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EXPLORING SCIENCE EDUCATION THROUGH PERFORMANCE-ARTS LENS

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Abstract

Literature points out that the continuing goal of science education research is the generation of pedagogical knowledge that can be used to improve meaningful understanding of science concepts by students. In view of this goal, the study adopted a performance-arts pedagogical lens being developed for mathematics education to explore the effectiveness of this lens for science education, particularly for middle grades. The study used the four categories: (1) Surprise/New/Wonderful; (2) Sense-making; (3) Emotional moments; and (4) Visceral sensation of the performance-arts lens to analyze YouTube videos that used a performative approach to presenting scientific concepts. Study findings showed that, while most of the videos satisfy the criteria for the categories “Surprising/New/Wonderful,” and “Visceral experiences,” the same cannot be said of the categories “Sense-making,” and “Emotional moments.” Based on these findings, some implications for science education were identified, and recommendations for future research suggested.

Keywords: performative, performance-arts lens, science education, content analysis

Dedication

This thesis is dedicated to my late mother, Comfort Akua Animah, for her special concern and support in my education and, my son, Kwame Osafo-Appiah.

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Table of Contents

List of Tables

Chapter 1: Introduction

Introduction

Until a few decades ago, information on the Web was largely text-based. Presently, it is becoming increasingly more multimodal, using textual, video, graphic and interactive content. Also, the text used to be “read” (R) only. Presently, and in many instances, it is more of “read and write” (R/W). A good example is the YouTube where users are able to read a piece of material, write their comments on it and post their own videos. With the increasing capacity of the Web to afford multimodal communication, the appearance of performative videos appears to be also increasing, including videos on YouTube that depict scientific performances. It is of interest to note that just few years ago, YouTube did not exist yet it now has the potential to become an educational phenomenon (Everhart, 2009). The exponential growth of YouTube’s content and popularity suggests that the resource is here to stay (Everhart, 2009). According to Everhart, “use of video file-sharing in elementary science classrooms is relatively unexplored territory” (p. 35), yet, as he observes, master teachers have posted instructional ideas and other useful content for others to access. Meanwhile it has been suggested that science performances (on YouTube) can enhance understanding of school science concepts (McCann, Marek, Pedersen, & Falsarella, 2007; Odegaard, 2003; Waters & Straits, 2008; Zembylas, 2005). As Everhart states, “I have watched science activities on YouTube and TeacherTube and replicated the experience with the students in the university classroom” (p. 35). This suggests the educational potential and benefits of scientific performances on YouTube and TeacherTube.

A quick glance at science education videos on YouTube will reveal that the educational quality of these videos is not consistent. Is there a systematic way to determine the quality of science education performances? A first step in this direction, in the area of mathematics education, has been taken by Gadanidis and Borba (2008), and Gadanidis, Hughes, and Borba (2008). They have developed an educational performance-arts-based framework for determining 'good' mathematics performances. This study specifically adopts the performance lens being developed by Gadanidis and Borba, and Gadanidis, Hughes, and Borba for mathematics education to explore the nature of school science performances on the Web. The study also aims to explore the effectiveness of this lens for science education, particularly for elementary and middle grades.

Statement of the Problem

Most science concepts appear to be abstract (Chiappetta & Koballa, 2006; Fang, 2006; Irving, 2006; Koc, 2009; Uce, 2009) particularly from the perspective of elementary and middle school students making it difficult for them to understand scientific concepts (Walker & Wilson, 1991). To understand and remember scientific concepts, children must be taught in ways that help them to relate such concepts to what they already know about the world (Walker & Wilson). As Vitale and Romance (2006) note, the continuing goal of science education research is the generation of pedagogical knowledge that can be used to improve meaningful understanding of science concepts by students. *The Ontario Curriculum, Grades 1–8: Science and Technology, 2007* (Ontario Ministry of Education [OME], 2007) outlines the skills and knowledge that students will develop, as well as the attitudes that they need to develop in order to use their knowledge and skills responsibly. The curriculum spells out three key goals:

> **1.** to relate science and technology to society and the environment
>
> **2.** to develop the skills, strategies, and habits of mind required for scientific inquiry and technological problem solving
>
> **3.** to understand the basic concepts of science and technology. (p. 3)

It also adds that teaching is key to student success and that teachers are responsible for developing appropriate instructional strategies to help students achieve the curriculum expectations.

Pedak and Davidson (1991) also state that "[s]tudents do what we ask them to do according to the interpretation of the 'game'. If we expect them to become active participants in learning, our instructional framework must be consistent with their expectation" (p. 85). It is also important that "in order for students to learn science, they must be motivated and engaged in the exploration of topics and questions that are interesting and relevant" (Moreno & Tharp, 2006, p. 301) to them. This suggests a need for alternative pedagogical approaches that help students to learn in a more authentic way.

In feminist science education literature, Bentley and Watts (as cited in Chiappetta & Koballa, 2006) outline three approaches to consider to make science classes more inviting particularly to girls: The first and most important approach to this study states that "[g]irl-friendly science advocates making traditional science more attractive to girls by changing the image of science presented in classes; challenging stereotypes, emphasizing the aesthetic appeal of science, and framing science curricula in a social context ..." (p. 114).

As Wickman (2006) states, "it is not unusual in a debate where many science educators ask what should be added to science instruction in making it more pleasing for students to digest" (p. 3). Perhaps there is the need to explore through performance-arts teaching approaches (Gadanidis et al., 2008) the special place of the 'unique' values and potential of aesthetics in science education (Wickman, 2006). It is noteworthy that, most commonly, in science education research, aesthetics values are treated under the rubric of affect, attitudes, motivation, or emotions (Wickman) which form indispensable components of Gadanidis et al.'s performance-arts teaching approach.

Wickman (2006) observes that:

> There are numerous scientists and science educators who today point out the importance of aesthetics more specifically in learning science and warn against the existential risks involved in eschewing aesthetics (e.g., Lemke, 2001; Watts, 2001). This is because, a purely cognitive emphasis on learning in science education easily cuts us off from being in the world (Tauber, 1996a), and education becomes more 'like, as a lesson' rather than 'like, as a life' (Szybek, 1999a, p. 188), and possibilities of participating and being personally involved (Marting & Brouwer, 1991). (p. 46)

This observation indicates a science education without aesthetic dimensions bears little resemblance either to science or to any human practice (Wickman, 2006). Wickman contends that, as far as aesthetic is concerned, we need to ask more generally how it could make science education more meaningful with regards to our overall purposes with school and education. Wickman however argues that “aesthetic experience necessarily must be an aspect of any chosen purpose of science education, because aesthetic experience, just like cognition, in one way or another is with us as we press forward in our doings” (p. 47).

Likewise, related literature on science education shows that science learning cannot be explained solely by examination of cognitive factors. Learners’ attitudes and motivation should be taken into account in explanations of science learning (Koballa & Glynn, 2007). Clearly, theoretical orientations and models describing meaningful relationships among affective constructs and cognition are becoming more evident in the research of science learning (Glynn & Koballa, 2007). It is important that students of science, particularly elementary and middle school students develop positive attitudes that motivate them to achieve at high levels. Their achievement should be reflected not only in their understanding of science and their development of scientific skills, but in their appreciation of the world around them (Koballa & Glynn, 2007); the world beyond the confines of their classrooms (Gadanidis, Hughes, & Borba, 2008). Also, “students of science should learn to use their knowledge and skills to become takers of the world, preserving it and enhancing it for generations to come” (Koballa & Glynn, 2007, pp. 95–96). In this regard, Koballa and Glynn recommend that science educators who wish to help students achieve such goals to embark on programs of research that focus upon how to best foster the growth of students’ positive attitudes and their intrinsic motivation to learn science.

Similarly, Hildebrand (1998) offers an argument for expanding the academic genre of scientific writing. Hildebrand contends that classroom science teaching is hegemonic. In exploring alternatives, she suggested that a pedagogical approach be explored that would allow individuals to apply personal perspectives to scientific writing, which would incorporate the context of critical, creative, affective, and feminist pedagogies. Meanwhile, many science teachers are traditionalist in their teaching methodologies (Prensky, 2007) and the knowledge that students acquire from such approaches tends to be fragmented and diffused (Ferrira & Justi, 2007). Thus, in many situations, students find school science uninteresting and often describe it as boring and often difficult to understand (Aryee, 2009; Irving, 2006). It is therefore important that because of the difficulty students have in learning science, science teachers need to understand and use many strategies and techniques to guide them in planning and teaching (Chiappetta & Koballa, 2006). There is a widely held view that traditional teaching approaches and strategies adopted by most teachers to the teaching of these science concepts do not help students conceptualize such concepts in ways that are practical, fun, and meaningful (Gooda, 2008; Byerly, 2001; Kind & Kind, 2007, Odegaard, 2003). Perhaps there is the need to explore alternatives, in terms of teaching pedagogy (Hildebrand, 1998) to augment more 'traditional teaching' strategies (Ferreira & Justi, 2007) in science education.

As Moreno and Tharp (2006) have observed, "[a]ccomplished teachers use a variety of instructional approaches to guide learners toward knowledge about the natural world and about how science, as a discipline, gathers knowledge and condenses knowledge about the world" (p. 301). Moreno and Tharp suggest that instead of teachers asking questions that emphasize rote recall of information, they should rather ask open-ended questions for which there may not be a single "right" answer. They assert that, by this approach, "[s]tudents become more engaged and science class becomes interesting" (p. 299). Though the use of performative teaching approach to science learning appears to be a promising pragmatic strategy capable of enhancing student learning, it remains largely untapped for science learning (Odegaard, 2003). Considering such teaching approaches as some recent research on science education recommend (see e.g., Vitale & Romance, 2006), appears worthwhile.

It is in this light that I find that the use of performance approach, in addition to practical or experimental and theoretical teaching approaches might be helpful to provide school science teachers a powerful teaching tool for the learning of science. As a starting point for exploring the role of a performance lens in science education, we might look at the growing number of science education performances posted on YouTube. YouTube is particularly interesting as a venue of study because it is publicly-available, it is widely popular, and its read/write affordances capture the ethos of the active learner, as students may post their videos. Towards this end, it would be useful to use the performance lens being developed in mathematics education by Gadanidis et al., as it uses what experts in the film industry identify as criteria for good movies. Such criteria form the basis for informing their model of determining the quality of mathematics teaching and learning 'classroom stories'.

Research Questions

The following questions are the basis of this study: a) In what ways do science performances as depicted on YouTube videos address the criteria for good educational performances laid out by the Gadanidis and Borba educational lens?; b) What does this lens tell us about creating a 'good' science performance?; c) How well can the lens developed by Gadanidis and Borba be adapted for use in future studies seeking to investigate science performance?

Significance of the Study

As the Web continues to be enriched with 'performances' in all aspects of learning, there is the need to tap from it resources that are appropriate and capable of enhancing studies in a particular discipline. School science performances both within the physical school environment and on the Web are not new (see e.g., Budzinsky, 1995; Cole & Degan, 1995, 1997; Odegaard, 2003; Waters & Straits, 2008). However, it is noteworthy that school science performances on YouTube on the Web are increasing both in number and in the richness of their design and presentation. Everhart (2009) finds such science performances very informative and suggests that it can be a "valuable venue for professional development" (p. 35). The study might help us to better understand the pedagogical value of these resources and help guide future developments in terms of designing and presenting such videos for users to obtain educational benefits. The study can also offer models for classroom practice, both to teachers and students, for improved and enhanced science education.

If students can be guided, encouraged and supported to write their own songs, poems, or dramatize the very salient ideas in key scientific concepts, then it is not unreasonable to expect they might better understand and enjoy the subject–science. As Odegaard (2003) observes, the potential of drama in science education remains largely untapped. Odegaard's viewpoint harmonizes with Halpern (2008) who describes the field of performance studies in science education as still in its youthful stage. Viewed from this perspective, such a new direction of research may also help contribute to reducing the often talked-about abstractness (Chiappetta & Koballa, 2006; Fang, 2006; Irving, 2006; Koc, 2009; Uce, 2009) that seems to characterize most school science concepts. The foregoing discussion suggests that performance lens approaches hold the potential for discovering good/new grounds in our quest to explore a more effective pedagogy in science education. The findings of the study may help to inform school science teaching practices, particularly when using Web-based resources, and provide a better understanding of science performance with new media.

Thesis Overview

In this chapter, I have set out the background to the study, including the major issues and a brief related literature review, explained the significance, and listed the research questions. In chapter two, I review and discuss literature on performance studies as it relates to science education and more important, how the related studies help to ground my research questions. The third chapter of the thesis discusses the theoretical framework and methodology underpinning this study. In chapter four, I analyze selected YouTube videos using the framework developed by Gadanidis et al. (2008). In Chapter five, I discuss the findings in light of literature in the field. Chapter six gives a conclusion of the study where I answer the research questions, identify implications of findings for science education and suggest recommendations for future research.

Chapter 2: Literature Review

Introduction

This chapter has three main sections: (1) Science Education Directions–which looks at science research on pedagogy and instruction, emphasizing scientific literacy and inquiry-based science teaching approaches; (2) Performance in Science Education–which reviews related literature that advocates for a performative approach to science teaching/learning; and (3) Performative Science and Mathematics Teaching/Learning Models: Harnessing the 'potentials,'–which looks at related literature in the two subject areas.

Science Education Directions

Looking for pedagogical strategies to achieve the goals set for science education in the 21st century.

At the heart of science education is a need for all students to become scientifically literate individuals, both within the school and in their lives after school. According to the National Science Teachers Association (NSTA), "[t]he major goal of science education is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and action" (NSTA, 1971, p. 47). The Ontario science curriculum makes the goal set out by the NSTA more explicit. *The Ontario Curriculum, Grades 11 and 12: Science* (Ontario Ministry of Education [OME], 2000) document states that scientific literacy can be defined as "possessing of the scientific knowledge, skills, and habits of mind required to thrive in the science-based world of the twenty-first century" (p. 3.). In reference to the *Common Framework of*

Science Learning Outcomes, K to 12: Pan-Canadian Protocol for Collaboration on School Curriculum (Council of Ministers of Education Canada [CMEC], 1997), the document notes that scientific literacy for all has become the goal of science education throughout the world. The Council of Ministers of Education Canada describes scientific literacy as "evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them" (CMEC, 1997, p. 4).

Furthermore, Science Co-ordinators' and Consultants' Association of Ontario (SCCAO) and Science Teachers' Association of Ontario (STAO/APSO), 'Position Paper: The Nature of Science' (as cited in OME, 2000*)* states*,* "A scientifically and technologically literate person is one who can read and understand common media reports about science and technology, critically evaluate the information presented, and confidently engage in discussions and decision-making activities that involve science and technology (p. 3). The preceding observation suggests a need for necessary curriculum reforms and more importantly sound pedagogical knowledge that impacts positively on student learning by all science teachers in this 21st century.

As Vitale and Romance (2006) note, the continuing goal of science education research is the generation of pedagogical knowledge that can be used to improve meaningful understanding of science concepts by students. Bybee (2006) observes that:

> Among the 21st century issues and trends in science education, one must acknowledge the fundamental importance of the science curriculum. It is the one component that brings together social aspirations, content standards, research on learning, appropriate assessment, and meaningful professional development. (p. 21)

On curriculum, Bybee notes that in the end, what students learn is directly influenced by how they are taught. Bybee's assertion suggests among other things that making research findings and recommendations on effective and efficient teaching practices available to classroom teachers is needed. The National Research Council (NRC, 2005) reporting on the findings of *How People Learn: Bridging Research and Practice,* notes that:

> Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or that they may learn them for purposes of a test but revert to their preconceptions outside the classroom. (p. 10)

According to Dyasi (2006), one elementary science program in particular, *The Elementary Science Study* (ESS), developed at the Education Development Center, directly discussed open inquiry as an essential component of its pedagogical approach:

> Rather than beginning with a discussion of basic concepts of science, ESS puts physical materials into children's hands from the start and helps each

> child investigate through these materials the nature of the world around him. Children acquire a great deal of information, not by rote but through their own active participation. We feel that this process brings home even to very young students the essence of science–open inquiry combined with experimentation (ESS, 1970, p. 7). (p. 69)

Bredderman and Shymansky et al. (as cited in Dyasi, 2006) have observed in their studies that, "[m]eta-analysis of learning studies on these early elementary and middle school science programs showed they had a more positive impact on students' growth in science learning than traditional programs in general achievement, analytic skills, process skills (reading, mathematics, social studies and communication), and in attitude towards science" (pp. 69–70).

As Dyasi notes, the National Science Education Standards (NSES) claims that engaging students in science inquiry helps them to develop:

- understanding of scientific concepts,
- an appreciation of how we know what we know in science,
- understanding of the nature of science,
- skills necessary to become independent inquirers about the natural world, and
- the dispositions to use the skills, abilities, and attitudes associated with science. (pp. 70–71)

Further, "[t]he goals of science education reform articulated by the American Association for the Advancement of Science and the National Research Council (AAAS, 1989, 1993; NRC, 1996) have not changed" (Nelson & Landel, 2006, p. 215). If we are successful in achieving them, *every* student will graduate from high school

- knowing a coherent set of important ideas in science, how those ideas were conceived and tested, and how they are used to build technology or to explain natural phenomena;
- confident he or she deeply understands some concepts and possesses some skills, is capable of learning more when necessary and applying scientific habits of mind to new challenges; and
- capable of thinking through issues scientifically, gathering and evaluating evidence, drawing and testing conclusions, and making and communicating sound personal and social decisions.

Nelson and Landel hold the view that there is a need for everything to come together to meet this "ambitious goal: teaching, classroom resources, curriculum materials, assessments, and policies" (p. 216), adding that even though students spend only 14% of their time in school (NRC, 1999), the classroom is where learning is motivated, facilitated, and assessed. "Effective teaching of all students ... by effective teachers is the key" (Nelson & Landel, 2006), which also results in meaningful understanding of science concepts (Vitale & Romance, 2006). Vitale and Romance add that the "purpose of the field of science education is applying the methods of scientific inquiry to advance pedagogical knowledge of how students gain a meaningful understanding of science content and the nature of science processes of science to establish knowledge that, when applied, results in science being taught more effectively" (p. 330). Vitale and

Romance admit that although science and science education are complex and overlap, certain characteristics clearly distinguish them:

- First, *science* can be considered broadly as a process for establishing and organizing cumulative knowledge that leads to prediction or control of events.
- Second, the process of science can be considered as the means for generating such knowledge in the domains of science (e.g., Physics, Earth science, Biology).
- Third, student learning of both the resulting knowledge of science and the process of scientific inquiry in school settings is the domain of science education, and ,
- Fourth, the domain of science education research, using the processes of science, focuses upon the development of pedagogical knowledge that improves teaching science content and process. (p. 331)

O'Neill and Barton (2005) add that an important challenge in *science education* is finding ways to engage all students in the learning of science. Sadly, as they observe, "research in this area has consistently shown that around *middle school* student engagement in science wanes" (p. 292). Finding ways to salvage this disturbing trend requires not only the attention of science educators and the research community but also an immediate response. O'Neill and Barton maintain that for students to have fair access to, and experiences in science, the science must somehow be connected to their lives at the core. "Embedded within each of these studies is the assumption that if students owned the science they were expected to learn, either by connecting science to their lives or helping students feel a part of the culture of science, then they would be more motivated to learn science" (p. 293).

Using aids or live performance as enhancements for sound pedagogy and classroom engagement.

In this 21st century classroom, educational technology continues to find its way into many schools for which Canada is no exception. According to Haché (n.d), although there is non-agreement on how technology should exist in Canadian schools, there is much evidence to indicate that the nature of technology that is in the schools responds to local needs, because long-standing accepting of diversity has made this possible. Today diversity is the standard for Technology Education as the programs continue to be deployed differently in all Provinces (Yamansaki & Savage, 1998). Computer technology may be seen as a tool for productivity and problem solving in a constructivist learning environment, generally in the context of clearly defined standards (ISTE, 2002). *The Ontario Curriculum, Grades 1–8: Science and Technology, 2007* (OME, 2007) recognizes that during the twentieth century, science and technology played an increasingly important role in the lives of all Canadians. In the 21st century, "Science and technology underpin much of what we take for granted, including clean water, the places in which we live and work, and the ways in which we communicate with others" (p. 3).

Little doubt exists that advances in educational technology have transformed the American classroom (Irving, 2006) and classrooms elsewhere. Irving however notes that not every domain in a science class will fit the use of educational technology equally well. Although "[h]ands-on activities where students manipulate objects and create artifacts in the classroom offer compelling strategies for many science concepts" (p. 14), Irving observes that many concepts in science are abstract, complex, and invisible without the aid of special technologies, or too subtle for ordinary viewing in the classroom. The multimedia functionality of many electronic educational technological tools "offer[s] science teachers a host of powerful tools to help students visualize these concepts" so as to enhance their better understanding. Thus educational movie clips, downloads from electronic sources such as the YouTube and use of electronic simulations may add to the pedagogical flair of teachers for classroom purposes.

Teaching with movie clips is one strategy to increase student understanding of environmental science (Bergman, 2010). "Movie science" can expose students to phenomena that are difficult to explore in the typical classroom (Bergman, p. 57). As Bergman observes, adding movie segments to your curriculum not only increases student interest and enjoyment of environmental science, but also demonstrates that science is not limited to the school laboratory. As students interact with movie science they develop as "both critical viewers and critical thinkers" (p. 60).

In related studies, Gandolfo (1998), Sundberg, Armstrong, and Wischusen (2005) find that though there is nearly uniform agreement that replacement of laboratory experiences with computer simulations or other e-resources is insufficient, even irresponsible, and markedly diminishes the concrete comprehension of scientific concepts by students, "all agree that in order to gain true appreciation of the intrinsically complex nature of the natural world and the seemingly abstract and confounding material presented in science courses, students simply must investigate these phenomena for themselves with their own hands and eyes in the laboratory setting

(Brown, 2001; Sung, Gordon, Rose, Getzoff, Kron, Mumford, et al., 2003). This objective can however be achieved if students are engaged in ways of learning that are educationally meaningful, fun and interesting to them (O'Neill & Barton, 2005; Worch, Scheuermann, & Haney, 2009).

Similarly, visual learning materials–electronic or print–can be quite effective in enriching the classroom experience for students by enabling them to observe situations and processes which are otherwise difficult to portray inside the classroom (Panjwani, Micallef, Fenech, & Toyama, 2009). According to Katsioloudis (2007), there is extensive evidence in the literature to support the claim that the use of digital visual materials–either static images or video–in the instruction process can raise students' attention levels and can also significantly improve their performance in retention and comprehension tasks. Also, Katsioloudis has observed that such evidence exists across all grades of schooling (ranging from middle school all the way up to university education) and in almost all curricula, although science education seems to have received the greatest amount of research attention.

In a related development, *FMA Live!,* named for Sir Isaac Newton's second law of motion, (force = mass x acceleration), uses professional actors, original songs, music *videos* and interactive science demonstrations to teach *middle school* students Newton's three laws of motion and universal law of gravity (Honeywell; Honeywell & NASA Launch 2009 Spring Tour of FMA Live!, 2009).

> Created in 2004, FMA Live! is a collaboration between NASA and Honeywell and is the only nationally touring, multi-media, science-education production of its kind. Designed to make science relevant to kids' everyday lives, the

> program brings an authentic, live, hip-hop concert experience of unprecedented size and proportion to middle schools across the country. FMA Live! is completely underwritten by Honeywell and has traveled 63,263 miles, reaching more than 200,060 students at 593 middle schools in 43 U.S. states and Canada. (Honeywell; Honeywell & NASA Launch 2009 Spring Tour of FMA Live!, 2009, p. 17)

Joyce Winterton, assistant administrator for Education, NASA, observes that "Our nation's future scientists, engineers and explorers are in middle school classrooms today" (p .17), throwing out a challenge to all stakeholders of science education to intensify our efforts at exploring a more effective pedagogical alternatives.

The preceding discussion draws attention to the fact that the search for ways to make science learning an engaging, fun, interesting and meaningful activity (O'Neill & Barton, 2005; Worch, Scheuermann, & Haney, 2009) not only rests on the shoulders of science educators and its research community, but also many individuals or bodies that see a pressing need to help students enjoy the learning of the subject. It also demonstrates one way of exposing to science teachers and school authorities other creative and innovative ways/ideas worthy of being explored in their quest for presenting science concepts to help their students 'love' the subject–science.

