%	2.11%
Q12	23.16%	45.26%	17.89%	11.58%	1.05%	1.05%
Q13	12.63%	9.47%	18.95%	40.00%	17.89%	1.05%
Q14	4.21%	16.84%	22.11%	36.84%	18.95%	1.05%
Q15	18.95%	40.00%	22.11%	13.68%	3.16%	2.11%
Q16	64.21%	20.00%	7.37%	4.21%	2.11%	2.11%
Q17	21.05%	49.47%	14.74%	5.26%	5.26%	4.21%
Q18	37.89%	35.79%	11.58%	7.37%	5.26%	2.11%
Q19	9.47%	8.42%	9.47%	27.37%	43.16%	2.11%
Q20	22.11%	23.16%	28.42%	15.79%	8.42%	2.11%