Performance in Science Education

Studies on science education show that science performance often takes the form of a drama, play/role-playing or experiments (see for example, Carlsson, 2003; Lacina & Hannibal, 2009; Odegaard, 2003; Waters & Straits, 2008; Worch, Scheuermann, & Haney, 2009). Following, I review studies that use ideas of dramatic arts such as drama, role-playing and theatre to teach science concepts to students. Klein (1979) notes that, science should be taught as a drama of ideas not as a battery of techniques. What then has dramatic arts got to offer science education? The review below sheds some light on this.

Drama in science education.

Classroom dramas are beneficial for focusing on the science in the society dimension of science education (Odegaard, 2003). "Though making scientific concepts come to life through the use of a dramatic model is not uncommon, it is particularly in addressing the nature of science and science in a societal context that drama has a lot to offer to science education (Odegaard, p. 78). Odegaard contends that it is in this area that, in general, drama seems to be an untapped resource in the science classroom. This brings into focus perhaps a need for effective use of drama in science education especially at the elementary and middle school levels to ascertain its potential in enhancing better understanding of science concepts. Teaching in the form of drama offers a way of overcoming boredom of learning abstract concepts (Carlsson, 2003; Fang, 2006; Koc, 2009; Uce, 2009) and can lead to "genuine student understanding of the concepts" (Carlsson, 2003, p. 26). Also noted by Lacina and Hannibal (2009), performance of scientific concepts in a form of drama helps to find ways that make learning "fun and relevant to children's lives" (p. 68). In drama, music often plays a key role. As Malhmann (2000) questions: "How are we bringing the power of music to bear where it can make a difference–for learning?" (p. 24).

Odegaard (2003) examined how drama and theatre activities may enhance learning in science education by creating a learning situation that is significant in the lives of students. She reports that "[t]here is evidence that the use of drama in a well-considered manner, guided by reflective science teachers, may provide empowering learning environments for students" (p. 75). Studies on science education show that the invaluable role a science teacher plays is guiding the students in their reflection after a drama activity about how their experience relates to their own life and their relationship to science (see e.g., Odegaard, 2001; Odegaard & Kyle, 2000). In a survey of teaching styles, Christofi and Davies (1991) found that 70 per cent of students were enthusiastic about drama, but over fifty per cent of the teachers surveyed never used drama in their teaching. Christofi and Davies observed that secondary school teachers in particular hardly ever used this instructional method. According to Odegaard (2003), there is evidence that students are much happier with drama than teachers. "If the view that drama has a positive effect on learning science can be sustained, then it seems there is a large unused potential here waiting to be tapped" (Odegaard, p. 92).

Meanwhile, drama can prove a useful tool for teaching scientific, mathematical or geographical concepts to pupils (Bloom, 2007). Ms Precious (as cited in Bloom, 2007, p. 14) comments that "[i]t takes confidence to act in front of other people. That's a skill for life. And drama makes the subject accessible to children who cannot write or verbalize well. It encourages them to communicate in different ways." For students to perform a scripted science play [drama] will of course involve them more, and encourage them to reflect about what they want to communicate (Braund, 1999). The two preceding observations find fit with Odegaard

(2003) who contends that to fulfill the educational potential of drama, science education must seek non-authoritarian and creative learning environments, which enable students to be both critical and curious about science and the world that surrounds them, and at the same time offer them an insight into the value of critical reflections within science and scientific activity itself. Odegaard further asserts that the pedagogical advantage of drama is that it can create such environments, and can successfully be used for making simulations of the real everyday world, especially in learning about science in the context of society, or where science is recontextualized for specific societal purposes. Odegaard holds the view that though classroom dramas are beneficial for focusing on the science in society dimension in science education, it offers students the possibility of experiencing cognitive, affective and active aspects of learning in an integrated way.

Odegaard observes that a group of students who create their own model of a scientific concept are together reconstructing knowledge so as to enhance their conceptual understanding by exploring and communicating how science may intervene in different ways in our lives. In order to guide the students, it may sometimes be necessary for the teacher to provide scaffolds in complicated scientific matters (Odegaard, 2003).

In a related study, McCann, Marek, Pedersen, and Falsarella (2007) report of Cool Life Science Investigations (CLSI) where more than 100 K-5 students came together to experience an afternoon of fun, learning, and the real life drama of accurate science:

> Students took home the idea that the science presented in television dramas and in the media may not always be complete or accurate. Providing opportunities to explore accurate science concepts shown in media programs through programs such as this one can help students become savvy consumers of media science information. (p. 26)

Research identifies students' increased understanding, and the teacher's increased ability to assess students' understanding immediately and informally in the course of using drama in science (Bailey & Watson, 1998; Linfield, 1996). Since dramatization is usually based on the students' own shared experience, the learning environment may easily convey an anti-authoritarian tone (Odegaard, 2003). These results are supported by Palmer (2000) and Carlsson (2003). For example, Carlsson developed a structured dramatization of photosynthesis in order to facilitate students' understanding of the particle model and material transformation. She indicated that this is possible because the drama creates amusement, engagement and activity amongst the whole student body. In another dramatization of a scientific concept, a science class performed a meiosis-ballet; a highly structured model produced for presentation (see van der Kooij in Odegaard, 2001). Ghiaci and Richardson (1980) assert that children who engage in dramatic play develop more and longer-lasting mental constructs than children who did not have the opportunity to learn through dramatic play. The above discussion suggests that perhaps breaking the barriers of direct instruction or traditional teaching practices (Coberna, Schuster, Adamsa, Applegatea, Skjolda, Undreiub, et al., 2010) in the science classroom in order to explore alternatives may be needed. Ferreira and Justi (2007) contend that "the knowledge that students acquire from traditional teaching tends to be fragmented and diffuse, and it does not go beyond memorization of facts, equations, and procedures" (p. 66). This brings to light a need for alternative potential ways of teaching approaches such as use of drama and play in science classrooms.

Play/role-playing in science education.

Braund (1999) notes that, for students to perform a scripted science play will of course involve them more, and encourage them to reflect about what they want to communicate.

In Frasier's (1999) study on *STAGE a water show*, an inventive science performance (play) about the water cycle by students, made the concept fun and interesting to the students. In Waters and Straits (2008), students pooled their knowledge and creativity to make a song presenting what they had learnt in a unit on rock. As Waters and Straits note, "the highly motivating, integrated performance assessment incorporated multiple intelligences, reinforced learning and it was the students' favorite in the elementary and the middle school grades" (p. 23).

In another development, Reinsmith (as cited in Yager, 1996) has posited ten factors for learning that, Yager asserts, must be contextualized, discussed, and debated by every science teacher. Two factors most relevant to this study are: "The more learning is like play, the more absorbing it will be"; and "Students will learn only what they have some proclivity for or interest in" (p. 53). Also relevant, the science-technology-society (STS) initiatives posit the need to "[a]llow adequate time for reflection and analysis"; "[e]ncourage self analysis, collection of real evidence to support ideas, and reformulation of ideas in light of new experiences and evidence" (National Science Teachers Association [NSTA], 1998-1999, p. 228).

According to Cohen, Manion, and Morrison (2007), "Role-playing is defined as participation in simulated social situations that are intended to throw light upon the role/rule contexts governing 'real life' social episodes" (p. 448). Role-playing, also known as dramatic play, is fun, stimulating, and engaging, making it a marvelous strategy to motivate children to learn (Worch, Scheuermann, & Haney, 2009). Unfortunately, as Bergen (2009) observes, there persists an erroneous belief that academic content standards cannot be met through play-based activities, which has caused playful methods of learning to virtually disappear from school classrooms, yet, role-playing can be used to support meaningful content learning through socially and emotionally rewarding experiences. Cohen, Manion, and Morrison (2007) observe that the choice lies with teachers either to borrow a ready-made role-play or to write their own. They suggest that in order to ensure that the background is familiar to the intended participants, it is better that teachers write the role-play scripts themselves.

Ladousse (1987) identified a number of advantages of role-play in the classroom, including (1) allowing students to act upon their personal experiences, (2) helping teachers to identify misconceptions, (3) encouraging creativity, and (4) increasing student motivation. Other important studies on role-playing highlight various educational values and potentials of the technique: Aubusson et al. (1997) found that role-playing in science classrooms developed deeper student understanding, improved student motivation, and facilitated learning across a range of ability levels; Johnson (1998) observed that role-playing encourages creativity and imagination which are essential skills for scientists; Frost, Wortham, and Reifel (2008) observed that the integrated nature of role-play allows for individual differences in development; Isenberg & Jalongo (2006) observed that role-playing is fun and motivating for students; Hickey and Zuiker (2005) asserted that meaningful, motivating contexts help students better internalize their learning and improve their recall. Though the short literature review on role-playing shows that a lot of efforts are being made to use performative approach to help student learning in science education, not much has been documented for reference and other purposes. More work is needed on science education and the arts interface for the benefit of the former in this context. Perhaps Odegaard (2003) has put the point well when she states that the field of dramatic arts in science education is neither highly theorized nor researched. As Halpern (2008) notes, apart from Shepherd-Barr's (2007) book, there is very little research on science in theatre (or the arts), as it is not seen as a particularly important domain for scientific education or engagement. Meanwhile *The Ontario Curriculum, Grades 1–8: The Arts, 2009* (OME, 2009) outlines quite extensively potential values that the arts study offers:

> Education in the arts is essential to students' intellectual, social, physical, and emotional growth and well-being. Experiences in the arts–in dance, drama, music, and visual arts–play a valuable role in helping students to achieve their potential as learners and to participate fully in their community and in society as a whole. The arts provide a natural vehicle through which students can explore and express themselves and through which they can discover and interpret the world around them. Participation in the arts contributes in

> important ways to students' lives and learning–it involves intense engagement, development of motivation and confidence, and the use of creative and dynamic ways of thinking and knowing. It is well documented that the intellectual and emotional development of children is enhanced through study of the arts. Through the study of dance, drama, music, and visual arts, students develop the ability to think creatively and critically. The arts nourish and stimulate the imagination, and provide students with an expanded range of tools, techniques, and skills to help them gain insights into the world around them and to represent their understandings in various ways. (p. 3)

Harnessing the benefits of the arts curriculum, as expressed clearly above, for perhaps the benefit of science education in terms of pedagogy may be long-overdue. This, in effect, points to the need for more research into the potential effect drama, play and role-playing and so forth can have on science education.

As a field still in its youth (Halpern, 2008), "performance studies is a broad discipline that incorporates research from other fields: for example, critical discussions of artistic performance (Bail, 2006; Schechner, 2003b, 2006); performance as part of everyday life, as in Goffman's use of theatre as a metaphor for human interactions (Goffman, 1959; Beeman, 1993; Bial, 2004)" (as cited in Halpern, 2008, p. 8). Meanwhile performance scholars find that performance "... evokes and solidifies a network of social and cognitive relationships existing in a triangular relationship between performer, spectator, and the world at large"

(Beeman, 1993, p. 386) suggesting the potential of performance approach to teaching/learning generally.

Performative Science and Mathematics Teaching/Learning Models: Harnessing the 'potentials'

In the Gadanidis and Borba (2008), and Gadanidis, Hughes, and Borba (2008) performance-arts lens teaching approach for exploring what makes for a "good drama" in mathematics education, they reported that students found the use of teaching approaches such as drama, poem and song in communicating mathematical ideas and concepts both educational and fun. The potential of this innovative performative approach to mathematics teaching/learning is also supported by many literatures on science education (see for example, Bergman, 2010; Carlsson, 2003; Halpern 2008; Lacina & Hannibal, 2009; Odegaard, 2003; Waters & Straits, 2008; Worch, Scheuermann, & Haney, 2009).

In their most recent study, Gadanidis, Borba, Hughes and Scucuglia (in press) explored through investigative means

> *what might happen when*, in the context of rich math activities: (1) students are supported in scripting dialogues to be shared with their peers and with the wider community, as a way of communicating about their math experience; (2) students use cell phones to record, edit and share digital performances; and (3) researchers attempt to capture the collective experience in the form of lyrics and songs." (p. 1)

They reported that, in one case study, teachers in the project noticed a difference in their students' communication patterns as they began to show real understanding of the mathematics concept treated and more so became capable in explaining their ideas to their peers. Thus the careful/strategic combination of the arts, mathematics and technology appears to have offered the students a new way of learning mathematics, equipping them with the necessary tools to reorganize and reorient their thinking of the subject with new media (Borba & Villareal, 2005) as a student participant in their second case study indicated: "[t]he arts and the mathematics together change[d] my viewpoint, because the art is something different. The mathematics is always the same, but when we put both together, both are different. I started to like mathematics as much as I like the arts. Mathematics became something different" (p. 5).

It is not surprising that the technological collective and performative dimension generated a rich scenario where imagination, creativity, and surprise supported students' engagement and mathematical learning (Gadanidis, Borba, Hughes, & Scucuglia, in press). Several studies on science education (see e.g., Bergman, 2010; Waters & Straits, 2008; Worch, Scheuermann, & Haney, 2009) particularly those that advocate for performative approach to the teaching of school science share this view.

Gadanidis, Borba, Hughes and Scucuglia (in press) state that, findings from their studies using their performative-arts lens in mathematics education have changed their view about teaching, instruction, and research development, stating, "[t]echnologies and the performing arts have shaped our lenses about (1) mathematical thinking in pedagogic scenarios and (2) doing research" (p. 6). Similarly, research on performative teaching/learning approaches–drama, game, play or role-playing, experimentation–that target enhancement of learner-centred school science learning practices may be in a position to add another dimension to its critical discourse by exploiting and harnessing the potentials/strengths of the Gadanidis and Borba (2008) performance-arts model being used in mathematics education with increasing success in some provinces in Canada and elsewhere as their studies show. What is more, their model appears to hold a potential for learning at all pre-tertiary levels of education. Gadanidis Hughes and Borba (2008) note that "[g]ood problems worthy of performance are not grade specific. We have used the L activity in the context of patterning in fourth-grade and sixth-grade classrooms; in eleventh grade classrooms ..." (p. 173), suggesting its potential versatility though they admit that not every mathematics experience necessarily needs to lead toward such performances. As the search for pedagogical knowledge and skill, and other classroom teaching/learning strategies to engage students in science education continues, "[t]he final determinant of success in our effort to improve science education will be measured by the quality of science programs delivered to our students and student outcomes" (Rhoton & Shane, 2006, p. xiii).

Chapter Summary

This chapter has presented literature as it relates to current research issues on science education, particularly in the area of pedagogy. It found that science educators and researchers have as their central goal, a need to look for pedagogical strategies and techniques that could enhance a meaningful understanding of science concepts to students. The chapter reviewed related studies that favor performative teaching methodology in science and mathematics education. It established that performative teaching approaches in both subject areas made learning much more fun, interesting and educational to students. The chapter also touched on the potential of the Gadanidis et al.'s performance-arts lens as reported in some of their studies and the lens' possible usefulness when adapted in science education. The next chapter presents the research design–methods and methodology used in this study.

Chapter 3: Research Methods

Introduction

This chapter has two main sections; the theoretical framework, and the methodology for the study. In adopting the performance-arts lens developed by Gadanidis and Borba (2008), and Gadanidis, Hughes, and Borba (2008) for mathematics education for the purpose of this research study to explore the nature of school science performances on the Web, and to explore the effectiveness of this lens for science education particularly for middle grades, the theoretical perspective combines constructivism in the broader/general sense and performance lens, as a more specific case.

Theoretical Framework

Constructivism.

For knowledge to be meaningful, students need to construct it themselves (Foxx, 2001). Constructivist learning theory posits that real learning can only occur when individuals engage their minds in the process of actively constructing meaning for themselves (Yager, 1994). According to Foxx (2001), constructivists compare an "old" view of knowledge to a "new" constructivist view and that constructivism is based on the fundamental assumption that people create knowledge from the interaction between their existing knowledge or beliefs and the new ideas or situations they encounter (p. 13).

In harmony with the preceding observations, Marcum-Dietrich (2008) outlines four basic premises of constructivism: 1) Knowledge is constructed, not received; 2)

Learning is a process, not a product; 3) Students' prior knowledge affects learning; 4) Learning requires effort and purposeful interaction with the phenomenon (p. 83). Related studies note that in recent times, the classroom learning environment research has focused on assessment and improvement of learning and teaching within the context of constructivist learning environment (see e.g., Aldridge, Fraser, & Sebela, 2004; Aldridge, Fraser, Taylor, & Chen, 2000; Taylor & Fraser, 1991). This viewpoint is supported by Council of Ministers of Education Canada ([CMEC], 1997) document which notes that scientific literacy for all has become the goal of science education throughout the world. Yilmaz-tüzün and Topcu (2010) add that in a constructivist learning environment, teachers are accepted as facilitators and they encourage students for conceptual development. Students use their prior knowledge and reflect upon other students' ideas in the classroom while developing their conceptual understanding of new scientific topics.

Yilmaz-tüzün and Topcu observe that social constructivist perspectives were later included in the constructivist learning environment research. "In this perspective, it is accepted that scientific knowledge is produced as a result of scientific inquiry but this knowledge 'must be validated against the community norms'" (Taylor et al. 1995, p. 2). In other words, "learning is not only individual activity but also a social process" (p. 259). Trowbridge and Bybee (1990) also state that the central goal of the constructivist teaching model is to allow students to apply previous knowledge, develop interests, and initiate and maintain curiosity towards the material at hand.

Foxx (2001) finds that an instructional approach congruent with constructivist theory is the "learning cycle." She asserts the learning cycle has become an important component in most classrooms today. She summarizes this learning approach as it relates to science:

> Learning something new, or attempting to understand something familiar in greater depth is not a linear process. In trying to make sense of things, we use both our prior experience and the first-hand knowledge gained from new explorations. In the model, the process is explained by the 'Five Es'. They are: Engage, Explore, Explain, Elaborate and Evaluate (Miami Museum of Science, 2000). (p. 20)

Noteworthy is that the constructivist model to teaching and learning in today's classrooms, which is espoused by many teacher educators and researchers (see for example, Colburn, 2000; DiEnno & Hilton, 2005), finds strength in and parallels performance-oriented teaching approach akin to that of Gadanidis et al.'s being explored in mathematics education in some provinces in Canada and elsewhere. In Canada, as Chistie (2007) has noted, "Curricular reforms over a decade (1995-2005) indicate adjustments and implementation towards newer learning theories based upon constructivism" (p. iii). Chiappetta and Koballa Jr. (2002) noted that many science educators view constructivism as a guide for learning and teaching science. Constructivism promotes critical thinking (Colburn, 2000; DiEnno, & Hilton, 2005) particularly amongst students. Performance studies routinely "address critical thinking, as well as oral and written communication skills, along with objectives oriented to the specific course" (Stucky, 2006, p. 264). Thus, constructivism and a performance-oriented teaching model are not mutually exclusive. In fact, as we will see in the forthcoming discussion, cognitive dissonance and sense-making, two key aspects of a constructivist model, are also integral components of the Gadanidis et al. educational performance model.

Performance lens.

The (more) specific theoretical inclination of this study is the educational performance lens (being) developed by Gadanidis and Borba (2008), and Gadanidis, Hughes, and Borba (2008) for understanding and enhancing classroom instruction, particularly for elementary school mathematics. Thus, this study extends the use of this lens to school science, particularly that of middle grades. A performance lens, in this context, may be viewed as a teaching approach that encompasses several techniques and strategies in an attempt to help students communicate their ideas about ‘concepts’ (of subjects such as math and science) within the classroom and the world beyond (Gadanidis & Borba, 2008; Gadanidis, Hughes, & Borba, 2008). It is noteworthy that Gadanidis et al.’s framework for analyzing what makes for a good mathematics performance or story for classroom purposes is based on Boorstin’s (1990) categories for analyzing film. As they state:

> [w]e analyze the design of this performance through the three categories developed by Boorstin (1990) for analyzing film. Boorstin suggests, ‘We don’t watch movies one way, we watch them three ways ... [we] derive three distinct pleasures from watching a film’ (p. 9)–which he calls the voyeur’s pleasure of ‘seeing the new and the wonderful’ (p. 12), the vicarious pleasure of savouring the ‘empathetic pleasure of the moment’ (p. 80), and the visceral pleasure of experiencing ‘the gut reactions of the lizard brain’ (p. 110). (p. 46)

Gadanidis et al. also make reference to the work of McKee (1997). McKee holds the view that by “engaging in a movie experience, or more generally by engaging with the ‘entertainment’ of a story or performance, we are engaging with an educational experience” (p. 46). McKee’s viewpoint posits that learning through performance is not simply entertainment but rather a vehicle towards a more durable and authentic way of learning. Performance teaching models for classroom use are supported by many science educators (see e.g., Kind, & Kind, 2007; Odegaard, 2003; Watts, 2001).

Gadanidis, Borba, Hughes, and Scucuglia (in press) “consider parallels between the arts and mathematics: between what makes for ‘a favorite book or movie’ and what makes for ‘a favorite math idea or activity’” (p. 1). In their study, Gadanidis and Borba (2008) have found that performance studies offer a valuable lens for analyzing the quality of mathematics teaching and learning. Gadanidis, Hughes, and Borba (2008) contend that the performative lens also helps to view mathematics as a human feeling experience where its stereotypical description as a cold, hard science fades to the background as students’ emotional, aesthetic and imaginative inclinations are valued.

Other researchers also use a similar framework in their studies as the following indicate: mathematics is an aesthetic human experience (Sinclair, Pimm, & Higginson, 2006); narrative is a fundamental vehicle for communication of meaning (Bruner, 1996); engaging students in imagination is a key element of learning (Greene, 1995); and performance can be a vehicle for disrupting traditional power and authority structures in classrooms (Boal, 1985).

The discussion above brings to light that perhaps looking at (science) teaching through a performing-arts lens (Gadanidis & Borba, 2008), and teaching as a performing art (Sarason, 1999) may help make classroom teaching and learning educational as well as interesting and fun for students. This approach may also help challenge their thinking powers or capabilities in imaginative, innovative and creative ways: ways that increased students' conceptual understanding of scientific facts and principles (Chiappetta & Koballa, 2006); promoted their critical thinking skills (Chiappetta & Koballa, 2006; Colburn, 2000; DiEnno & Hilton, 2005); and offered them opportunities to experience science in a meaningful manner (Wickman, 2006).

It can be said that, constructivism supports active learning environment, inquiry-based learning, critical thinking, sense-making of concepts, and all such situations that help to engage students in purposeful and meaningful learning. Also, a significant proportion of science education literature (see, e.g., Marcum-Dietrich, 2008; Trowbridge & Bybee, 1990; Yilmaz-tüzün & Topcu, 2010) supports constructivist teaching/learning model for enhanced science education.

Gadanidis et al. performance-arts lens geared towards exploring what makes for a "good math story" or drama shares similar learning goals as the constructivists. Gadanidis et al. developed their performance-arts lens based on Boorstin's model of what makes for a "good movie". Boorstin (1990) identified a number of pleasures that good movies offer an audience, which I will paraphrase for a science education/movie context by inserting science: (1) A good science movie offers the "joy of seeing the new and the wonderful" (p. 12) in science. As students watch the movie they guess what might happen next. However, if they are always correct in their guesses, the movie becomes predictable and boring. "Audiences want their overall expectations fulfilled–they want the hero to triumph and the lovers to be united–but moment to moment they want to be wrong (…) to be surprised" (p. 50). For the teacher, "this means constantly creating expectations that (for the right kind of reason) aren't quite fulfilled" (p. 50); (2) Although students want to be surprised, the surprise needs to make sense. If the science movie surprises without "a rational explanation" (p. 46) then students eventually stop attending; (3) Good science movies also offer emotional moments. Here students vicariously experience the human, emotional aspects of a science education experience, by putting their "heart in the actor's body: we feel what the actor feels, but we judge it for ourselves. The tension between the two impulses–the urge to be the character and to judge him simultaneously–gives the vicarious experience grit" (p. 67). In this way, the science movie resonates with students in a personal, emotional way; (4) Lastly, good science movies offer visceral pleasures. "The passions aroused are not lofty. They are the gut reactions of the lizard brain–thrill of motion, joy of destruction, lust, blood lust terror, disgust. Sensations, you might say, rather than emotions." Visceral experiences make you feel that you are having "the experience yourself, directly" (p. 110).

Viewing a "good science movie" through Boorstin's perspective, we can see that a science movie is much more than simply "entertainment." In fact, the four "pleasures" identified above, map nicely on some of the key ideas of constructivism. It may be said that, a good constructivist lesson (1) helps students experience the "new and the wonderful in science, in a way that creates surprise or cognitive conflict; (2) it focuses on sense-making, by providing students with opportunities to understand and overcome their cognitive conflict; (3) it connects with students in a personal, emotional way; and (4) it affords opportunities for students to experience science concepts directly.

A problem is that, the Gadanidis and Borba (2008) lens is not well-defined, particularly as it regards to a clear-cut distinction between what explicitly constitutes emotional moments category, and that of visceral sensation category. In fact, a close and critical analysis reveals that, the boundary between the two categories is fuzzy and apparently confusing. Some common emotions are expressed in a form of anger, fear, love, sadness, grief, jealousy, hurt, disappointment, and joy. The observed problem is that some of these elements that define emotional moments also fall in the visceral category. Put simply, the difference here, according to Boorstin (1990), is that while we feel the visceral sensations directly by ourselves, for the emotional moments, we do so through the actor. In chapter five, I use specific examples from the videos to explain this anomaly in an effort to suggest or, better still, help establish a reasonable distinction between the two categories.

Research Methodology

In this section, I present the research methodology used to answer my research questions. I also provide detail regarding the methods of data collection, data analysis, and the limitations of the study.

My research was to study performative school science concepts presentations (videos) on YouTube using a qualitative methodology with case study approach. The study was to answer the questions: a) In what ways do science performances as depicted on YouTube videos address the criteria for good educational performances laid out by the Gadanidis and Borba educational lens?; b) What does this lens tell us about creating a "good" science performance?; c) How well can the lens developed by Gadanidis and Borba be adapted for use in future studies seeking to investigate science performance?

The goal of qualitative research is to develop a rich understanding about a phenomenon as it exists in reality (York, 2010). Merriam (1998) explains that the product of a qualitative study is richly descriptive and uses words and pictures rather than numbers to learn about the phenomenon. York (2010) adds that qualitative research encompasses a complex, iterative process that eventually ends with an explanation of the phenomenon of interest as it is constructed by individuals within the context of that world. In a qualitative methodology, the researcher can set out to explore and to examine the application and operation of the same issues in different contexts (Cohen, Manion, & Morrison, 2007), which for my study the context was school science videos on the YouTube.

A qualitative research approach was most appropriate for this study, because my data involved "organizing, accounting for and explaining the data [YouTube videos]; in short, making sense of data in terms of the participants' [videos'] themes, categories, and regularities" (Cohen et al., 2007. p. 461) in relation to the categories underlying the Gadanidis et al. performance-arts lens adopted for this study.

Specifically, I undertook a qualitative study because this research design best fits the purpose of my research, which adopts Gadanidis et al.'s arts-lens for mathematics education to explore the nature of school science performances on the Web and to explore the effectiveness of this lens for science education, particularly for middle grades. Through qualitative method I examined ways in which the presenters of school science performances carried their presentations within their natural settings (Creswell, 1998; Merriam, 1998), which for this study were Web-based settings. It also allowed me to use words rather than numbers (Merriam, 1998) to answer my research questions and to present my findings.

Case study.

This study used a case study approach because it looked at a specific case by selecting videos from YouTube on the Web especially those that used performative approach to teaching science concepts particularly to middle grades. Merriam (1998) defines a qualitative case study as an "intensive, holistic description and analysis of a single entity, phenomenon, or social unit" (p. 27). Browne (2005) explains that case study research methodology is based on the interpretive view of inquiry. According to Patton (2002), the purpose of case study is to observe, organize, and analyze in-depth information, problems and relationships within a specific case of analysis. Nisbet and Watt (1994) define case study as a “specific instance that is frequently designed to illustrate a more general principle” (p. 72). Cohen et al. (2007) add that the “single instance” is of bounded system such as a class, a school or community. Robson (2002) finds that case studies opt for analytical rather than statistical generalization; that is they develop a theory which can help researchers to understand other similar cases, phenomenon or situations. According to Hitchcock and Hughes (1995), the case study approach is particularly valuable when the researcher has little control over events;

events such as YouTube videos. They state that case study has hallmarks (relevant to my study are):

- It is concerned with a rich and vivid description of events relevant to the case.
- It blends description of events with the analysis of them
- It highlights specific events that are relevant to the study
- An attempt is made to portray the richness of the case in writing up the report. (p. 317)

Also noteworthy, Cohen et al. have observed that "[s]ome case studies are divided into two main parts (e.g., Willis, 1977): the data reporting and then the analysis, interpretation, [and] explanation" (p. 263). My study was analyzed along this approach. Further, cross-case analysis was done. Huberman and Miles (1994) note that while either variable-oriented analysis or case-oriented analysis can be incorporated in such a qualitative study, this study focused primarily on case-oriented analysis.

Sampling.

The researcher used purposive sampling technique to select 20 videos for analysis. As noted by Cohen et al. (2007), "in purposive sampling, a researcher can hand pick the cases to be included in the sample on the basis of their judgement of their typicality or possession of the particular characteristics being sought. This way, they build up a sample that is satisfactory to their specific needs (pp. 114–15). My study was particularly interested in middle school science videos on YouTube that used performative approach to present a scientific concept, so the purposive sampling technique was best suited for it.

Data sources and data collection.

In this section, I indicate the source of data collection, criteria used to select the 20 videos for analysis and how each video was analyzed.

I conducted a search on the Web for the videos on YouTube with the help of browsers such as Mozilla Firefox. Specifically I used phrases such as *Science experiments, Science experiments for middle schools, Science for middle school and drama, Performative science for middle schools, Science and Theatre, and Science Play* to explore these performances on YouTube. These phrases were used to select 20 school science performative presentations, particularly those based on middle school science concepts, which have the following characteristics: (a) they focus on an important science curriculum idea; and (b) make use of performative approach to exploring and communicating science knowledge.

Criteria for including video.

In selecting the 20 videos that fit out of thousands possibly related to this study, I have watched over a 100 in full, and numerous others in part. The selection process was however not a random one; I considered those (videos) that represented 'best' examples at that given time, used visuals or relevant aids (e.g. real objects), and more importantly were most promising pedagogically. I intentionally avoided presentations that were merely talking-head oriented, boring and subtle in their educational sense or value, indoctrinating or self-serving.

Additionally, in deciding on whether to include a video in the top 20, I considered the potential impact such videos could have on other individuals who watch them, by considering the comments posted online, if any. For example, a viewer (who appears to be a school teacher) commented on selected Video 10, by Dr. Carlson, on Newton's 3rd Law of Motion: "Thanks from Mèxico. My students were able to understand because of the video demonstration," (panterbreaker, 1 year ago). This comment suggests the usefulness and benefits of this video to the classroom situation, and confirms Everhart's (2009) standpoint "I have watched science activities on YouTube and TeacherTube and replicated the experience with the students in the university classroom" (p. 35). This also suggests that such videos can be a potential educational resource across all levels of study.

For example, as another viewer commented on selected Video 13, posted by two females who appear to be middle school students (as their science project) that demonstrated the calculation of distance covered and the final velocity of a 'free falling' object: "how can the final velocity and distance be negative [as the object was not falling or acting against gravity]*?"* (BladePenguin, 6 months ago). This comment expresses doubt about the answers arrived at by the presenters, thus drawing attention to a need to critically analyze each video closely especially if its conceptual idea is to be replicated in classrooms.

Instrumentation.

The researcher was the key instrument for data collection and analysis (Creswell, 2007; Merriam, 2002).

Data analysis.

This study employed a qualitative content analysis methodology. Content analysis has been defined as a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding (Krippendorp, 2004; Weber, 1990). According to Cohen, Manion, and Morrison (2007), content analysis "simply defines the process of summarizing and reporting written data–the main contents of data and their messages" (p. 475). Cohen et al. further note that "content analysis involves coding, categorizing (creating meaningful categories into which the unit of analysis–words, phrases, sentences–can be placed) comparing (categories and making links between them), and concluding–drawing theoretical conclusions from the text" (p. 476).

Neuman (1997) on the other hand noted that "[q]ualitative content analysis is not highly respected by most positivist researchers. Nonetheless, feminist researchers and others adopting more critical and interpretative approaches favour it" (p. 273). The last sentence of Neuman's assertion finds fit with the Gadanidis and Borba (2008) performance-art teaching model of research in Mathematics education, which was used in this study. However, in exploring the research questions as stated in the opening paragraph under methodology, this study specifically looked at online videos that portray science concepts on the Web rather than a typical text-format. The content analysis methods were used on the video data, oral and visual images.

Cohen et al. outline five ways of organizing and presenting qualitative research data for analysis. One way of organizing the data analysis is by *individuals* [videos]. They explain:

> [h]ere the total responses of a single participant [video] are presented and then the analysis moves to the next individual [video]. This preserves the coherence and integrity of the individual response and enables a whole picture of that person [video] to be presented which may be important for the researcher. However, this integrity exacts its price, in that, unless the researcher is interested only in individual responses, it often requires him or her then to put the issues arising across the individuals (a second level of analysis) in order to look for themes, shared responses, patterns of response, agreement and disagreement, to compare individuals and issues that each of them has raised, i.e. to summarize the data. (p. 467)

With this in mind, I analyzed each video separately. Next, I did cross-case analysis of the data to find common themes that emerged from the individual data analysis.

In analyzing the *individual* videos, I indicated the science topic and quite broadly described the very or exact issues treated therein. I stated the position of the presenter e.g., student, teacher; mode of presentation such as experiments, images, graphics, science project and the target audience if clearly defined or inferable. In terms of 'popularity,' each selected video shows the number of views from the very date it was put on the Web till the date of selection. Using the analytical framework developed by Gadanidis and Borba (2008), I subjected each video to a critical analysis using the categories of "Surprising/New/Wonderful (voyeurs)," "Sense making," "Emotional moments (vicarious)," and "Visceral experiences." It needs indicating that Gadanidis and Borba educational performance-arts lens has been used for analyzing classroom actions and not videos.

In respect to the above interconnectedness and interrelatedness of constructivism and the performance-arts lens, the table below gives a snapshot of issues and events that help to define the four categories under the performance-arts lens being employed analytically in this study.

Surprising/New/Wonderful (Voyeurs)	Events, ideas, images, and so forth that the presenter uses to help make his or her presentation produce "surprises" or create cognitive conflict that encourages learning. Also, events that help the viewer experience something "new" in relation to everyday practices/beliefs or general/ taken-for-granted situations, as the presentation helps him or her (the viewer) to explore the "wonderful world" of science, or a "new" pedagogical approach and techniques.
Sense-making	Two key things: (1) Does the approach have the potential to help a viewer understand that particular scientific concept 'better'? (2) Is the logical flow convincing or believable?
Emotional moments (Vicarious)	Events, ideas, images, and so forth that the presenter uses in his or her presentation to help put the audiences in a position where they can potentially experience the emotional moments vicariously (indirectly).
Visceral experiences	Events that generate elements or instances that can potentially generate sensations in a viewer as he/she

	watches the video presentation. These sensations may be expressed in several forms such as fear, awe and quick change, and are experienced directly.

I also integrated comment(s) that help raise important issues by viewers, if any, on each selected video in the analysis. Though the number of views per selected video was indicated, the researcher did not use it for numerical purposes or for drawing statistical inferences in the analysis but to inform this study how often such videos were viewed by the general public.

Limitations.

One major limitation of this study is that I only used a single source of data for the analysis making it almost impossible to triangulate the data. However, triangulation extracts from the data what is heard, seen, and read (Theadford, 2008). Under this definition of the term, my data were triangulated for I carefully watched the videos, described in much detail the science concept being performed and read comments by viewers if available. Also, the accuracy of self-reported data and the overall interpretation of the data are sometimes uncertain. Another limitation is researcher bias (Cohen et al., 2007) that could be built into the study in that I selected videos that made much more sense on the basis of: a) my adopted performance lens, b) its relevance to school science.

Delimitation.

The study was limited particularly to middle school science concepts that used performative approach to teaching them. Although the pedagogical affordances of the videos selected are particularly appropriate for the middle grades, some may be used with younger or older grades as well.

Ethical issues.

The study analyzed science performances that are publicly available on the Web, and thus did not require an Ethics approval.

Chapter Summary

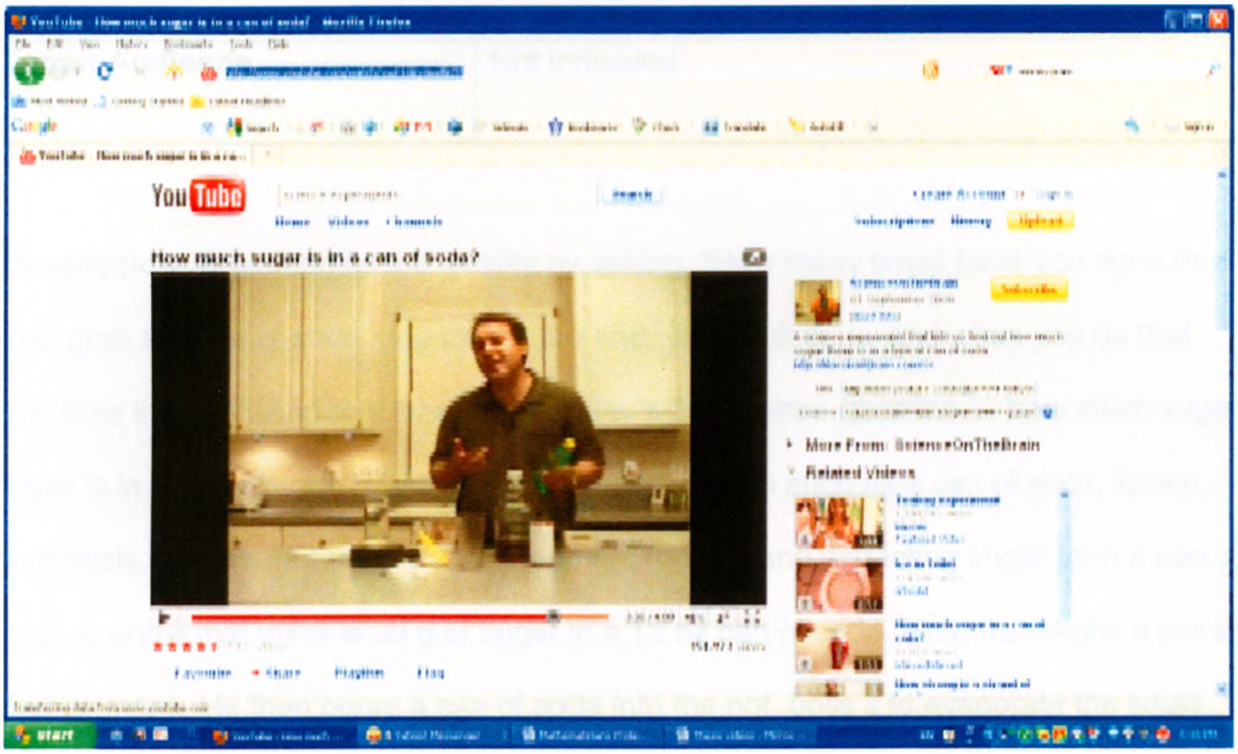
In this chapter, I have discussed the two key theoretical perspectives–constructivism and performance lens–that underlie this study. Brooks and Brooks' (1999) statement that constructivist teachers encourage initiative, accept autonomy, use cognitive terms (e.g., analyze, classify, create, predict), encourage dialogue, exercise wait time, and foster curiosity perhaps summarizes the core values of constructivism to education–teaching and learning. Gadanidis, Hughes, and Borba's (2008) contention that the performative lens also helps to view mathematics as a human feeling experience where its stereotypical description as a cold, hard science fades to the background as students' emotional, aesthetic and imaginative inclinations are valued, perhaps helps define the lens. The chapter also highlighted the research design–qualitative content analysis with case study approach of school science performative videos on YouTube used in this study. Limitation and delimitation for this study were also discussed. The next chapter presents findings of the study. I analyze each of the 20 selected videos separately.

Chapter 4: Findings

Introduction

This chapter presents the findings of the study, based on the analysis of 20 YouTube videos. The selected videos were particularly middle school science videos that used performative approach to present a scientific concept. I try to give a comprehensive description of the scientific issues being addressed in each video. I analyze each of the videos separately using the categories “Surprising/New/Wonderful,” “Sense making,” “Emotional moments,” and “Visceral experiences.” On each video, I use a table to provide information such as the URL, date posted, poster, and so forth.

Title of Video 1: How Much Sugar is in a Can of Soda?



URL	http://www.youtube.com/watch?v=F10EyGwd57M
Date posted/Poster	September 1, 2006/*ScienceOnTheBrain*.
Popularity	369,026 views (March 20, 2010)
Presenter	Marshall Brain[1]
Approach	Experimental demonstration

[1] Marshall Brain is best known as the founder *of How Stuff Works* and also known for the *Robotic Nation* essays and the book Manna. His blog shows that he has several articles and books to his credit. "I am also known as a member of the *Academy of Outstanding Teachers* at North Carolina State University, where I taught in the computer science department for 6 years. Today I am a writer, a well-known national speaker and a consultant" (http://marshallbrain.com/).

Place of Presentation	Appears to be Kitchen
Target Audience	Not indicated

Description: Brain begins the activity by asking, "How many times have you done this? You grab a bottle of soda, pop up the top end, you drink it. ..., and when you do that, you take in sugar. And that leads us to today's big science question … how much sugar there is in a can of soda?" With the help of real objects such as a can of soda, spoon and scale, the presenter uses an experiment (boiling and extracting sugar from a can of pop) to show that there is 39 g of sugar in a 12 oz can of soda. First, he weighs a pot to find its mass. He then pours a can of soda into the pot, boils it to evaporate the liquid component leaving sugar granules and measures its mass together with pot. (He cautions that "if you're a kid, you need an adult to help you do this.") He finds the difference between the two measured masses to determine the mass of sugar in the can of soda. He calculates the experimental yield of sugar to be 37 g. Second, he mentions that there is enough information on the can to tell us how much sugar there is in it without having to do the experiment. He shows to the audience the 39 g value of sugar as indicated on the 12 oz can of soda and says that that is close to the 37 g experimentally obtained. He also mentions that fruit juice contains the same amount of sugar for the same volume, and shows that this is stated on the fruit juice container label. The presenter indicates that knowing such amounts can help individuals choose carefully what they drink in order to promote healthy-lifestyle practices. Based on his scientific understanding of health implications of too much intake of sugar, he suggests that water might be a better thirst-quenching choice.

Surprising/New/Wonderful: Beginning the experiment, the presenter asks: "how many times have you done this? You grab a bottle of soda, pop up the top end, you drink it. ..., and when you do that, you take in sugar. And that leads us to today's big science question ... how much sugar there is in a can of soda?" drawing the audience's attention to something normally taken for granted and the need to find out exactly how much sugar we consume when we drink a can of pop. He uses an experiment involving ordinary kitchen tools/gadgets to show that there is 37 g of sugar in a 12 oz can of soda and indicates that "... we didn't have to do all that because" the label on the can indicates 39 g of sugar which is close to the experimental yield of 37 g. The presenter also shows that simple science experiments such as this one can be carried out even in the kitchen and obtain a fairly accurate result just like a typical laboratory. This has the potential to generate a "surprise" in viewers as much as to experience "the new and the wonderful" in knowing that the kitchen can function as a miniature laboratory for (some) simple science experiments. It also helps students in particular to appreciate the fact that science is all around them/us and not only in the typically equipped science laboratories can they test certain basic science concepts. Continuing, the presenter mentions that fruit juice of equivalent volume has the same amount of sugar.

The presenter potentially increases the experience of surprise by actually demonstrating how much sugar there is in 39 g. He urges the audience "let's find out" and uses a teaspoon, raw sugar and with the help of the balance to show that one teaspoonful of sugar weighs "about" 6 g. He therefore measures into a transparent glass placed on the balance, by counting, 7 “and a little bit” teaspoonfuls of sugar to obtain the 39 g as required. He adds 12 oz of water to the glass and says “and that's what you're drinking.” He questions: “Will you ever eat 7 ½ teaspoons of sugar?” He also asks the audience to experiment by drinking a solution of 1 teaspoonful of sugar and 12 oz of water and repeating the procedure with 2 teaspoonfuls of sugar and water until say 15 teaspoonfuls of sugar which gives a total of 78 g of a 24 oz bottle of soda and compare the differences in taste. Ending the activity, the presenter suggests to the audience that water might be a better thirst-quenching choice.

In summary, the presenter offers the following ways of potentially experiencing surprise: (1) he uses everyday objects (can of pop) in everyday contexts (a kitchen) which may lead students to not expect to be surprised; (2) he demonstrates that there are about 7 ½ teaspoons of sugar in 39 g, helping students realize that they would not normally (or knowingly) eat this much sugar; (3) finally, he draws students' attention to the soda pop label, which clearly states that it contains 39 g of sugar, helping them be surprised with the fact that they may not have noticed this information or understood its meaning.

Sense-making: The presenter shows to the audience how to experimentally calculate the amount of sugar in a bottle of soda through heating on a stove and measuring using a balance. He helps viewers through teaspoonful measurements to see for themselves how much exactly 39 g of sugar is. He points out that fruit juice contains the same amount of sugar as soda in a given volume. He also tells them they can find the same piece of nutritional information on the label, and to rethink their choices of what they drink. These demonstrations help show that the surprises potentially experienced do in fact make sense. This is supported by one of the comments posted by viewers: "Well, I think I'm going to think twice next time I pick up a soda. Thanks for the info" (NaturePhotographist, 2 months ago). This comment shows that the viewer has learned a "new" thing that he/she is likely to apply in his/her life.

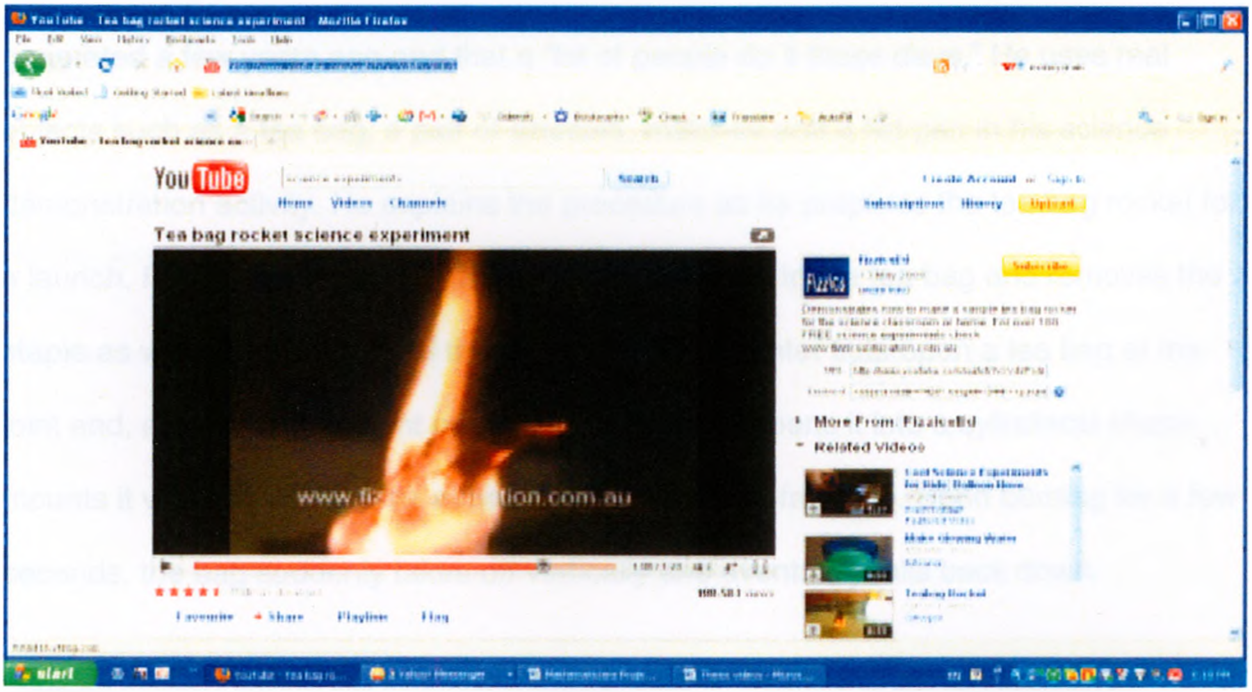
However, some comments show that some viewers were not convinced with some of the evidence provided by the presenter. Though the presenter mentions that one teaspoonful of sugar is "about" 6 g, he obtains his 39 g by counting 7 ½ teaspoonfuls. One viewer comments, "did anyone [notice] that he says there[']s 6 grams of sugar in each teaspoon, but then he goes on to put in 7 ½, which is about 45 grams , not 39....[,] fail[!]" (suppaman12, 1 week ago). The preceding comment suggests that the presenter's use of "about" in the measuring process was problematic and the confusion generated could have been avoided had he been more careful in stating the mass of one teaspoonful of sugar with the help of the balance. It is also possible that some viewers will wonder what else, besides sugar, might be left behind when the pop is boiled, such as salt or food coloring. Such lapses may provoke doubt in the mind of a viewer just as it would be for one watching a movie that shows a scene that is unrealistic and apparently doubtful.

It is interesting that some viewers commented on the physical characteristics of the presenter. One viewer states, "[t]his guy looks like he's been drinking too much soda (my89tube, 3 months ago). Another adds, "[f]at guy lecturing you about not having too much sugary stuff? Hmm...." (CrimsonSuperNova, 1 week ago). It seems that viewers use stereotypical images to interpret or make sense of learning situations. In the case of these two viewers, they seem to be expecting the presenter to be reflective of the image he 'preaches '- that is, drink water rather than pop.

Emotional moments: The presenter appears passionate about what he feels is an excessive amount of sugar in a can of pop and tries to connect the viewers to his feelings. He does this by: (1) asking questions that relate to their everyday experiences. For example he asks: "How many times have you done this? Will you ever eat 7 ½ teaspoonfuls of sugar?" and answers "no ...," (2) urging viewers to find out differences in taste as they vary the number of teaspoonfuls of sugar in a 12 oz glass of water. Also, after drawing the viewers' attention to the 39 g value of sugar on the nutrition label of the 12 oz pop can, he performs his dialogue: "So now, the obvious question is how much sugar is [he laughs] 39 g of sugar? .... "Now will you ever eat 7 ½ teaspoons of sugar [changes voice tone, laughs]" perhaps demonstrating his disapproval for such a practice. It is likely that the way he laughs at such a practice may cause the viewers to share his feeling about the 'high' sugar content of the can of pop. However, drama often uses more than one character, to help portray emotional moments. For example, if the video had someone that the presenter was talking to, and that person exhibited emotional reactions as the 'story' unfolded, it might create a better opportunity for the viewer to experience emotional moments vicariously.

Visceral: The video shows how a can of soda poured into a pot and boiled for sometime on a burner evaporates leaving behind mainly sugar granules in the form of a sludgy substance. The brownish color of the sugary sludge obtained in the pot does not have the same appeal as a cold can of pop. It is possible that viewers will have a visceral reaction of disgust when they see that sludgy substance that is 'hiding' in a can of pop. The sludgy substance also presents a contrast to the attractive portrayal of pop in commercial advertising. In addition, the concrete representation in the video of the amount of sugar in a can of pop as 7 ½ teaspoons of sugar may potentially cause viewers to experience a sense of fear in relation to the effect on drinking pop on their health. Viewers may also sense the beauty of science, especially in the way it can be applied using everyday tools (like a stove and a pot) to better understand the nature common substances (like pop). Changes of state may also potentially cause a sense of awe at the nature of substances around us. This potential of sensing fear, disgust, beauty or awe is enhanced by the 'concrete' way that the presenter presents his evidence.

Title of Video 2: Tea Bag Rocket Science Experiment



URL	http://www.youtube.com/watch?v=VdzPix9CKck

Date posted/Poster	September 1, 2006/*FizzicsEd*[2]
Popularity	369,026 views (March 20, 2010)
Presenter	Male Adult
Approach	Experimental demonstration
Place of Presentation	Appears to be Kitchen
Target Audience	Not indicated

Description: The presenter gives a simple demonstration of the basic principles on which rocketry works. He indicates that it is a simple experiment that a science teacher generated a few years ago and that a "lot of people do it these days." He uses real objects such as a tea bag, a pair of scissors, matches and a flat pan in his science demonstration activity. He explains the procedure as he prepares the tea bag rocket for a launch. First, he pulls off the piece of string attached to the tea bag and removes the staple as well. With the help of the scissors, the presenter cuts-open a tea bag at the joint end, empties the content on a hard flat surface, opens it into a cylindrical shape, mounts it vertically, and lights a match to burn the bag from top. Upon burning for a few seconds, the bag suddenly takes off vertically and eventually falls back down.

[2] ***FizzicsEd*** website indicates that they offer engaging hands-on experiments and fully-interactive demonstrations designed to improve students understanding and appreciation of science. They state that their school science workshops have been previously assessed by the NSW Department of Education & Training Performances for Schools Unit. "Our science programmes are presented by qualified teachers, science communicators and science undergraduates each with experience in reaching audiences of all ages no matter what the setting" (http://www.fizzicseducation.com.au/index.html).

Surprising/New/Wonderful: The presenter's demonstration perhaps helps the audience to potentially experience "the new and the surprising" in seeing a tea bag launch itself like a rocket as it burns. It may also help them appreciate the wonderful world of science and the many unexplored basic scientific concepts in everyday materials around us (like a tea bag). After a short while of the tea bag's take-off, the presenter catches it in a pan as it falls back to the ground. He explains that the burning produced hot air, a convectional current, which caused the bag to rise and that as the burning extinguished the convection effect (which needs heat) dissipated causing the tea bag rocket to fall back to the ground. This may help viewers to appreciate the wonders of science especially as it relates to the concept of gravity and convection currents.

In sum, the presenter potentially increases the surprise experience by lighting an empty tea bag which finally launches itself upwards like a rocket, for viewers might expect that the teabag simply burns and falls to the ground, as there do not 'appear' to be any forces acting on the teabag.

Sense-making: The presenter prepares the rocket and sets it up in a take-off position; he supplies the rocket the energy it needs to take-off through burning; he explains how the burning provides the convectional current so needed; and why the tea bag rocket returned to the ground upon exhausting the energy it was supplied with. Thus, (1) the combination of the visual demonstration of the tea bag rising as it burns and (2) the explanation provided by the presenter might help the viewer make sense of the phenomenon. However, the viewers might wonder why the teabag did not launch itself as soon as it was lit. Since gravity works against all objects launched opposite to its pull, the presenter's explanation perhaps should have included its effect in the activity. He could have indicated that the tea bag could not immediately take off when it started burning because the convection current so produced at that given moment was not strong enough to overcome the force of gravity acting on the bag; and that the launch was subsequently made possible when the convection currents increased in strength, coupled with the fact that the bag had been reduced to a small piece through the burning process hence relatively lighter (less mass) enough to be carried away against gravitational pull by the convection currents. Also one may ask why the tea bag was made into a cylindrical shape, and in an upstanding position, but not in a flat position before being lit.

Emotional moments: This demonstrational activity appears to fall short of meeting the criteria for vicarious emotional moments. Perhaps if the presenter had someone on stage as he performed the activity and that person exhibited some emotions as the demonstration progressed, it might have made the emotional moments much more profound for viewers to experience it vicariously.

Visceral: The sudden change of state in which the solid tea bag burns into flames turning into smoke and ashes produces contrasting images which may help the audience to potentially experience a sense of quick change. Such quick changes of state potentially help elicit visceral sensations. That sensation of fear/destruction that people usually associate with naked fires (flames) now brings them to see something almost its exact opposite–flames of fire providing 'wings' for an ordinary tea bag to fly into 'space,' at least for a moment. Not only may the entire tea bag's launch into air and its momentarily return to the ground denote a sense of scientific fit, it also by extension might help the audience sense the beauty and potential of scientific methods, however simple.

Title of Video 3: Dry Ice Fun–Cool Science Experiments

URL	**http://www.youtube.com/watch?v=kLO5SJ2uxEE**
Date posted/Poster	July 15, 2009/*Stevespanglerscience*
Popularity	107,638 views (March 22, 2010)
Presenter	Steve Spangler[3]

[3] Steve Spangler is described in the information provided on the video as a celebrity teacher, science toy designer, speaker, author and an Emmy award-winning television personality. Additional information on his Website (http://www.stevespanglerscience.com/) indicates that on the education side, Steve Spangler is nationally known as a teacher's teacher who shares his passion for learning in the classroom, on the platform, and through the airwaves. Moreover, he speaks regularly to educators and administrators at regional and national association meetings who want to learn how to integrate more science with their curriculum and use his techniques for turning ordinary moments into unforgettable learning experiences. He is the founder of *Steve Spangler Science*, a Denver-based company specializing in the creation of educational toys and kits and hands-on science training services for teachers.

Approach	Experimental demonstration
Place of Presentation	Appears to be Kitchen
Target Audience	Not indicated

Description: Before the main activity, Spangler shows to the audience some pieces of dry ice–frozen carbon dioxide–which he describes as the secret ingredient for the activity; which in contact with different liquids, reacts to generate 'mountains' of bubbles containing carbon dioxide gas. One also hears the "screaming noise" of the dry ice cubes in the video. The scientific concept for this video is sublimation–whereby a substance changes from a solid phase to gaseous without passing through the liquid phase.

Orderly arranged on an immovable stand with a flat surface are materials needed for the demonstrational experiment such as dry ice cubes in a cooler, cylinders, glasses, and a bottle each of dishwashing soap and apple juice. Spangler carries out the presentation with the support of a male companion and three young children (sitting close to one another) in a place that appears to be a kitchen. Beginning the activity, he shows to the audience a pack of dry ice in a cooler. The first child gives its temperature to be 110 degrees below zero and Spangler indicates places where one can possibly obtain it and how to store it for future use. Next, the children take it in turns with the first 2 using two transparent cylinders containing different liquids in terms of color by introducing into them cubes of the dry ice. The first child used a pair of tongs to handle the dry ice.

Each child offers a brief explanation to his demonstrational activity. The bubbles spontaneously erupt sparking up excitement amongst the presenters especially the children as the dry ice makes contact with the liquids. Making the generated fun more interesting is the exceptionally beautiful bubbles formed when the second child added a few drops of dishwashing liquid to his 'bubbling cylinder.' The children played with the bubbles, touching them with their bare hands. Spangler tells us, "[t]his's pretty cool because the kids can touch it; it's filled with carbon dioxide (CO_2) gas so it's safe." Referring to the 'mountainous bubbles,' Spangler remarks: "This is how Halloween looks like the whole night." The third child, with the help of Spangler, prepares a carbonated apple juice in a transparent glass by adding cubes of the dry ice generating bubbles containing CO_2gas. Spangler asks his adult companion to taste a carbonated apple juice which he describes as tasting "very refreshing" and delicious. Spangler demonstrates creation of a huge crystalline bubble in a big bowl with the help of a piece of cloth that has a "bubble solution" on it.

Surprising/New/Wonderful: It may be surprising to the viewers in finding out that the dry ice is made up of frozen CO_2, at 110 degrees below zero and that it makes a screaming noise. It may also be surprising to viewers in finding out that while frozen water does not generate bubbles (visibly) when in contact with water and other liquids, the dry ice does.

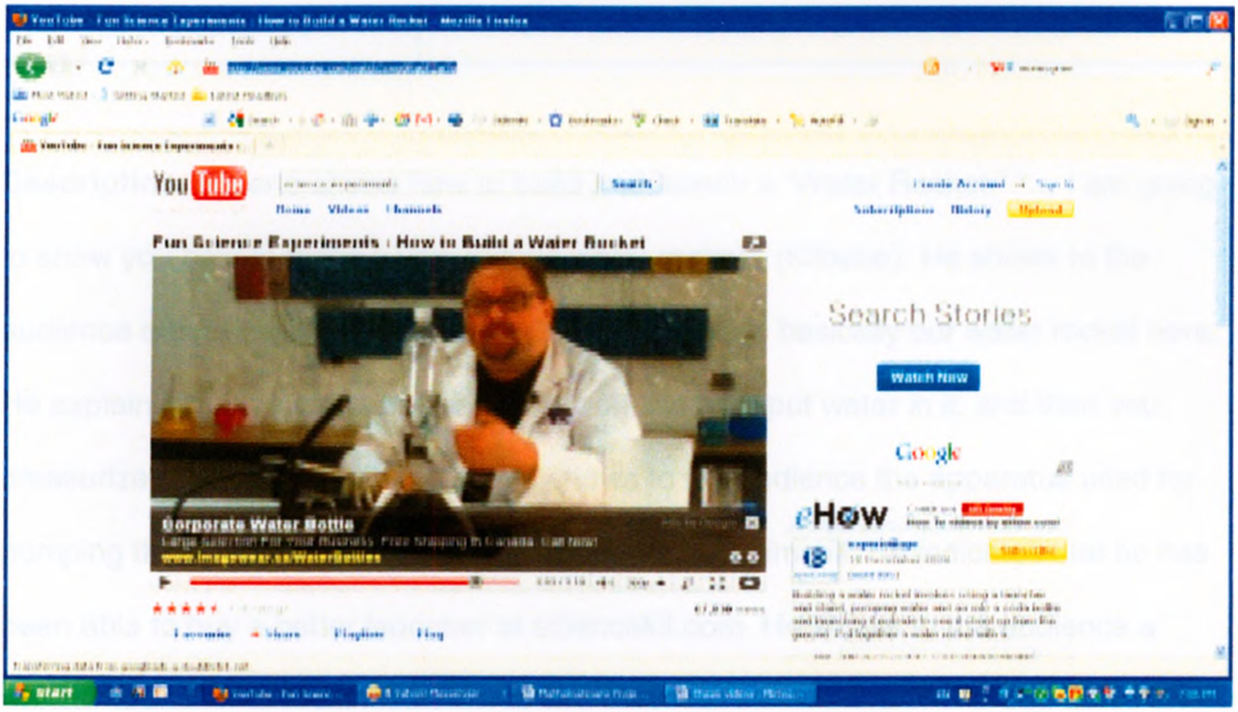
In sum, Spangler potentially offers the experience of surprise by: creating a situation where the dry ice makes a screaming noise; (2) showing the concrete representation of the spontaneous bubbling effect produced by the dry ice's contact with different liquids while ordinary ice cubes (solid water) do not visibly do so.

Sense-making: The video demonstrates the subliming effect of dry ice in contact with liquids. Spangler demonstrates the dry ice's effect on several liquids producing bubbles containing carbon dioxide gas. Extrapolating the idea, the concept herein performed may help the audience understand that, for an eruption such as the one in the video to occur, there ought to be a causal factor, for which in this experiment, is dry ice and its tremendous subliming 'power.' Though, using a liquid helps to see the bubbles, Spangler does not explain this. This is a miss in sense-making. A viewer might also wonder why solid water (ice) does not sublime the way the dry-ice does, or why sublimation occurs. The surprise of the bubbles (changing from a solid state to a gaseous state) becomes a promising but missed opportunity to develop a conceptual understanding of sublimation.

Emotional moments: The feelings and the excitement of the children–playing with the bubbles, touching with their bare hands, and laughing–in the video may help the viewers to emotionally experience the surprises vicariously.

Visceral: The dry ice upon contact with the liquids produces 'mountains' of bubbles containing CO_2 gas that demonstrates a quick change. It is likely that that sensation of quick change might trigger wonder in the mind of a viewer that can lead to asking questions such as, "What is happening here?, "How come the dry ice's contact with the liquids generated so much bubbles?, "What is special about dry ice as compared to the usual ice cubes or solid water?" Moreover, addition of drops of the dishwashing soap to the cylinders containing dry ice and a liquid made the bubbles erupt much more beautifully generating excitement in the kids who reacted to it with "uhhs, ahhs," amidst smiles on their faces. The foregoing shows that the children in the video 'loved,' and enjoyed the bubbling effect that characterized the "Dry Ice Fun" experiment.

Title of Video 4: Fun Science Experiments: How to Build a Water Rocket



URL	**http://www.youtube.com/watch?v=o8Ra6F2ai7o**
Date posted/Poster	December 18, 2008/*expertvillage*
Popularity	79,691 views (March 30, 2010)
Presenter	Colin Kilbane[4]

[4] Information on the video describes Kilbane as "the head scientist of a school program called *Mad Science*." Additional information on his Website has it that Kilbane has a degree in chemistry from Kansas State University. Currently, at *Mad Science*, he "teaches kids how to do science experiments from every field of science" and "chess to children of all ages" (http://www.madscience.org/locations/mn/).

Approach	Experimental demonstration
Place of Presentation	Chemistry lab; Open field
Target Audience	Not indicated

Description: Kilbane shows how to build and launch a "Water Rocket." "… I am going to show you how to make a very simple water rocket," (Kilbane). He shows to the audience a transparent pop bottle and says, "… this is basically our water rocket here." He explains that the way a water rocket works is "you put water in it, and then you pressurize it. You pump air into it." He shows to the audience the apparatus used for pumping the air likewise a launcher that he has built himself. He indicates that he has been able to buy a better launcher at sciencekit.com. He shows to the audience a 'typical' launcher and explains how to use it. He cuts off the top of one pop bottle and fits it unto the bottom of the other bottle (the top of the rocket) saying that it makes the bottle more air-dynamic. He shows to the audience a 'typical rocket' with fins on it and says that was built by his friend but for the day's activity he was going to keep it simple. He grabs the prepared bottle, pours water to half of it, puts a plug with a valve into it, inverts it and with the help of two keys, fits it unto the air pump. He explains that as he pumps air into the bottle, it pressurizes the inside of the bottle since the air wants to get out but the water blocks it and that when the pin blocking the water is pulled outdoors, the air was going to push the water out the bottom of the rocket. He refers to Newton's 3rd Law of motion, which simply states that to every action there is an equal but opposite reaction, to explain the (general) rocketry principle: "So the force pushed out of the bottom of the rocket, is going to push the rest of the rocket out…" stating that every rocket works on the same principle. He indicates that while model rockets use chemical energy, his water rocket was using the force provided by the pressurized air in the bottle. He moves to an open space, outside the laboratory, and demonstrates the launching process by pulling off the attached valve which allowed the air to push the water out the bottom of the rocket, causing the bottle to launch into air.

Surprising/New/Wonderful: Kilbane uses an ordinary pop bottle, air pump, though with the help of a locking pin, to prepare his water rocket which launches into air. The preceding approach may help the audience realize that Kilbane's rocket and model rocket work on a similar principle: they each push 'stuff' out from behind against air to move forward. It may be surprising to the audience to know that Kilbane was able to build his own rocket launchers. The concrete way he carries out the activity may also open new ways to viewers (particularly students) that can help them to rethink their decision about the subject science as this comment shows: "Now i know something new[.] (elcochipit, 6 months ago).

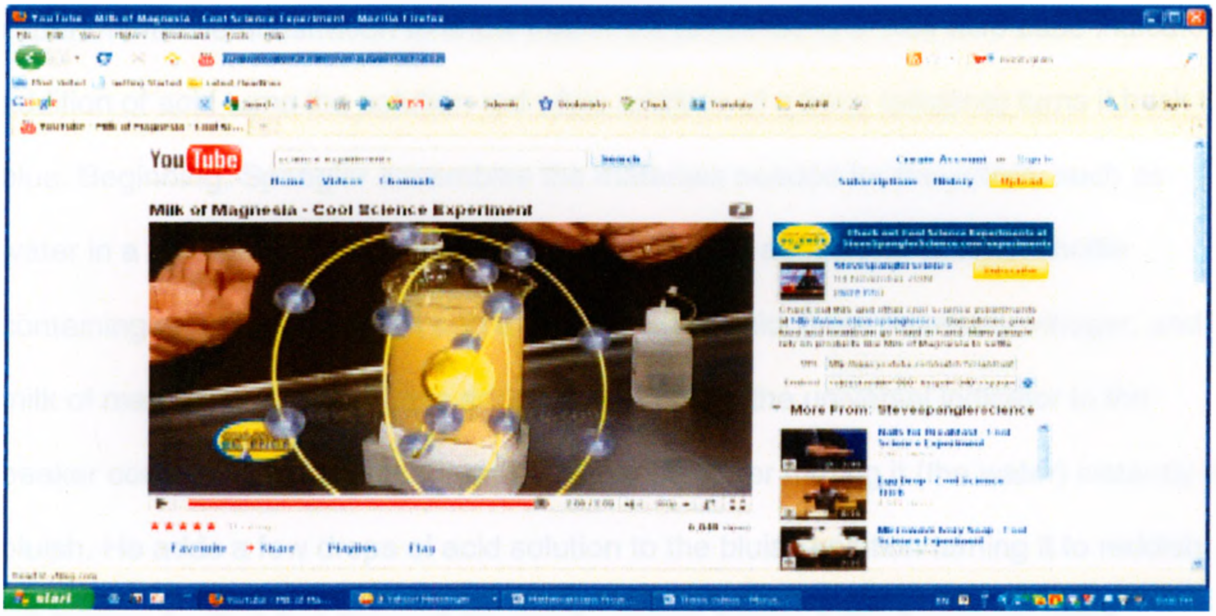
In summary, Kilbane offers the following ways to potentially increase surprise and wonder: (1) with the help of a locking pin, he uses an ordinary pop bottle containing some amount of water, pumps air into it to make his "Water rocket" without supplying it with any chemical source of energy; (2) he indicates that he is able to build miniature launchers by himself suggesting it does not take only engineers to do this; (3) his water rocket shoots at a 'high' speed upward as if it is being powered by a special automotive engine perhaps helping viewers to be surprised in that they might not have thought that water and air under pressure in an ordinary pop bottle could 'fly' this way.

Sense-making: Kilbane helps the audience with the understanding of making a water rocket using mostly simple tools and equipment such as pop bottles and an air pump. He states the concept of Newton's 3rd Law of motion as applicable in rocketry science. He shows to the audience how to mount a 'rocket' on a 'launcher'. He helps the audience understand the function of the launcher's fins. He tells them that typical or model rockets use chemical energy to propel them or power their movement (motion). Perhaps he helps the audience make sense of the activity and its underlying principle and possibly use his ideas to be able to build their own miniature rockets as these comments show: "my cousin made this rocket for her science class.... when she was like in the 5th grade, it was awesome!" (leozafina, 3 weeks ago); "wow thanks man, you helped me a lot on my project. You ROCK!!!" (PaintballBroPro, 3 weeks ago). On the flip side, he does not explain why the induced pressure stays in the bottle till his rocket was launched. Though he states that the water was blocking the air from gushing out; this appears to be the function of the locking pin which he bought from a shop. The viewer might wonder what might be the difference if there was no water in the bottle. Would it travel as far? An inflated balloon might have been used to help viewers relate the principles that make the water rocket function to something they have personally experienced and understood. When released untied at its opening or neck, an inflated balloon moves around in a similar rocketry fashion. He does not explain the Newton's 3rd Law of motion. He could have used the balloon as an example. It is interesting that a comment posted by one of the viewers, "if i do the same thing only without water it work[s] well," (moshe135, 3 months ago) suggests that Kilbane's explanation that "the air wants to get out but the water blocks it" may not be the right one.

Emotional moments: Kilbane tries to connect his presentation to the audience in a personal way as the following statements show: "… I am going to show you how to make a very simple water rocket, "… this is basically our water rocket here, "We gonna keep it simple…." However, these ways alone may hardly help the viewers to potentially experience emotional moments vicariously. Had he someone in the video, who reacted to the "surprise experiences," then through that, the potential in this sense could be enhanced profoundly. Another way might have been for Kilbane to relate a story of his own first experiences with such rockets: what surprised him, what questions were raised in his mind, what emotions he felt when he saw the rocket launch, or fail to launch under certain circumstances, and so forth.

Visceral: The sudden shooting of the water rocket from the ground likely causes viewers to have a visceral reaction of awe. To some viewers, the launch may send a wave of fear or danger especially when they associate it to missiles and their catastrophic consequences. To others, it may also demonstrate the beauty of scientific methods, principles and concepts.

Title of Video 5: Milk of Magnesia–Cool Science Experiments



URL	http://www.youtube.com/watch?v=iqAOuiZcDhc
Date posted/Poster	November 4, 2009/*Stevespanglerscience*
Popularity	8,301 views (March 30, 2010)
Presenter	Steve Spangler[5]
Approach	Experimental demonstration
Place of Presentation	Appears to be kitchen
Target Audience	Not indicated

[5] For additional information on Steve Spangler, see video 3.

Description: Spangler's science topic is on neutralization reaction. He uses experimental demonstration to show that in the presence of a blue acid-base indicator, addition of acid turns the solution red while addition of a base (alkaline) turns it back to blue. Beginning, Spangler assembles the materials needed for the activity such as water in a transparent graduated beaker mounted on a magnetic stirrer, a bottle containing universal indicator, and a bottle each of acid, base (alkaline), vinegar, and milk of magnesia–$Mg(OH)_2$. He adds a few drops of the universal indicator to the beaker containing water placed on the magnetic stirrer turning it (the water) instantly to bluish. He adds a few drops of acid solution to the bluish solution turning it to reddish. He follows it with a few drops of the base solution turning it back to bluish color (neutralization). He describes the procedures and reactions taking place as he demonstrates the science activity and describes the activity as "chemistry in action." He then adds a quantity of the milk of magnesia to the resulting solution turning it to milky color. He explains that that is what happens when milk of magnesia (an antacid) enters the stomach. He adds a quantity of vinegar (acid) to the milky solution turning it acidic (reddish) but after a few seconds, the solution returns to its milky color indicating how the milk of magnesia works. He adds that as more acid is added, the milk of magnesia gets used up. When his companion asked whether the neutralization process that takes place in stomachs happens so fast as the demonstration portrays, Spangler said probably they would have to find out that from medical doctors.

Surprising/New/Wonderful: Spangler mentions that an ordinary extracted juice of boiled cabbage-leaf works similar to a universal indicator. This enlightenment that a cabbage juice can function as a universal indicator may be something new and surprising to the audience (particularly elementary and middle graders). Upon adding a quantity of the milk of magnesia to the resulting bluish solution, it turns to a milky color. The indication he makes that that is what happens when milk of magnesia (an antacid) enters the stomach may be a new thing to the audience as they might have not given it a thought that such reactions do also take place in their stomach. The various color changes that are produced as the milk of magnesium and the vinegar solutions are alternatively added on may help the viewers appreciate wonders of science and its place in our everyday lives. As well, it may as much be surprising to them. Viewers who may not have known of a magnetic stirrer and its function might have learnt a new thing as this comment suggests: "magnetic sturer [stirrer!]" (nooloo3000, 6 months ago).

In sum, Spangler offers the following to increase the surprise and wonder experience by: (1) indicating that an ordinary extracted juice of boiled cabbage-leaf works similar to universal indicator in neutralization reactions as viewers may have thought that a universal indicator could only be prepared under special laboratory conditions; (2) demonstrating that in the presence of a blue acid-base indicator, addition of acid turns the solution red while addition of a base turns it back to blue; (3) relating the idea to how the milk of magnesia works in human stomach as viewers may not have thought that neutralization reactions which are normally done in the laboratories also take place in a similar way in the human stomach.

Sense making: Spangler helps the audience recognize how an acid-base or universal indicator works in neutralization reactions under laboratory situations/conditions. He also helps them to perhaps realize that, without the indicator, the color change(s) observed will not be possible though neutralization will have taken place. He connects the significance of that scientific idea or concept to reactions that normally take place in the human stomach. Connecting the conceptual understanding to what normally happens in the stomach upon taking antacids, Spangler probably helps the audience to relate the two scenarios–physical science experiment and that of 'covert' stomach reactions–perhaps with a relative ease. Though he talks of the human stomach, Spangler however does not indicate to the audience that naturally, the stomach is of acidic medium (containing dilute hydrochloric acid–HCl) and for that matter adding vinegar or other acid containing substances increases the acidity level while adding a base or alkaline substances like the milk of magnesia helps to reduce the acidity through a neutralization process thereby restoring 'normalcy' in the stomach environment. Also, he does not answer his guest's question that, "does it [the reaction] work as fast in the stomach?" though he says they will have to consult a medical expert. All the same, the video appears to help the audience make sense of the concept neutralization as these comments show: "lol nice vid! 5/5: D" (jes9044, 3 weeks ago), "oh for heavans [heavens] sake ... lol)" (hobgoblin98076, 4 months ago).

Emotional moments: In the video, his companion reacts to some instances of the demonstration with interjections such as "wow!", "it's amazing", "chemistry!", with Spangler responding , "...chemistry in action." (2) the connection he makes in his explanation that that is what happens when milk of magnesia (an antacid) enters the stomach, perhaps puts the audience in a position which helps them experience the vicarious moments by associating with the color changes that simulate the actual happenings in the stomach when they take antacids. On the other hand, if Spangler had someone in the video describing say indigestion and then the effect of milk of magnesia on them personally, the vicarious experience by viewers could be profoundly enhanced.

Visceral: The alternating color changes that characterize the demonstrational activity of the scientific concept neutralization may help the audience to potentially experience a visceral sensation of quick change. The concrete representation of the colors in the neutralization demonstration also help portray the beauty of scientific methods.

Title of Video 6: Fun with Liquid Nitrogen–Cool Science Experiments

URL	**http://www.youtube.com/watch?v=MaxZwsqstFs&feature=PlayList&p=962F9AFB6A9700CD&playnext_from=PL&playnext=1&index=40**
Date posted/Poster	September 24, 2008/*Stevespanglerscience*
Popularity	90,032 views (April 3, 2010)

Presenter (s)	Steve Spangler[6]
Approach	Experimental demonstration
Place of Presentation	News studio
Target Audience	Not indicated

Description: Spangler makes his presentation with the help of a hostess. Beginning the demonstration, the hostess, introduces Spangler and asks him about what is it that they were going to do with the liquid nitrogen that morning. Spangler (humorously) cautions that they put on their glasses so they do not "get the emails." He pours into a silver bowl some quantity of the liquid nitrogen and states that about 79% of the air that we breathe is made of nitrogen and that when compressed under very cold conditions, liquid nitrogen was obtained. He gives its temperature as 320 degrees below zero and adds that the liquid "was not happy to be outside" and for that matter was boiling away. One could also hear a 'screaming' sound of the liquid as it was being poured. Continuing, he puts into the liquid nitrogen a live-flower with a long stalk, removes it after a few seconds and asks the hostess to crash it in her palm. The crashing of the petals creates a crunchy sound as they get removed, leaving a petal-less flower. Next, he gradually pushes into the liquid nitrogen an inflated balloon which he says contains his breath (air molecules). The balloon after a little while shrinks to a fraction of its original size.

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[6] For additional information on Steve Spangler, see video 3.

Spangler explains that the extremely cold nature of the liquid nitrogen causes the balloon to shrink as his breath, mainly air molecules, become compressed turning to liquid in the balloon. He thus cautions people to be careful not to fill their car tires too full during wintry conditions as summer temperature would increase the pressure in the tires which might cause them to burst. He then takes out the balloon from the liquid and displays it openly to the audience. After a few seconds, one could see the balloon turning from its shrunken state to a full size again. Spangler explains how the outside air (warmer than that of the liquid nitrogen) warms the balloon causing the molecules to move faster and increasing the pressure bringing the balloon to its original size. Next, through a funnel fitted unto another balloon, he pours some quantity of the liquid nitrogen into it, detaches the funnel, and clamps firmly the neck of the balloon with his fingers. The balloon gradually bulges out. He explains that the enclosed liquid turns to gas generating increased pressure. Finally, he asks the hostess to pour a cup of the liquid nitrogen into a vessel containing a liquid that looks like water. Upon contact, "a beautiful little cloud" erupts and starts spreading out. He pours more liquid nitrogen into the vessel creating an eerie scene. Ending, the hostess hints to the audience that Spangler will be on *The Ellen's Show* next week, and gives the Website address of the studio where people can find more information about the show.

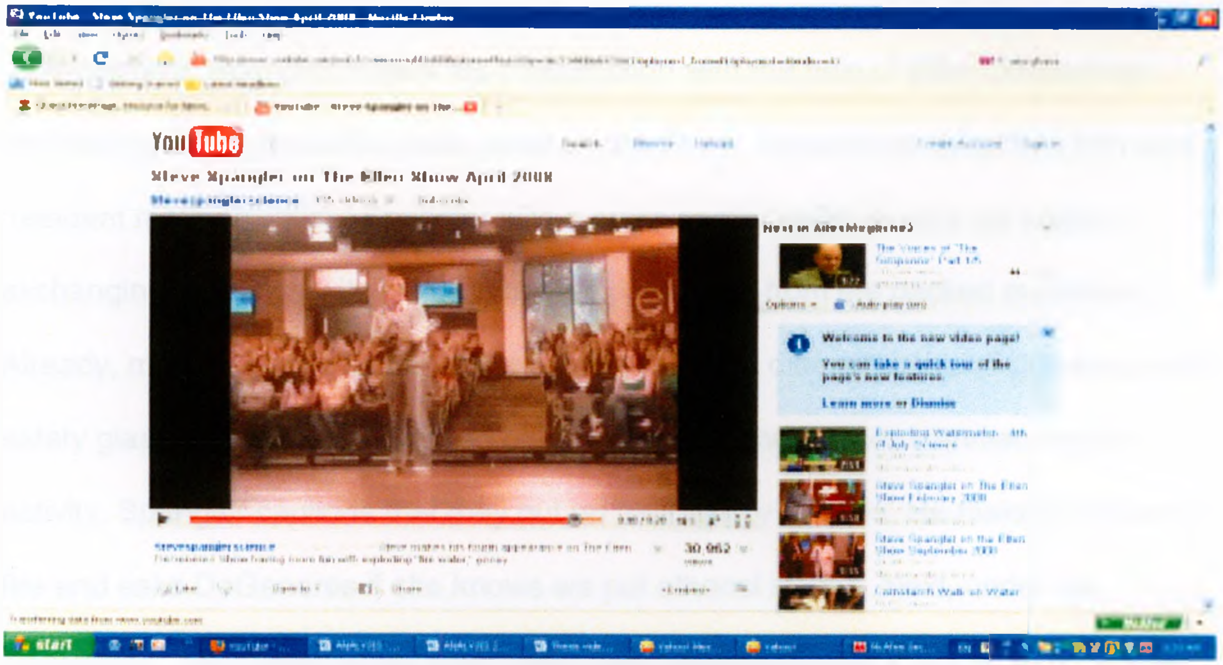
Surprising/New/Wonderful: Spangler offers many experiences that may be surprising, new and a wonder to viewers: (1) The crashing of the petals of the life-flower after its contact with the liquid nitrogen creating a crunchy sound as they get removed, leaving a petal-less flower may equally be surprising as liquids normally soak objects rather than hardening them. (2) The shrinking of the balloon containing Spangler's breath, mainly air molecules, upon contact with the liquid nitrogen in the balloon may register another surprise to the viewers. (3) Extending this idea to car tires and cautioning people to be careful how they inflate them to avoid bursting may be a new learning to the viewers.(4) Also, pouring some quantity of the liquid nitrogen into an ordinary balloon and clamping firmly its neck with his fingers, the balloon gradually bulges out. This may be new and surprising to the viewers in learning that a liquid in a balloon causes it to bulge out for viewers might expect that the balloon would not be expanding continuously as the activity showed. (5) Finally, the "beautiful little cloud" that erupts as his companion pours a cup of the liquid nitrogen into a liquid that looks like water, spreading out the entire place may be a source of wonder to the viewers.

Sense-making: Spangler demonstrates the liquid nitrogen's effect on many substances to help the viewers make sense of his 'science-learning show.' First, he states as a fact that about 79% of the air that we breathe is made of nitrogen and that when compressed or cooled under very cold conditions, liquid nitrogen is obtained. Second, he makes the viewers aware that the liquid nitrogen was at a temperature as low as 320 degrees below zero and that the liquid "was not happy to be outside" and for that matter was boiling away. He adds that the surrounding or room temperature was high enough to effect the boiling process. He further supports his assertion with the 'screaming' noise that accompanies the liquid nitrogen as it is being poured. Third, he uses the episode of the shrinking of the inflated balloon upon contact with the liquid nitrogen and its bulging out after removing it from the liquid to caution people to be careful how (full) they inflate their car tires during wintry conditions. Fourth, Spangler demonstrates the reality of his assertion on the preceding point by pouring some quantity of the liquid nitrogen into an ordinary balloon and clamping firmly its neck with his mere fingers; the balloon gradually bulges out. Spangler explains that the enclosed liquid turns to gas (due to the higher room temperature) generating an increased pressure. As room temperature is generally given as 72° F, or 22° C and that of the liquid nitrogen was at -320 ° F–its boiling point–relating these numerical values would help the viewers make a better understanding of his statement that the liquid nitrogen was boiling away. He also does not explain to the viewers what causes the “beautiful little cloud's” eruption. He could have indicated that just like fog formation, the said cloud was made possible due to the fact that the liquid nitrogen makes the nearby air very cold and that, since air cannot hold as much water vapor when it is colder, some of the water vapor condenses into small water droplets that we see as fog.

Emotional moments: The nervous reaction of the hostess to the crashing of the flower in her hands as she pulls off her hands saying “This is chilly!”; the hostess pulling her body away for suspecting that the balloon might explode as Spangler gradually pushes the balloon containing his breath into the liquid nitrogen; and her body visibly shivering at an instance when Spangler introduces the inflated balloon close to her face all demonstrate emotional impulses that can potentially cause viewers to be carried along that line of emotional moments.

Visceral: Spangler demonstrates the liquid nitrogen's effect on many substances. The screaming noise that accompanies the pouring of the liquid nitrogen into a container in the studio may produce a visceral sense of awe and fascination as normally other usual liquids such water and oil do not produce such an effect. Also the shrinking of the inflated balloon upon contact with the liquid nitrogen and its bulging out after removing it from the liquid is a representation of a quick change that can potentially enhance a visceral sensation of intrigue. Finally, the "beautiful little cloud" that erupts spreading out the entire place as the hostess pours a cup of the liquid nitrogen into a vessel containing a liquid that looks like water can cause viewers to experience a sense of beauty of the nature of substances.

Title of Video 7: Steve Spangler on the Ellen Show April 2008



URL	http://www.youtube.com/watch?v=esoYoqbMrAI&feature=PlayList&p=962F9AFB6A9700CD&playnext_from=PL&playnext=4&index=43
Date posted/Poster	April 15, 2008/*Stevespanglerscience*
Popularity	30,962 (April 3, 2010)

Presenter	Steve Spangler[7]
Approach	Experimental demonstration
Place of Presentation	*The Ellen DeGeneres Show* – studio
Target Audience	Variable

Description: Spangler makes his presentation with the help of Ellen DeGeneres. Introducing Spangler as the next guest on the Show, DeGeneres describes him as a "resident math-scientist." Spangler with a smile briskly walks in unto the stage exchanging greetings with DeGeneres amidst cheers from the packed audiences. Already, materials such as large plastic water bottles, different sizes of glass cups and safety glasses had been displayed on a table-like stand. Before commencing his activity, Spangler cautions that they put on their safety glasses. He makes mention of fire and asks DeGeneres if she knows we put ethanol in cars. Next, under his instructions, they each empty from a test tube ethanol into the 2 empty water bottles separately; shakes, spins and hits bottles vigorously to coat the inner wall with the ethanol, and keep them upstanding. Spangler explains that the attempt was to turn the liquid ethanol to the gaseous form so when "we light it on fire, we want a nice 'squissss…'" demonstrating the act with hand movements, the shrill sound that usually accompanies burning of highly inflammable gases. He further describes to DeGeneres that they would light a match, introduce it to the tip of the bottle and finally drop it into

[7] For additional information on Steve Spangler, see video 3.

the bottle and watch happens. Immediately the lighted matches entered the bottles, sparks of fire were produced and the sparks kept on flashing for a while before being extinguished. (Spangler explains that, that reaction is similar to those that happen in car engines.) Following almost immediately, they place their palms on the opening of the bottles (DeGeneres however quickly removes her palm pulling hand away saying "Jesus, it's hot"), that of Spangler gets squeezed from the outside deforming it. On removing the hand, the squeezed bottle immediately regains its original shape creating a sound. The audiences show their delight by responding with applause and laughter. Spangler explains that the temporary deformation of the bottle was due to the outside air pushing on the bottle (i.e. less pressure in the bottle due to the burning which consumed the oxygen component of the enclosed air; and the carbon dioxide gas and water vapor produced out of the burning was far not enough to compensate for the difference in volume and for that matter the inner exerted pressure). They then take on another activity. Spangler gives a paper cup to DeGeneres, fills it with water until almost half full, covers it with a piece of material that looks like a cardboard. He helps DeGeneres turning the cup upside down, sends it in that position and rests it on DeGeneres' head. He asks DeGeneres to "take responsibility of her own actions" by helping her hold onto the cup with her two hands. The hall roars simultaneously registering perhaps the pleasure of the audiences. Next, he quickly pulls off the cardboard from underneath the cup of water leaving it sitting on DeGeneres' head. To the surprise and anxiousness of the audiences, Spangler lifts up the cup from DeGeneres' head and empties content into her palm; the water had turned to a block. He explains that inside a diaper is a polymer that absorbs liquids (water) very rapidly.

He shows to the audiences a sample of the polymer in a glass, pours water unto it, and it quickly turns the water into a solid. He explains that the solid can later dehydrate and then be used again or added to soil to improve its fertility. He describes such a polymer as a "super absorbent." The audiences then took a break. Resuming the Show, he helps DeGeneres to pierce through a tuber of potato using the usual drink straw - the thumb seals one end of the straw, grabs firmly in hand and then vertically directed into the potato with some appreciable amount of force. He repeats the process with the other end of the straw. The two ends of the straw got sealed as they became trapped up with a piece of potato. Spangler explains that, in-between the sealed ends of the straw were air molecules, and as one pushes with a piston-like tool the potato piece at one end towards the other, the air molecules become compressed consequently firing the potato piece at the other end at "about 60 miles per hour." He demonstrates that with a bigger and tougher plastic straw. They each fire their potato shooter from a distance at a target bag creating excitement amongst the audiences. He then introduces a more sophisticated type of the potato shooter which he calls "potato shooter 3000" to the audience. He then sprays into it some quantity of ethanol and closes its opening. He prepares another shooter for DeGeneres. He asks the audience to watch what was going to happen. He explains that, on the shooter 3000, as one pushes the red button on it, it causes sparks of fire; with the energy generated pushing out the potato piece at the end of the shooter. They demonstrate the shooting capability of the potato shooter 3000 to the audience.

Surprising/New/Wonderful: It may be new and surprising for the viewers in knowing that liquid alcohol can burn and that the reaction is similar to those that happen in car engines as Spangler explains. Spangler's explanation that the temporary deformation of the bottle was due to the outside air pushing on the bottle (i.e. less pressure in the bottle due to the burning which consumed the oxygen component of the enclosed air; and the carbon dioxide gas and water vapor produced out of the burning was not enough to compensate for the difference in volume and for that matter the inner exerted pressure), may be a wonder to the viewers since air pressure is not visible to the eye. Another surprise of the video may be the action of the "super absorbent" that causes the water in the cup to solidify in a matter of seconds. It may be new and surprising for the audience in knowing the substance that 'hides' in a diaper to make it work the way it does–a super absorbent. He indicates that the potato shooter made of the ordinary plastic straw can shoot the potato piece at the other end at a speed of about 60 miles per hour. It may be surprising to the viewers to know that the "potato shooter 3000" could fire at targets in a similar way as a gun.

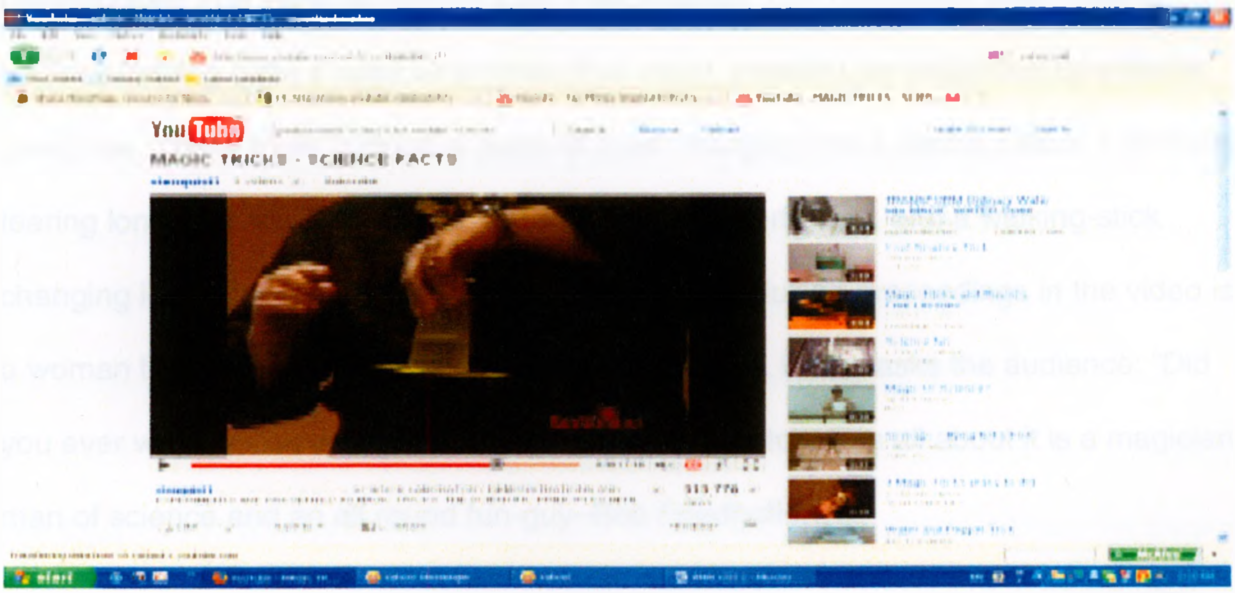
In summary, Spangler offers the following ways of potentially experiencing surprise: (1) he burns alcohol in a water bottle and relates the idea to the burning that happens in automotive engines; (2) he states what makes a diaper a super absorbent and demonstrates how fast it works before the audience; (3) he builds a potato shooter using a straw by sealing both ends with a piece of potato which he indicates that the shooter is able to fire the potato piece at one end of the straw with a speed of about 60 miles per hour when the trapped air molecules were compressed.

Sense-making: Spangler uses the burning of alcohol in the water bottle demonstration to simulate burning that occurs in car engines. Spangler however does not explain why the sparks of fire in the bottle, flash periodically before being extinguished. One explanation may be that perhaps because the bottle has a smaller opening (neck) compared to the actual diameter of its middle section, and also the fact that the flashes were gushing out through the same narrow neck, the continuous supply of oxygen needed from the outside (as the oxygen inside the bottle was increasingly getting used up) to support the smooth burning of the (gaseous) alcohol was interrupted intermittently. In the “super absorbent” demonstration, he states that inside a diaper is a polymer that absorbs liquids (water) very rapidly. He shows to the audiences a sample of the polymer in a glass, pours water unto it, and it quickly turns the water into a solid. As to what makes the polymer work like a magic is something that might leave a viewer wondering. In the potato shooter demonstration, Spangler explains that, in-between the sealed ends of the straw are air molecules, and as one pushes with a piston-like tool the potato piece at one end towards the other, the air molecules become compressed, in effect, firing the potato piece at the other end at about 60 miles per hour. He demonstrates that with a bigger and tougher plastic straw (or pipe). What he does not indicate is that the potato fits snuggly at the firing end, sealing the straw and making it air-tight so the trapped is unable to escape, hence building pressure when compressed. They each fire their potato shooter from a distance at a target bag. In the more sophisticated type of the potato shooter which he calls “potato shooter 3000,” he sprays into it some quantity of ethanol and explains that, on the shooter 3000, as one pushes the red button on it, it causes sparks of fire; with the energy generated pushing out the potato piece at the end of the shooter. This probably helps the audience to relate the energy produced during the burning of the alcohol in the water bottles to that of the “potato shooter 3000” and perhaps to make sense of it.

Emotional moments: Spangler appears passionate about his demonstrations and with the help of DeGeneres tries to connect the audience to their feelings as the following indicate: (1) in the burning of alcohol demonstration, he urges DeGeneres, "put your hand on the top [of the bottle]." Although DeGeneres does so, she quickly removes her hand exclaiming, "Jesus, it's hot!" (with the audience laughing); (2) in the second activity, he places the cup of water turned upside down on DeGeneres' head and asks her to take responsibility of her "own actions [the audiences laugh]." He removes the cover underneath the cup with DeGeneres holding on to the cup with both hands and smiling (the audience shouts ooh, amidst laughter). He picks up the cup from DeGeneres' head, empties its content into her palms; it has turned to a solid. DeGeneres exclaims, "Wow, what did you have in there [in the cup]?" Spangler responds: "Nuclear waste [they all, including the audience, laugh];" (3) in the last activity, DeGeneres fires the potato 3000 shooter finding the target and the audience goes "wooow", amidst clapping of hands. The manner in which the demonstrations were carried out in a dramatic fashion as indicated above perhaps helps the audience experience the emotional moments vicariously. Moreover, DeGeneres shows a good understanding of how to help an audience experience emotional moments vicariously. She states that she does not want to know what will happen before the Show. This helps her experience and demonstrates her surprise, wonder, fear and other emotions in a natural and believable way, so that the audience can better experience her emotional reactions vicariously.

Visceral: The video shows a demonstration of three activities–the burning of alcohol in water bottles, the super absorbent nature of a polymer used in a diaper, and the potato shooter. In the burning of alcohol demonstration, liquid alcohol, on turning into gas in contact with a source of fire produced beautiful sparks of fire that kept flashing awhile before being extinguished. In the super absorbent polymer activity, the powdered substance within 'split of a second' changed the liquid water into a solid. In the potato shooter activity, the alcohol sprayed in it upon burning released energy to fire the potato piece. These demonstrations perhaps help the audience experience visceral sensation of the beauty of scientific methods.

Title of Video 8: Magic Tricks–Science Facts



URL	http://www.youtube.com/watch?v=4EABdAEt_fM
Date posted/Poster	September 22, 2006/*stenquist1*
Popularity	313,776 views (April 3, 2010)

Presenter	Bob Friedhoffer[8]
Approach	Experimental demonstration/Acting (magical)/Face-to-face interview
Place of Presentation	Appears to be Physics laboratory
Target Audience	Not indicated

Description: The video is dubbed *Live Performance: City University, New York*. It begins showing quite a number of tricks that could, possibly, be explained by science principles. These tricks include a piece of scarf changing into a walking-stick, a lab coat tearing longitudinally into two parts from behind the performer, and a walking-stick changing into a string with a loop at its one end. Introducing proceedings in the video is a woman by name Susan Powel. Beginning the event, Powel asks the audience: "Did you ever wonder how everyday objects work? …here to tell us all about it is a magician, man of science and an all round fun-guy–Bob Friedhoffer…."

Powel: So how does science affect our lives, even ways we don't even know, right?

[8] Available information describes Bob Friedhoffer as "The Madman of Magic" who has performed in venues from private homes to Atlantic City revues to the White House (for President Carter), and has made numerous television appearances. "Bob is the author of more than 25 books for children about science and magic. His last four books have focused on creating physics labs from products found in the supermarket, the home, and in hardware and housewares stores, emphasizing the physical principles underlying common household gadgets" (http://events.caltech.edu/events/event-2467.html).

Friedhoffer: Absolutely … science is everywhere, no matter what you're doing, if it's eh turning on your television, if it's eh getting in a car and starting it up, if it's just walking down the street, there's something about science every moment of the day.

Powel: So you gonna show us eh, you gonna reveal to us something that we may not have thought about it?

Friedhoffer: Absolutely …!

Friedhoffer starts his set of … activities with a demonstration on air pressure, which he describes as something we neither see nor feel but does exist. He indicates when doing science programs for children, he asks them what would happen if he places a 30 cm wooden ruler beneath a sheet of newspaper such that they rest on the surface of a table with about 5 cm piece of the ruler pointing out of the edge of the table and then bangs down that part with a hand. He indicates that he gets a lot of different answers such as the "paper will go flying" and the "ruler will break." He demonstrates this before the audience and the ruler breaks. He explains that air pressure measures about 15 pounds per square inch and with the graphic paper having about 200 square inches, the total air pressure comes to about 3000 pounds, hence the break. Next, he demonstrates the principle of inertia. On a table stand 4 glass containers of same dimensions almost fully filled with water, a single cardboard tray covers the openings of all 4. On top of the cardboard tray, and in a vertical alignment, to each glass container stands a card roller of same dimensions. Friedhoffer then places on top of each roller, a boiled egg. He then quickly knocks off the cardboard tray and the eggs fall into the respective glass containers. The audience responds with a "uuuuuh." Friedhoffer explains that that demonstration was in conformity to Newton's First Law of motion. For the next activity, he tells the audience they can all do at home: He pours water into a cup and waves over it a "very expensive magic wound" and says "the water disappears." He turns the cup upside down and the water does not pour out. In that inverted position, he puts it on the table. Next, he picks up a transparent container half filled with water, covers it with a card-like paper saying he was "going to trap the water" and "if the water is trapped, it cannot get out." He asks the audience: "Do you want me to turn it over, you think I cheat…? Audience gives mixed answers such as "yes", "no." With the right palm supporting the covering cardboard, he turns the cup upside down. Audience asks him to remove his hands. He turns the cup back into its original upstanding position before taking the hand off the cardboard. Audience makes noise for perhaps they expect him take his hand off the cardboard while cup was inverted. Finally he does that yet the cardboard stays in place and the water does not pour out. The audience goes "uuuuh," probably registering their surprise. He begins counting, "3, 2, 1," the cardboard gets detached and the water pours out. He explains that the cup was not glass but a plastic one with a hole drilled close to its base where he covered with his finger so no air could enter, and that when he removed his finger, air entered the cup causing the inside pressure to increase thereby equalizing the outside pressure previously acting to keep the cardboard in place. He ends by stating that the reason he does this show is to let people know that science is fun and worth studying….

Surprising/New/Wonderful: Friedhoffer's explanation (of facts) that air pressure measures about 15 pounds per square inch and with the news paper having about 200 square inches, the total air pressure comes to about 3000 pounds, hence the break of the ruler, may be a new learning to the audience. It may be surprising to the audience for they might expect that the paper will go flying as he bangs on that pointed segment of the rule. On his demonstration of the principle of inertia, knocking off the cardboard tray causes the eggs to fall into the respective glass containers. This may be surprising for the audience might expect that the eggs' states of rest on the paper tray would be affected by the sudden displacement of it. Also, he pours water into a cup and waves over it a "very expensive magic wand," turns the cup upside down and the water does not pour out. This perhaps has the potential to surprise the audience as they might expect that the water would pour out in that inverted position of the cup with nothing covering it. In the final activity, the revelation he makes that the cup is not glass but a plastic one with a hole (leak) drilled close to its base where he covered with his thumb so no air could enter, and that when he removes his thumb, air enters the cup causing the inside pressure to increase thereby equalizing the outside pressure previously acting to keep the cardboard in place may be a new learning to the viewers. It may be surprising for the audience to know that there exists air pressure that is strong enough to keep the cardboard in touch the brim of the inverted cup stopping the water from pouring out.

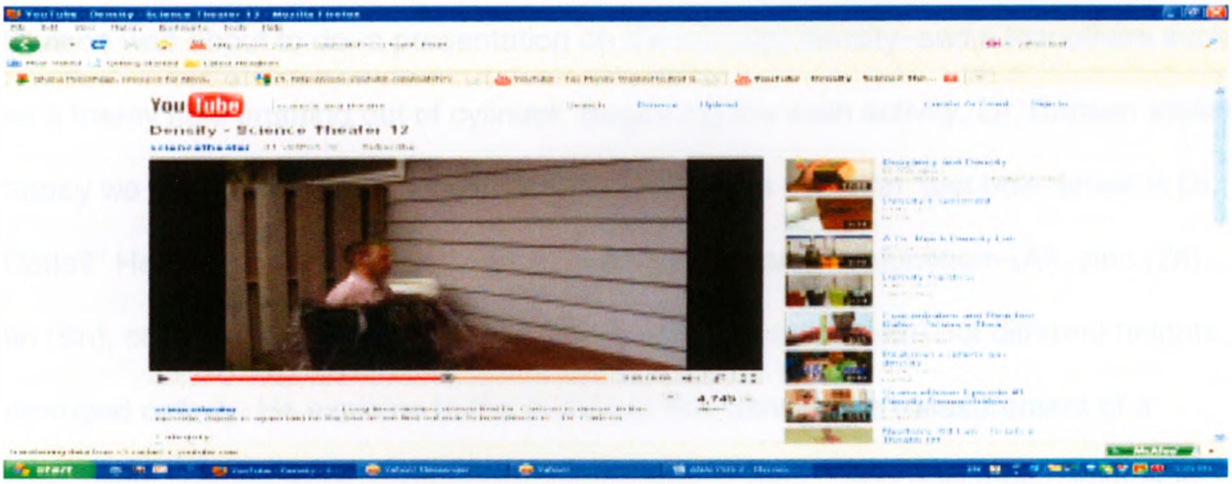
In summary, Friedhoffer offers the following ways of potentially increasing surprise experience: (1) he bangs on the pointed end of the 30 cm wooden ruler with the greater part covered under a mere graphic paper on a table and the ruler breaks; (2) he knocks off a supporting tray for the four rollers keeping the eggs yet their vertical states of rest are unaltered; (3) he pours water into a cup, turns it upside down after a few seconds yet the water does not pour out; (4) finally, he 'traps' water in a cup with the help of a leak and releases the water at his will.

Sense-making: Friedhoffer explains that the 30 cm wooden ruler placed beneath a sheet of graphic paper such that they rest on the surface of a table with about a 5 cm piece of the rule pointing out of the edge of the table breaks upon banging on it because acting to hold it in place is a total air pressure of about 3000 pounds. Although his demonstration may help the audience make sense of the fact that air pressure constitutes a tremendous amount of weight, not addressing the role of surface area might lead to a misconception. On his demonstration of the principle of inertia, knocking off the cardboard tray causes the eggs to fall into the respective glass containers. In the final activity, his revelation that as he covers the leak on the plastic cup, no air could enter and that the air pressure acting outside was greater than that in inside the cup and upon allowing air to enter through the leak both pressures equalized each other may help the audience to make sense of why the water poured out the cup at his will.

Emotional moments: Although Friedhoffer appears passionate about his demonstrational activities, this alone may not potentially enhance a vicarious experience in the viewer. Also, Powel did not (visibly) show her emotions even in instances where the audience reacted with the "uuuuuhs." If Powel had done the same, it would help the audience increase their emotional experiences vicariously.

Visceral: It is likely that viewers may experience a visceral sensation of awe at the way all the eggs fell into place perfectly. This is supported by their visceral "uuuuuh" response to that event. Also, he pours water into a cup, turns it upside down after a few seconds yet the water does not pour out perhaps due to the presence of a super absorbent. He 'traps' water in a cup with the help of a leak and releases the water at his will. It is likely that these two demonstrations involving water may cause a visceral sense of intrigue in viewers as they might expect that water in an inverted cup will pour out.

Title of Video 9: Density–Science Theatre 12



URL	**http://www.youtube.com/watch?v=14nahP_FVnM**
Date posted/Poster	April 29, 2008/*sciencetheater*
Popularity	4,749 views (April 3, 2010)
Presenter	Dr. Carlson[9]

[9] "As I taught classes in graduate school, I began to realize that I found explaining science to be much more fun than doing research. After finishing my PhD (in chemistry), I moved to Boston and became a licensed middle school science teacher. A few years later I moved to Lafayette, Indiana where I am now a public high school teacher teaching physics and chemistry at a school just outside of town" (Dr. Carlson) (http://www.sciencetheater.net/). Funding for the video was provided by the *National Foundation of Science*.

Approach	Experimental demonstration/Acting
Place of Presentation	Purdue University
Target Audience	Not indicated

Description: The video begins with a few snapshots that show highlights of what Dr. Carlson was about to do–a presentation on the concept density–and a few others such as a foamy fluid erupting out of cylinder. Beginning the main activity, Dr. Carlson states, "today we gonna talk about density" and to answer the question "just how dense is Dr. Carls?" He has on display, 5 cylindrical metallic substances–aluminum (Al), zinc (Zn), tin (Sn), copper (Cu), and lead (Pb)–of the same diameter (width) but different heights arranged orderly. He explains to the audience that density is a measurement of a substance "and we want to know how much mass it has … and how much volume it takes up…," adding that those two things put together tells one the density of a substance. He indicates that "the more mass you pack in small space, the more dense something is" emphasizing the point with his hand. On the screen appears the mathematical formula for density, d = mass/volume. He explains that all the metals have the "same exact mass" despite their different sizes. He indicates that though aluminum had the biggest size, its density was smaller than that of lead–the smallest metal on display for the activity–in the sense that, going by the formula, lead had the smaller volume comparatively. He adds that a quick way to find density of an object is to compare it to that of water which has a density of 1 g/cm^3 and that if it floats then it has less density than water and if it sinks, it has more density than water. He adds that density of a substance remains the same irrespective of size. Following, he urges: “So let’s go find out, how dense I’m.” He moves to a backyard. He stresses that audience should remember they would need two things to find out how dense a substance is–that is mass and volume. He finds his mass to be 71 g using a scale. In finding his volume, he fills a garbage container to the brim with water. Wearing a shirt and pair of shorts, he submerges himself in the water displacing a quantity of it representing his volume, comes out of the container, refills it with water, and finds out his volume (which is a measure of the amount of water he used in refilling the container back to the brim) to be 69 cm^3He puts his data in the density equation obtaining how dense he is: d = m/v = 71 g/69cm^3 = 1.03 g/cm^3 .. He explains that with water having a density of 1.03 g/cm^3 he is a little bit denser than water for his body is made up of a greater proportion of water and would sink in it if he blew air out of his lungs. He tells the audience that they could find out how dense they are by entering into a pool of water and blowing out the water in their lungs and see if they float or sink, asking them to remember that Dr. Carlson has a density just over that of water.

Surprising/New/Wonderful: Dr. Carlson indicates to the audience that “the more mass you pack in small space, the more dense something is.” He explains that all the metals have the “same exact mass” irrespective of their different sizes. He indicates that though aluminum has the biggest size, its density was smaller than that of lead–the smallest metal on display for the activity–in the sense that, going by the density formula d = m/v, lead had the smaller volume comparatively. The preceding indications and explanations have the potential to surprise the audience in knowing that density is directly related to the mass but inversely related to the volume of a substance. Also, Dr.

Carlson adds that a quick way to find density of an object is to compare it to that of water which has a density of 1 g/cm^3 and that if it floats then it has less density than water and if it sinks, it has more density than water. In a backyard, he finds his mass to be 71 g using a scale. In finding his volume, 69 cm^3 he uses an ordinary garbage container with water. He finds his density to be = 1.03 g/cm^3. He explains that with water having a density of 1.0 g/cm^3, he is a little bit denser than water for his body is made up of a greater proportion of water and would sink in it if he blew air out of his lungs. The steps Dr. Carlson uses to determine his density may be surprising, new and a wonder to the audience especially where he compares his density to that of water and states he is a little bit denser than water.

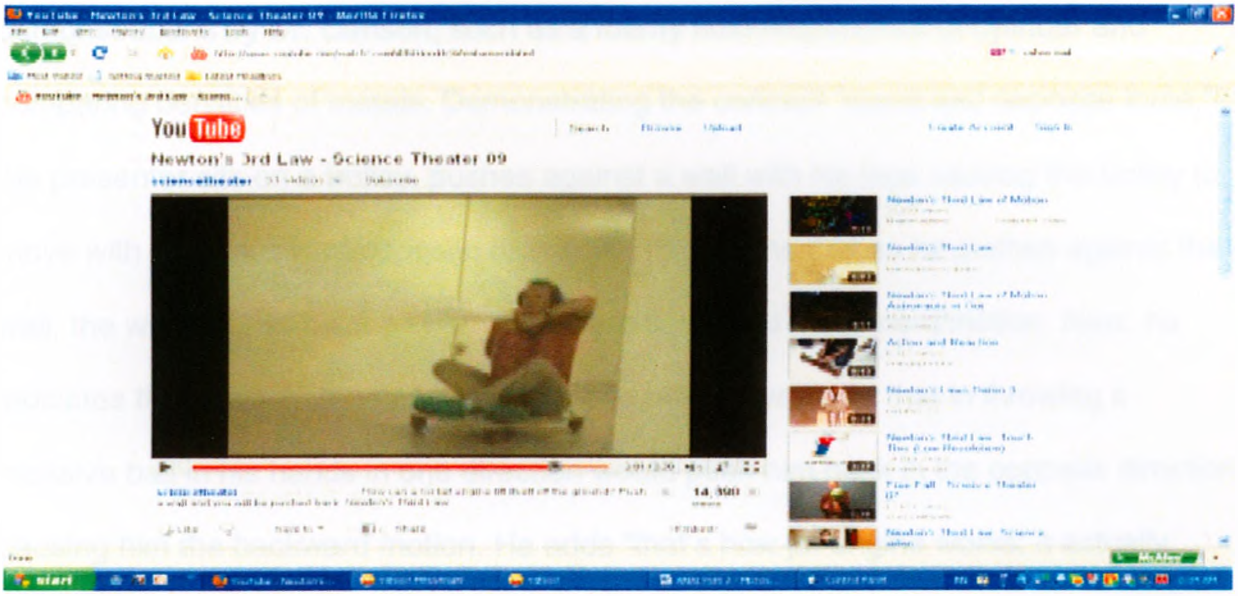
In sum, Dr. Carlson offers the following ways to potentially increase the surprise experience by: (1) indicating that, "the more mass you pack in small space, the more dense something is" and that all the metals (in the video) have the "same exact mass" irrespective of their different sizes; (2) indicating that a quick way to find the density of an object is to compare it to that of water which has a density of 1 g/$cm^3$and that if it floats then it has less density than water and if it sinks, it has more density than water an idea which viewers might not have thought of; (3) finding his volume using an ordinary garbage container and water; (4) indicating to the audience that he has a density just over that of water.

Sense-making: Dr. Carlson uses five metals of the same mass but different sizes (volume) to help the audience realize that the more mass you pack in small space, the denser something is. He uses aluminum which has the biggest (amongst his five set of metals) size yet least mass and lead which has the smallest size yet greatest mass, to illustrate the concept of density. He helps enhance perhaps the sense making by using the mathematical formula of density, d = m/v. Also, Dr. Carlson helps the audience with the understanding that, a quick way to find density of an object is to compare it to that of water which has a density of 1 g/cm^3 and that if it floats then it has less density than water and if it sinks, it has more density than water. He measures his mass using a scale and his volume using a garbage container and water. He puts his data in the density equation obtaining d = m/v =71 g/69cm^3 = 1.03 g/cm^3 as his density. He relates his measured density to water explaining that with water having a density of 1.0 g/cm^3, he is a little bit denser than water for his body is made up of a greater proportion of water and would sink in it if he blew air out of his lungs. He tells the audience that they could find out how dense they are by entering into a pool of water and blowing out the water in their lungs and see if they float or sink, asking them to remember that Dr. Carlson has a density just over that of water. Dr. Carlson's demonstrations perhaps help show that the surprises potentially experienced do in fact make sense. This is supported by one of the comments posted by viewers: "Nice demonstration. Easy to understand," (A1n3dr5e1234567890, 3 months ago). On the other hand, Dr. Carlson did neither take into account the amount of water absorbed by his clothes nor that adsorbed on his body during his volume measurement. Although the amount of water absorbed by the clothes and that adsorbed on his body may be very small, his mention of it would have saved him from comments posted by viewers such as: "good video, however, you did not take into consideration the water used to soak your clothes. I'm guessing it[']s negligible," (sekky123, 7 months ago).

Emotional moments: Dr. Carlson uses personal statements to try to connect to his audience as the following phrases show: "today we gonna talk about density" and to answer the question "just how dense is Dr. Carls?" "First, let's talk about what density is? Also, he performs his dialogue in a fun way. For example as he enters the garbage can, he sings "nice cold water ... someone displacing water here ... displacing water..." making the demonstration an emotionally fun activity as a comment posted by a viewer suggests: "thanks for videos!!! it's fun. [A]lso[,] i['m] learning [E]nglish from them," (sosna00, 9 months ago). On the other hand, he could have told a story of say Archimedes' "Eureka!" story, which relates to substances and the amount of water they displace when put into it. Stories usually generate emotional feelings. Telling a story this way can help a viewer experience a science concept in an emotional way, vicariously.

Visceral: The video shows how densities of five metals of the same mass but different sizes could be calculated and compared with each other. From the video, it becomes clear that lead has the smallest size and is the densest amongst the five metals compared. Also, the amount of water displaced in the garbage can which measures up to be (almost) the exact volume of Dr. Carlson. The above two examples perhaps help the viewer experience a visceral sense of fit of scientific methods.

Title of Video 10: Newton's 3rd Law–Science Theatre 09



URL	**http://www.youtube.com/watch?v=mNM5tHou4lQ&feature=related**
Date posted/Poster	October 27, 2007/*sciencetheater*
Popularity	14,390 (April 4, 2010)
Presenter	Dr. Carlson[10]
Approach	Experimental demonstration/Acting
Place of Presentation	Hallway at the Purdue University
Target Audience	Not indicated

[10] For additional information on Dr. Carlson, see video 9.

Description: The video begins with a few snapshots that show highlights of a few of demonstrations by Dr. Carlson, such as a foamy fluid erupting out of cylinder and comparing densities of metals. Demonstrating the concept "equal and opposite force," the presenter sits on a trolley, pushes against a wall with his legs causing the trolley to move with him backward/opposite direction. He explains that as he pushes against the wall, the wall pushes back on him, hence the backward movement/motion. Next, he indicates that there was no need to push against the wall, and that in throwing a massive ball in his hands in one direction would push him back in the opposite direction causing him the backward motion. He adds "that's how jet engine works; it actually grabs the air, and throws it backwards and that would push an airplane forward." He demonstrates that to the audience. Further, he indicates that the principle works with throwing smaller objects too but that will depend how fast the throwing was done. He demonstrates that using a bunch of tennis balls though the effect, this time, was quite negligible. Next, he sprays from an extinguisher, CO_2 gas in the forward direction causing the trolley to move together with him in the backward direction, lifts up hands and 'shouts' "the end."

Surprising/New/Wonderful: Dr. Carlson uses four simple ways to demonstrate to the audience Newton's 3 rd Law of motion–action and reaction are equal and opposite forces–at an ordinary hallway. This 4-set demonstration probably helps the audience to perhaps experience something new and surprising in realizing that as one does an act using force in one direction, an equal but opposite force is generated, though in many cases invisible. His explanation that jet engine works on the same principle by grabbing air and throwing it backwards and that is what pushes an airplane forward may be surprising, new and a wonder to the audience as they might not have thought that that simple act (pushing of air backward) explains an airplane's movement in air.

In summary, Dr. Carlson offers the following ways of potentially experiencing surprise: (1) he uses a simple trolley with different sets of objects (legs, massive balls, tennis balls and an extinguisher) at an ordinary hallway to demonstrate Newton's 3 rd Law of Motion, which in fact viewers might have not thought that demonstrations using such ordinary objects could perfectly explain such a Law; (2) he explains that an airplane by means of its engine, grabs ordinary air, pushes it backward causing it that kind of high speed it moves or travels with in air as viewers might unknowingly might think that something else rather that the mere pushing of air was responsible for an airplane's movement.

Sense-making: Dr. Carlson's four sets of demonstration of Newton's 3rd Law of motion as explained above perhaps help the audience to make sense of the concept action and reaction are equal and opposite forces. His explanation of the concept using everyday situations such as pushing against an immovable wall, throwing of objects (as fast as one can), and an airplane's movement probably helps the audience to perhaps relate the idea to similar situations such as NASA's Space Shuttles and other related ones in life. On the other hand, Dr. Carlson could however have indicated that demonstrating the concept on the trolley made the movement profoundly visible due to less friction between the tires of the trolley and the floor as compared to, for example, him standing on the floor with legs at a stride apart (greater frictional force between the sole of his feet and the floor). All the same, his simple demonstrational activities may help the audience understand and to perhaps replicate or experiment the idea on their own as a comment by one of the viewers suggests: "Thanks from Mèxico. My students were able to understand because of the video demonstration" (panterbreaker, 1 year ago).

Emotional moments: Dr. Carlson uses humor to connect his message to the audience. For example, in his final (4^{th}) example where he sprays CO_2 gas from a can, causing him a backward motion, he lifts up his hands and humorously 'shouts,' "hehehee ... the end." This illustration may help the audience experience the vicarious moments as two comments by viewers suggest: "omg this made me laugh so hard: P thanks this is interesting" (win2rgirl, 2 years ago), "Great video!" (delta0medusa, 1 year ago). However, the emotional moments would have been much more profound if he demonstrated the law with the help of someone. For if you ask that two persons stand straight with legs attached facing each other; while one of the them attempts to push at the other, the end result is that both simultaneously fall on their back in the process, helping the viewers to potentially experience vicariously, the emotional moments.Telling a related story might also help in this respect.

Visceral: All the four different demonstrations show movements in opposite directions which might help a viewer experience a sense of scientific fit. This visceral sensation of fit as may potentially enhance a viewer's conceptual understanding of Newton's 3 rd Law of Motion in knowing that several related happenings in our daily lives can in fact be explained by the Law. Also, the concrete representation of the Law may help viewers to see that science is in fact real, reproducible and interesting as a comment by a viewer portrays: "thank you ... love physics..." (michaellay06 , 4 months ago).

Title of Video 11: Acceleration due to Gravity

URL	http://www.youtube.com/watch?v=izXGpivLvqY&feature=related
Date posted/Poster	September 22, 2007/*noonscience*[11]
Popularity	8,543 views (April 4, 2010))
Presenter	Male Teacher
Approach	Experimental demonstration
Place of Presentation	Classroom
Target Audience	Students, Chicago, USA

[11] This channel contains a selection of educational videos produced for Mr. Noon's science students. "This demonstration uses stop motion video to visualize the distances travelled at regular time intervals of an object in free fall" (noonscience).

Description: On the whiteboard in a classroom shows calculations on acceleration due to free falling object. In front of the board, the teacher with the help of male student volunteer demonstrates the concept to the students. The student volunteer holds a 'graduated' vertical stick upright in front of the class. The teacher places a tennis ball at the very top of the stick so that as he releases the ball, it covers different distances at the same time intervals with the total distance equal to the height of the stick. The teacher tells the students that they will not be able to see the exact distances covered by the free falling object at regular time intervals but he will show them a video on it that will help them see the various time frames and their corresponding distances as the ball accelerates at a steady rate before hitting the ground. He makes reference to calculation of problems involving acceleration due to gravity in page 17 of the students' text book as he explains how to calculate the total distance covered by the object over a specified period of time. Though in his explanation, he indicates that at $t_1 = 0.1\ s$, d_1= 5 m, he shows to the students with the help of the demarcation on the stick the various distances covered at the various time intervals to be: t_1= 0.1 s, d_1= 5 cm; t_2= 0.2 s, d_2= 20 cm; t_3= 5 s, d_3= 45 cm; t_4= 4 s, d_4= 80 cm. He gives the actual acceleration due to gravity (g) value in Chicago to be 9.81 ms^{-2} and indicates that even though, for the purpose of easy calculation, in their text books they find 10.0 ms^{-2}. He gives the mathematical equation of d: d = ½gt^2 and shows them how to input values to obtain the total distance covered. He uses a slow motion to show the demonstration from d = 0 cm to d = 80 cm to the students again.

Surprising/New/Wonderful: The concrete approach with which the teacher tackles the concept “Acceleration due to Gravity,” has the potential of helping students experience new and surprising insights into acceleration due to gravity. It is interesting that his ‘new’ technique of teaching this concept has helped to change the perspective of a viewer about physics as this comment posted on the video suggests: “Haha, to someone with no knowledge of physics, this would be quite painful to watch (i.e. blackdwarfstar). But, to someone who knows enough about physics to understand exactly what the heck this video's about (i.e. a grade 11 physics student), it makes a HELL of a lot more sense than the way I learned about gravity: the old fashioned ‘sub-in-to-the-equation’. Thanks, for changing my view towards physics. Maybe I'll take it in grade 12 afterall,” (bllvv, 1 year ago).

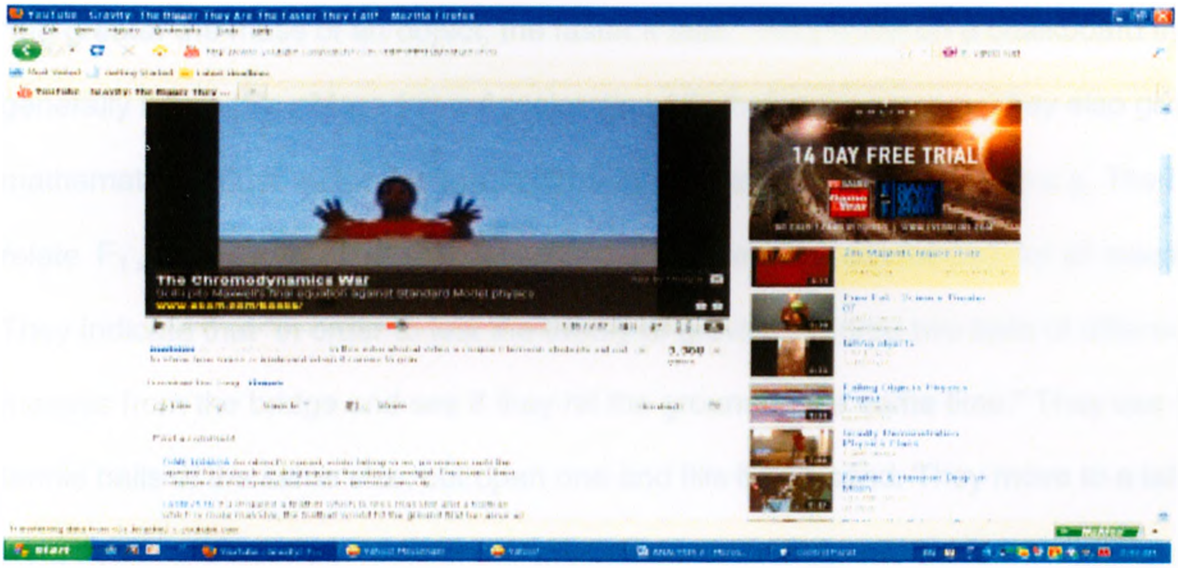
Also, the teacher’s indication that the actual acceleration due to gravity (g) value in Chicago is 9.81 ms^{-2} even though for the purpose of easy calculation, in their text books they find 10.0 ms^{-2} may be a new learning to the students in the sense that due to the unspherical nature of the earth’s surface, g value may vary depending on which part of the earth it is being considered, though the teacher does not explain it.

Sense-making: Although the teacher makes it clear to the students that they may not be able to see the various distances covered and the respective time frames as the ball falls from the top of the stick to the bottom of it, his concrete approach, combined with the video helps them perhaps to make sense of such abstract concepts. Also, the slow motion video the teacher uses may help the students make a better sense of the activity. Likewise, the mathematical equation of the distance covered (d) in each time frame: $d = \frac{1}{2}gt^2$ which the teacher uses as he explains the concept may help enhance the students' understanding, thought he does not explain where the formula comes from. Also, his calculated values for the various distances covered at the regular time intervals maintained in cm appear problematic as g has unit ms^{-2}. It would have been helpful if he changed the cm values to m before inputting values to obtain each d value.

Emotional moments: The teacher uses personal statements to try to connect the students emotionally to the lesson as the following statements indicate: "So, you, won't be able to see this, but I'll be able to take a video ... so you can see this, eh with time frames;" "Let's see that in slow motion." Missing, however, are opportunities for the viewer to experience emotional moments vicariously, through story-telling or emotional reactions of an observing guest.

Visceral: The video demonstrates the distances covered by a free falling object at regular time intervals. The slow motion the teacher uses after the actual demonstration reveals the exact distance covered by the tennis ball at the regular time intervals. This perhaps helps the students realize a sense of scientific fit of the activity and its underlying theory.

Title of Video 12: Gravity: The Bigger They are the Faster They Fall?



URL	http://www.youtube.com/watch?v=eCvHDFVMMTs&feature=fvw
Date posted/Poster	September 29, 2006/*mwisner*[12]
Popularity	3,368 views (April 4, 2010)
Presenters	Blake Hardee and Matt Dawkins
Approach	Experimental demonstration
Place of Presentation	Classroom, Lab, Overhead bridge
Target Audience	Not indicated

[12] Matthew Wisner owns the website http://www.youtube.com/user/mwisner, where, according to him, he puts on movies that he made or movies that he really likes. He does not state in his profile, his profession.

Description: In the video, Hardee and Dawkins set out to correct a misconception that "the greater the mass of an object, the faster it falls." They show on a chalkboard that generally Force (F) = Mass (m) x Acceleration (a), that is $F_1 = m \times a$. They also give the mathematical equation for F in terms of free falling objects, that is $F_2 = m \times g$. They relate $F_1 = F_2 \rightarrow m \times a = m \times g$, thus giving a = g (crossing out the m_s), for all masses. They indicate that "in order to test the theory of gravity, we drop two balls of different masses from the bridge and see if they hit the ground at the same time." They use two tennis balls of the same size, cut open one and fills it with sand. They move to a lab and weigh each separately on a balance with ball one at 36.5 g and ball two at 142.2 g. Next, they move unto an overhead bridge where Dawkins releases the two balls at the 'same' time. Observing, the balls hit the ground at the exact same time. He describes their experiment to be a success. Hardee adds that "gravity had the same effect on each ball independent of mass."

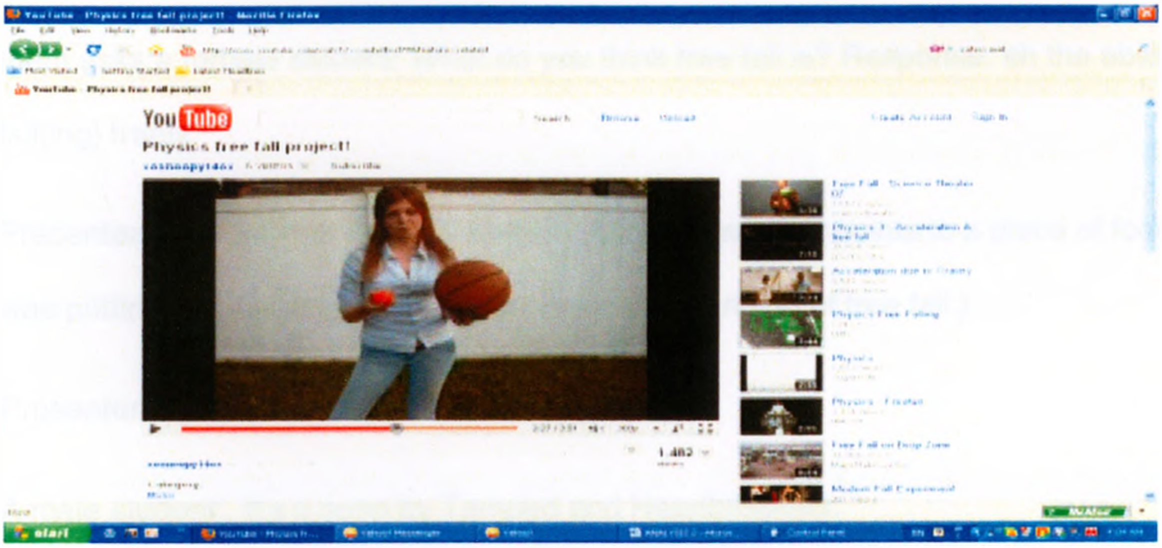
Surprising/New/Wonderful: It may be surprising to the viewers in observing that, on releasing the two balls on the bridge at the "exact same time," despite the huge difference in mass between the two balls, they hit the ground at the same.

Sense-making: Hardee and Dawkins show on a chalkboard that generally, Force (F) = Mass (m) x Acceleration (a), that is $F_1 = m \times a$. They also give the mathematical equation for F in terms of free falling objects, that is $F_2 = m \times g$. They relate $F_1 = F_2 \rightarrow m \times a = m \times g$, thus giving a = g (crossing out the m_s), for all masses. Relating the two equations perhaps helps the audience make sense of why the equation finally reduces to a = g and for that matter gravity being independent of mass of a substance. Also, releasing the two balls on an overhead bridge at the 'same' time which hit the ground at the “exact same time” helps the audience probably realize that indeed the surprise experience makes sense. This may also help the viewers to be able to replicate the idea on their own, if needs be, as this comment posted by a viewer appears to suggest: “Thank you[;] that helped me with my project!” (Amyjojo123, 2 years ago). On the other hand, the presenters could have indicated that surface area of an object under free fall can affect the rate at which it falls from a height to the ground due to a possibility of increased air resistance. Also, the force of impact can be part of the misconception that students might have about falling objects. Objects with greater mass hit the ground with greater force which may lead a student to think that they fall faster. This misconception is not addressed in the video.

Emotional moments: There is little one can say that this video meets the criteria for emotional moments as it does not practically relate to viewers personal circumstances but a practical way of proving a (physics) theory. Adding a good story that talks about someone else’s experiences and reactions when coming to understand the concept might help to connect to a viewer emotionally, in a vicarious way.

Visceral: Hardee and Dawkins show on a chalkboard that generally Force (F) = Mass (m) x Acceleration (a), that is $F_1 = m \times a$. They also give the mathematical equation for F in terms of free falling objects, that is $F_2 = m \times g$. They relate $F_1 = F_2 \rightarrow m \times a = m \times g$, thus giving $a = g$ (crossing out the m_s), for all masses. The relationship between the two equations helps the audience to perhaps experience a visceral sensation of scientific fit: $a = g$, for all masses. Also, the release of the two balls on the overhead bridge at the ‘same’ time which hit the ground at the “exact same time” may potentially cause a sense of awe in viewers as they might expect that the difference in mass would affect the time each ball takes to hit the ground as a comment posted by one of the viewers suggests: "dude.... [I] just tried it ... it really works. [S]cience is weird ... thanx for the vid," (Bouncert, 1 year ago).

Title of Video 13: Physics Free Fall Project



URL	http://www.youtube.com/watch?v=quhelbcrl78&feature=related
Date posted/Poster	May 25, 2009/*xosnoopy14ox*[13]
Popularity	1,482 views (April 4, 2010)
Presenters	Tracie Hearne and Kerri-Anne Bross
Approach	Experimental demonstration, Interview
Place of Presentation	School grounds

[13] Kerri-Anne Bross owns the website http://www.neoseeker.com/members/xosnoopy14ox/. She provides no special information on her or profession.

Target Audience	Appears to be high school Students

Description: Hearne and Bross set out to find out whether people "know what free fall is" in respect of physics terms. Their first place of call is the school cafeteria. One of them asks a female student: What do you think free fall is? Response: eh the ability of fall[ing] freely.

Presenter: How will you define free fall? (A female student points to a piece of food she was putting into her mouth to indicate her understanding of free fall.)

Presenter: What is free fall?

A male student: It's a song by Tamped and Heartbreakers.

Presenter: What do you think free fall is?

Another male student: When they fall.

Presenter: What would you say is free fall?

Another male student: This, is the result of free fall (showing on his arm fresh bruises).

Bross asks, "now let's figure out [what] free fall actually is." She states, "free fall means nothing else other than gravity is affecting it when it's falling" while Hearne adds that, "because of the acceleration due to gravity, the velocity changes at 9.8 ms^{-2}." Sitting on top of a building roof, Hearne notes that, "say you have this ball, before you drop it the initial velocity is 0 m/s and the acceleration due to gravity is negative 9.8 ms^{-2}. Now watch." She drops the ball to the ground. Bross records the time it takes for the ball to hit the ground to be 0.81 s. On a whiteboard, they indicate; "Given" data and "Unknown" data. Given: Vi = 0 m/s, a = 9.8 ms^{-2}, t = 0.81 s: Unknown: Vf = ?, d = ? (Where Vi → initial velocity, Vf → final velocity, a → acceleration due to gravity and t → time). They use the equation *Vf = Vi + at* and *d = Vit +* ½ at^2 in their calculation to obtain *Vf* to be -7.938 m/s and *d* to be -3.2 m. After this calculation, Hearne uses two balls of different sizes to demonstrate the concept of free fall again. She drops the two objects at her chest level, and they hit the ground at the same time. She explains that irrespective of their differences in size, they will both fall "at the same rate of acceleration." Concluding, Bross indicates that "free fall is when an object falls without any resistance from anything."

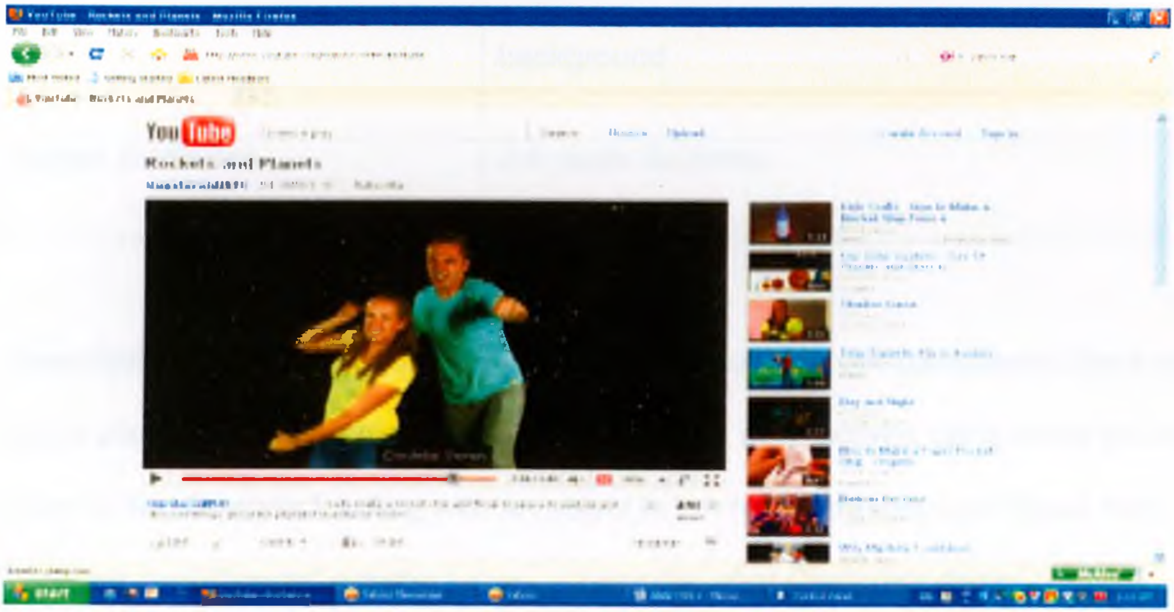
Surprising/New/Wonderful: The concrete way, whereby the presenter does the presentation from a roof top of a building, though appears dangerous, may be a wonderful demonstrational technique that helps the viewers understand the concept perhaps better. Also, Hearne's use of the two balls of different sizes to demonstrate the concept of free fall whereby they hit the ground at the exact same time in the video may demonstrate the wonders of science and its principles to viewers.

Sense-making: Sitting on top of a building roof, Hearne notes in her demonstration that, before you drop an object, "the initial velocity is 0 m/s and the acceleration due to gravity is negative 9.8 ms^{-2}." As she drops the ball to the ground, Bross records the time it takes for the ball to hit the ground to be 0.81 s. On a whiteboard, they indicate: "Given" data and "Unknown" data. Given: Vi = 0 m/s, a = 9.8 ms^{-2}, t = 0.81 s: Unknown: Vf = ?, d = ? (Where Vi → initial velocity, Vf → final velocity, a → acceleration due to gravity and t — time). They use the equation *Vf = Vi + at* and *d = Vit +* ½ at^2 in their calculation to obtain *Vf* to be -7.938 m/s and *d* to be -3.2m. Although the concrete representation of the demonstrational activity may help the viewers to understand the concept "Free Fall," they may question why (1) the acceleration due to gravity {g} is negative 9.8 ms^{-2} while the ball was not traveling against the pull of gravity; (2) their calculated values for both the final velocity of the ball and its distance traveled should be negative, which should not be the case thereby raising doubts as this comment posted by one of the viewers indicates: "how can the final velocity and distance be negative?" (BladePenguin, 8 months ago). This suggests that, from theoretical perspective, their calculations do not make much sense to the audience. On the other hand, Hearne's use of the two balls of different sizes to demonstrate the concept of free fall whereby they hit the ground at the exact same time in the video perhaps helps the audience realize that the surprise experience in this activity does in fact make sense, though they fail to make the assumption 'neglecting air-resistance.'

Emotional moments: Although Bross and Hearne appear passionate about their bid to find out whether people "know what free fall is," and ask personal statements of their interviewees such as "What do you think free fall is?," "How will you define free fall?," "What would you say is free fall?," these statements alone may not help the viewers to experience the emotional moments vicariously, as discussed for the previous video.

Visceral: Although visceral sensations appear to be difficult to infer in the video, the relevant equations they give on the board and how they show to the audience ways to input values or data to obtain the final velocity and the distance traveled by the ball may portray a sense of fit especially as it relates to the mathematical equations and conceptual theory. Also demonstrating the activity from the top of a building might generate fear (of heights) in a viewer.

Title of Video 14: Rockets and Planets



URL	http://www.youtube.com/watch?v=HiVOE5TbZ6E
Date posted/Poster	July 16, 2009/*QuestaconNSTC*[14]
Popularity	430 views (April 4, 2010)

[14] Available information indicates that, *Questacon Science Play* offers two programs: a hands-on science session for children aged 2-5 years and a workshop for educators. "Both programs tour regional, rural and remote areas of Australia, providing parents and carers of young children with an understanding of the importance of play in early development. Representatives of *Questacon Science Play* come from a variety of backgrounds with university degrees in areas including science, science communication, education and theatre. *Questacon Science Play* is produced by Questacon–The he National Science & Technology Centre" (http://scienceplay.questacon.edu.au/letsplay.html).

Presenters	Cordelia and Lang
Approach	Experimental demonstration, Drama, Chat
Place of Presentation	Appears to be a classroom with decorated background
Target Audience	2-5 years Students

Description: In a room, materials such as safety goggles, two transparent glass cups, and a plate are displayed on a table. Beginning the main activity, Lang walks into the room to find Cordelia fondling with an object in her hand and they chat about their “Rockets and Planets” activity. Lang: … I wonder what Cordelia’s doing.

Cordelia: I’m making a rocket ship! I want to fly up into space and discover things about the planet.

Cordelia: Have you ever seen a rocket launch? I think we need a countdown. (A launch of a typical rocket shows in video).

Lang and Cordelia: 10, 9, 8, …, 0; blast off (the rocket takes off reverberating the surroundings with the sound of its powerful engines).

Lang: Cordelia, are you really making a rocket ship?

Coderlia: Yes, but my rocket’s a bit smaller. (She picks up a piece of color paper, folds into conical shape, tapes to join it, cuts off the pointed end–representing the top-head of her rocket–and fits it unto a film canister to make her own rocket ship).

She shows to the audience a piece of fizzy tablet saying she was going to use it to "make her rocket fly." She precedes the launch of her rocket with a demonstration of how a fizzy tablet works as it reacts with water–the reaction generates effervescence. Lang cautions that, before the demonstration of the experiment, it was important they put on safety goggles. Having finished the experimental demonstration, Cordelia fills the canister with water to about ¾ full. She puts ½ the fizzy tablet into it and fits the paper rocket head unto the cup tightly. She asks Lang: "Ready?" Almost immediately, the top-head pops off, and in a dramatic display, the presenters fly along into space twisting their bodies and moving their hands in different directions and shouting "wooooooooo!" They continue with their chat:

Cordelia: Wow!

Lang: Check it out! Look back at the Earth. It looks blue (pointing finger to earth).

Cordelia: There are eight planets moving around the Sun. Let's count them.

As Cordelia does the counting, Lang gives the name of that particular planet adding a bit of description unique to it. For example, planet 4–the red planet. They name/describe each of the planets ending on Neptune. Cordelia indicates that the space counting had made her tired so they should head back to earth. With a "bye," they head back to the Earth.

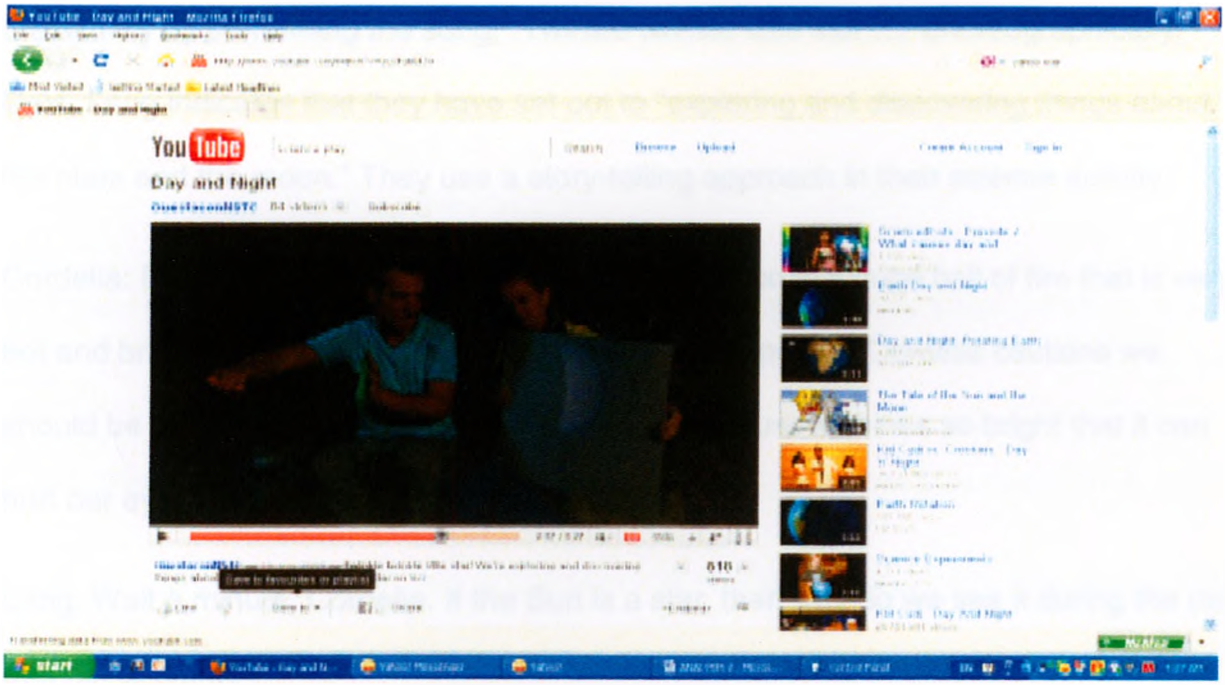
Surprising/New/Wonderful: Cordelia shows to the audience a piece of fizzy tablet and how it reacts with water generating effervescence. Next, she transfers the idea of the fizzy tablet as providing the required energy for her miniature rocket. Upon the top-head of her rocket popping off, and in a dramatic display, the presenters 'fly' along into 'space' twisting their bodies and moving their hands in different directions and shouting "wooooooooo!" The simulation of the fizzy tablet as providing the needed energy to power their self-made rocket, the piano sound denoting the loud sound that associate the take-off of model rockets may not necessarily be surprising but may be a new learning to a viewer particularly teachers as to how to improvise for materials for an activity of this sort.

Sense-making: The combination of the interactive chat between the two presenters, the improvisation they make for a rocket-ship, the video and sound effects used to simulate the idea of space exploration and planet movement, and the explanations provided; all together may help the viewers make sense of the phenomenon.

Emotional moments: Lang and Cordelia use interactive chatting strategy to show their passion in their demonstration as the following indicate: "... I wonder what Cordelia's doing;" "I'm making a rocket-ship;" "I want to fly up into space and discover things about the planet;" "Have you ever seen a rocket launch? I think we need a countdown;" "10, 9, 8, ..., 0; blast off!" Such interactive chat, accompanying it with drama, as they demonstrate with their bodies to signify a flying mode holds the potential for helping the audience experience the presenters' emotions vicariously.

Visceral: The solid fizzy tablet that reacts with water to produce bubbles and the sudden sound that accompanies the popping off of the top-head of the rocket may help viewers experience a visceral sensation of quick change. Also viewers may viscerally react with fear of heights as the rocket launches into air.

Title of Video 15: Day and Night



URL	http://www.youtube.com/watch?v=zuSfutl5fZ0
Date posted/Poster	July 16, 2009/*QuestaconNSTC*[15]
Popularity	610 views (April 4, 2010)
Presenters	Cordelia and Lang
Approach	Choreography, Story-telling
Place of Presentation	Backyard
Target Audience	2-5 years Students

[15] For information on the *QuestaconNSTC*, see video 14.

Description: Sitting in the open (backyard) on a piece of log, Cordelia and Lang begin the activity by performing the song, "Twinkle twinkle little star ..." choreographically. Next, Lang indicates that they have set out to "exploring and discovering things about the stars and the moon." They use a story-telling approach in their science activity.

Cordelia: Did you know that the Sun is a star? The Sun is a huge ball of fire that is very hot and bright.... (A video showing a 'burning' sun appears.) Cordelia cautions we should be careful not to look straight at the Sun because it shines so bright that it can hurt our eyes.

Lang: Wait a minute, Cordelia. If the Sun is a star, then why do we see it during the day and not at night?

Cordelia: Well, the Sun is the closest star to us. That's why it looks so big. The Sun shines brightly and gives us daylight. It's daytime now because we can see the Sun in the sky.

Lang: The Sun is a star but I want to see all of the other stars up in the sky. Why can't we see the other stars during the day?

Cordelia: All the stars are in the sky during the day but we can't see them because the Sun's light is so bright that it hides the light from the other stars.

Lang: So, in the night we can see the other stars in the sky because the sky is dark. (A dark sky interspersed with stars shows in video amidst cricket chirp. Presenters raise their heads to see the stars in sky).

Cordelia: Here we are at night time. Wow, where did that day go?

Lang: I have a torch here but if I turn it off we'll be able to get a better look at the night sky. (They look up into the sky and indicate that, the stars look like tiny dots of light because they are long, long away.)

Lang: Can you see the stars twinkling?

Cordelia: I can see the moon. But, a piece of it is missing! (Moon shows in sky, in the video.)

Lang: The moon doesn't always look big and round. Sometimes it has a different shape.

Lang gives a piece of cardboard to Cordelia. He shines the torch onto it producing a "big round shape like the moon." Next, he holds an opaque plate blocking a part of the rays (beam) from the torch saying, "it makes a different moon shape"–half-moon and crescent. Cordelia indicates that in other to make the moon look bigger and easier to see, she was going to use a telescope. She looks through it and asks Lang to also do same.

Cordelia: When I get home, I'm going to draw a picture of the moon with all the shapes and lines.

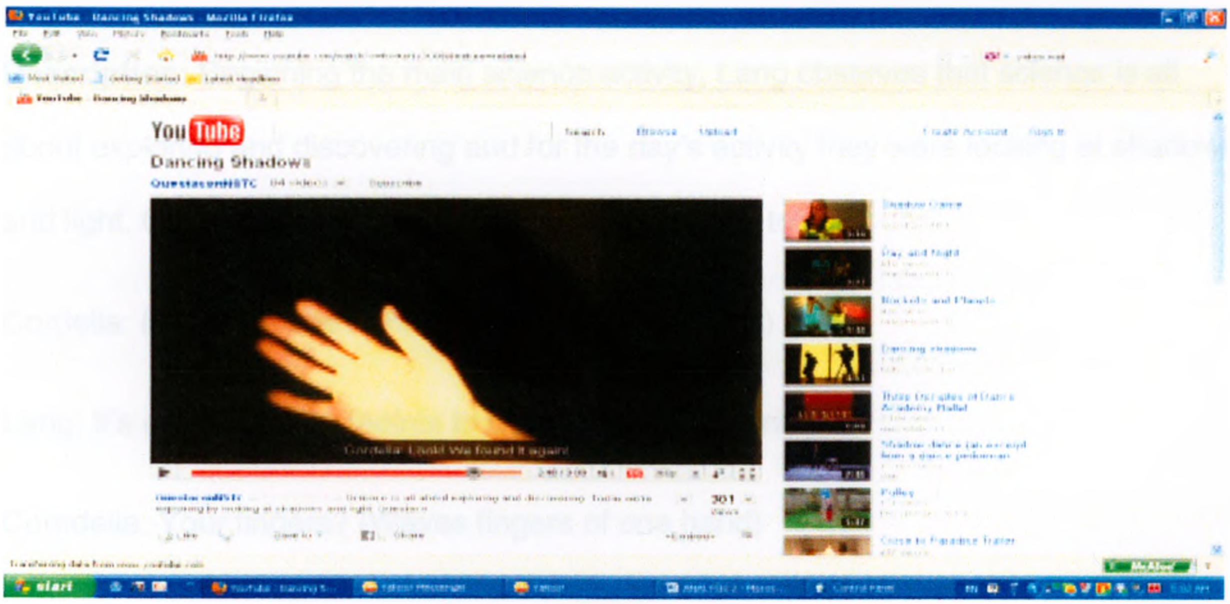
Surprising/New/Wonderful: Lang and Cordelia describe and show videos of the sun during the day and many other stars in the sky during nights. Their description and technique of showing the sun and many other stars may help the audience see the wonders of the universe. Also, Lang and Cordelia offer one way of teaching how the moon makes different shapes over a period of time. The concrete representation of the different moon shapes may help the viewers especially teachers to have a new way of teaching the concept and other similar ones.

Sense making: Lang and Cordelia perhaps help the audience realize that the sun is a star that shines so bright that its light hides the other stars in the sky from being visible during the day. They describe it and show videos of the sun as well as the numerous other stars in the sky as visible during the night. This may help the viewers realize that in fact the wonders of the universe as portrayed by the presenters make sense. Also, shining of the torch onto a cardboard producing a “big round shape like the moon,” and holding an opaque plate to block a part of the rays (beam) from the torch saying, “it makes a different moon shape,” may help the viewers make sense of the different moon shapes such as half-moon and crescent.

Emotional moments: Beginning their activity, Lang and Cordelia perform the song “Twinkle twinkle little star …” choreographically. This may help the audience to feel the passion and emotions the presenters attach to their activity. Also, they use a story-telling approach that involves personal statements that may help connect their viewers to their performative activity such as: “Did you know that the Sun is a star?;” “If the Sun is a star, then why do we see it during the day and not at night?;” “Here we are at night time. Wow, where did that day go?;” “Can you see the stars twinkling?” Stories help us experience for example someone else’s life. The story-telling approach together with the drama they attach to it as they tell the story of “Day and Night” may help increase the audience’s emotional moments experience vicariously.

Visceral: The video shows why the sun is visible during the day but that of other stars during nights. It also shows the different moon shapes as it orbits the earth. Lang and Cordelia demonstrate the presence of the sun during the daytime and that of other stars during nights by showing videos of them. This may potentially help viewers to have a visceral sensation of the changes that occur between the sun and other stars as a result of the earth moving round the sun causing “Day and Night.”

Title of Video 16: Dancing Shadows



URL	http://www.youtube.com/watch?v=Rv9us1z3O9I&feature=related
Date posted/Poster	July 16, 2009/*QuestaconNSTC*[16]
Popularity	301 views (April 4, 2010)

[16] For information on the *QuestaconNSTC*, see video 14.

Presenters	Cordelia and Lang
Approach	Experimental demonstration, Drama, Story-telling
Place of Presentation	A Room
Target Audience	2-5 years Students

Description: Beginning the main science activity, Lang observes that science is all about exploring and discovering and for the day's activity they were looking at shadows and light. Cordelia asks what part of our body we use to see.

Cordelia: Is it your nose? (Points to nose with a finger)

Lang: It's not your nose (points to nose with two fingers).

Coredelia: Your fingers? (Waves fingers of one hand)

Lang: Not your fingers (waves fingers of both hands).

Cordelia: Your ears? (Points to ear with a finger)

Lang: Cordelia, you hear with your ears (points to ears with all fingers)

Cordelia: What do you use to see?

Lang: Points to eyes with two fingers

Cordelia: That's right! We see using our eyes. Let's have a look at the light from Lang's torch.

Lang: I'm going to turn the torch on here and now we can see the light (he turns torch on).

Cordelia produces a plane mirror, Lang shines his torch on its surface, Cordelia directs the reflected light (ray) formed onto a shiny surface, causes it to move as she moves the mirror in different angles. She asks: "Can you see the light dancing?" Lang responds: "Wow, the light really is dancing. Can you dance too?," turning his face to the audience. Cordelia dances to the background music being played in the video. She moves close to a shiny wall surface, finds her shadow dancing along with her, doing exactly everything she did. Lang joins in and dances with Cordelia and her shadow. Suddenly, Cordelia dances her way close to a dark wall surface and asks: "Lang! Oh no! I've lost my shadow! Where did it go?"

Lang: I don't know. What did it look like?

Cordelia: Well, it was dark, and it was the shape of my body and last time I saw it, it was dancing (performing her message).

Lang proposes they look for it together and asks where she last saw it. Cordelia responds: "Over there where I was dancing in the light." Lang asks they take a look. Cordelia moves to where there was light and finds her shadow again, waves at it and saying "Hello shadow!" Lang wanted to find out "where Cordelia's shadow went." Cordelia explains. In an area with light she shows her shadow with her, but moving to a dark area, she loses it. Lang adds that "We must need light to make shadows!" and in the dark, he can use his torch to make a shadow. He shines his torch onto Cordelia's fingers showing its shadow. Cordelia hints that, outside in the daytime, we can see shadows from sunlight but in a room or at night we can turn on a torch or light to make shadows. They dance displaying their shadows in light.

Surprising/New/Wonderful: It may be surprising to a viewer that a science concept can be taught through story-telling. To some viewers, though there may not be something potentially surprising about the teaching technique the presenters use in teaching the concept "Dancing shadows" in the video, it perhaps offers to teachers in particular a powerful teaching tool which they can modify to suit their unique situations as they look for alternative ways of making science teaching much more fun, entertaining and interesting to students.

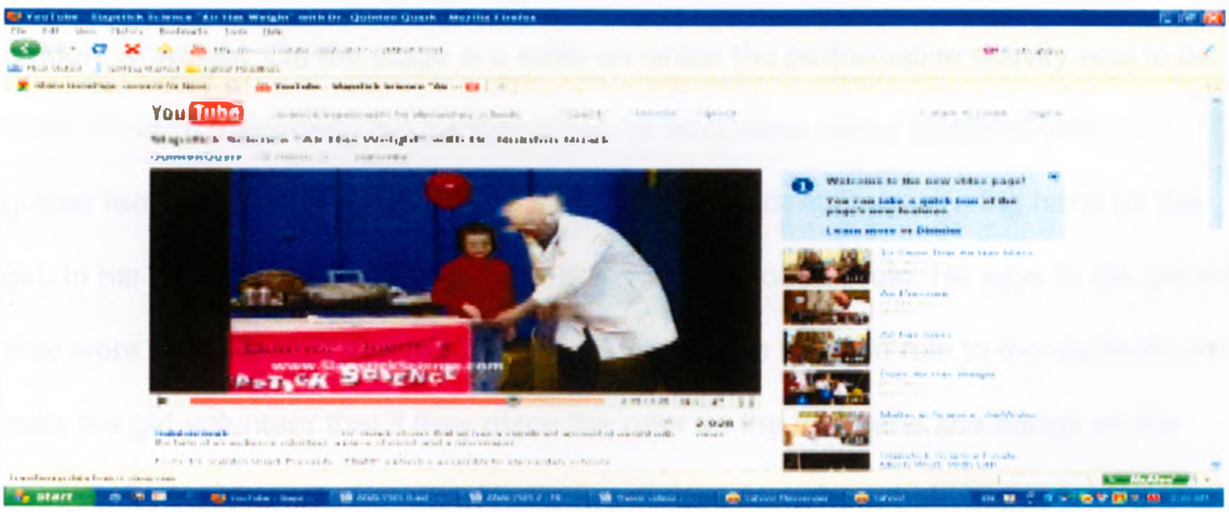
Sense making: The presenters perhaps help the audience realize that we need light such as those from the sun or torch light to make shadows; and in the absence of light, we cannot see our shadows. They combine the strengths of story-telling and drama to make their presentation. This may help offer viewers who might want to replicate the idea for classroom purposes a good understanding of doing it.

Emotional moments: Cordelia and Lang appear to show a lot of enthusiasm about their performative science activity. They dance in the light to show how their shadows mimic their movements, move to a dark place where they lose their shadows. In doing this, they use quick pace, smile, expressive body movements and personal statements such as: "When I swing my arms, my shadow swings too, and when I kick my legs, my shadow kicks with me;" "Look, I can see my dancing shadow!;" "Can you see it too?"

The presenters' enthusiasm, coupled with the dramatic fashion in which they present their science activity, has the potential of helping the viewers experience the emotional moments vicariously.

Visceral: When Lang shines his torch on the surface of the plane mirror, and Cordelia directs the reflected light (ray) formed onto a wall, it shows the shadow or image of the light. As Cordelia dances in the light to the background music being played in the video, her shadow dances along doing exactly everything she does. Lang's shadow does the same when he dances in the light. However, they both lose their respective shadows in an area where there is no light. It is likely that, viewers might realize a visceral sensation of scientific fit in terms of the performers and their shadows in the light and how they lose them in the dark area.

Title of Video 17: Slap Stick Science[17]: "Air has Weight" with Dr. Quinton Quark



[17] Available information on their Website indicates that, "Slapstick Science is an astounding, exciting, and entertaining series of science assemblies and workshops which use the circus as a laboratory. All programs are written and produced by certified science teacher and former Ringling Bros. performer, Ted Lawrence" (http://www.slapstickscience.com/).

URL	**http://www.youtube.com/watch?v=zbNkoR3rOeI**
Date posted/Poster	March 24, 2007/*QuintonQuark*
Popularity	2, 928 views (April 3, 2010)
Presenter	Dr. Quinton Quark
Approach	Experimental demonstration/Drama/Comedy
Place of Presentation	Appears to be Auditorium
Target Audience	K–3 Students

Description: Dr. Quark performs the science activity with the help of an audience volunteer, using a piece of wood, and a newspaper to show that air has a significant amount of weight. On the stage is a table on which the performative activity was to be demonstrated. Beginning the performance, he welcomes with a handshake the 3rd grader female-volunteer to the stage and asks the students to give a big hand for the girl. In his hand is a material that looks like a 30 cm wooden rule. He says to the girl that they were going to look at a hypothesis. He shows the wooden rule to the students and asks the girl-volunteer that if they place the ruler on the table and she bangs on the about a 5 cm piece pointing out of the edge of the table what would happen. He turns to the students asks: "Shall we do the experiment?" which they answer, "Yeah." The girl-volunteer bangs down the ruler which 'flies' into Dr. Quark's face. In reaction, he humorously shouts and stumbles almost falling. He asks the students why they think the ruler did not break. They answer that because nothing was holding it down. He then folds a piece of newspaper and puts it on the ruler. He asks the students if the ruler will break this time round. In their chorus response, they answer "No!" The girl-volunteer bangs on the ruler sending the folded paper flying yet the rule does not break. Next, he indicates to the children that "air does have weight" adding "it weighs about 15 pounds per sq inch." He spreads onto the ruler a sheet of newspaper still leaving just about a 5 cm piece pointing out of the edge of the table. He emphasizes that given the surface area of the newspaper, there is over 300 pounds of air sitting on top of the paper pressing down the ruler and that if he is right, the ruler might break when the experiment is done this time round. The girl-volunteer bangs on the ruler and it breaks. He asks the students if air has weight and they answer "Yeah." Finally, Dr. Quark asks them how weighty is air, and they answer 15 pounds per sq inch.

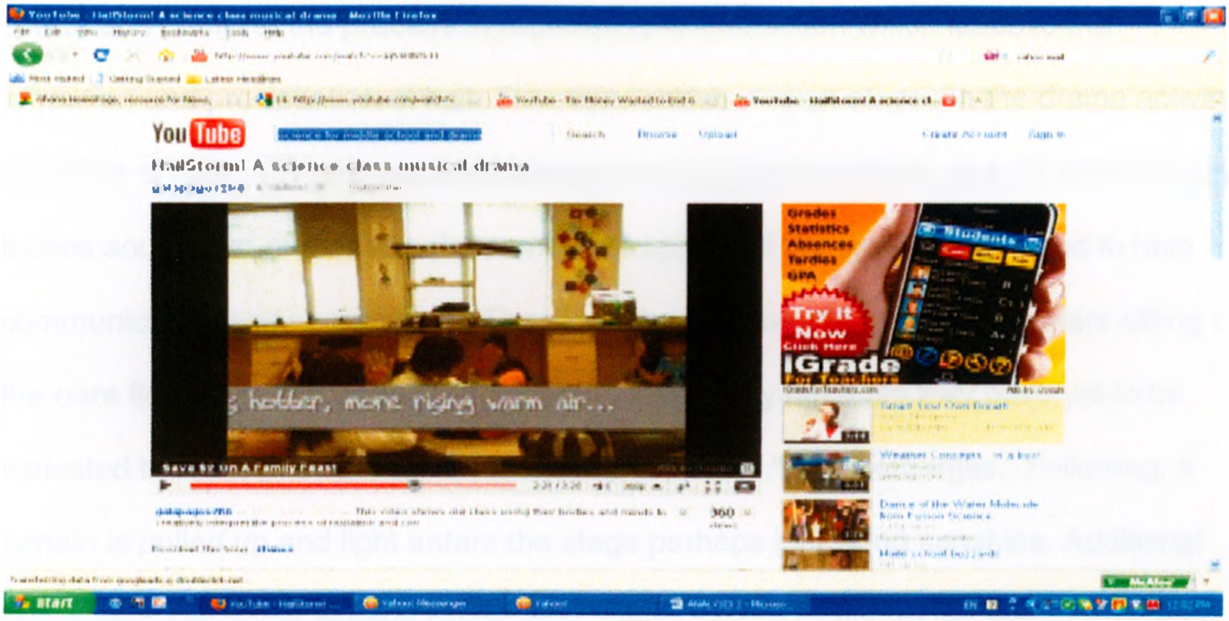
Surprising/New/Wonderful: Dr. Quark uses three stages in his "Air has Weight" demonstration: first, he puts nothing on the ruler and it does not break as the girl bangs it down; second, he folds a piece of newspaper and puts it on the ruler, the girl bangs it down and it does not break; finally, he spreads onto the ruler a sheet of newspaper leaving just about a 5 cm piece pointing out of the edge of the table, the girl bangs it down and it breaks. Given the activities involved in the above three stages, it may be surprising for the students to find out that the air acting on the surface of the newspaper could hold the ruler down to the point of causing it to break.

Sense making: After the first two demonstrations in which the ruler does not break, Dr. Quark explains to the children that "air does have weight" which measures about 15 pounds per sq inch." He indicates that, considering the total surface area of the newspaper covering the greater part of the ruler, about 300 pounds of air was "sitting" on that part of the ruler. In consequence, the ruler breaks upon banging on it. The three stage demonstrations, together with the explanations Dr. Quark gives on the activity, may help the students realize that the surprise experience indeed makes sense, for the students might think that if the folded paper went flying upon banging on the ruler, then the spread paper would easily do likewise.

Emotional moments: Dr. Quark combines humor and drama as he makes his presentation to the students. He involves the students in his demonstration as he intermittently asks questions that elicit their thoughts on the science activity. For example he asks them if they think the ruler will break if no weight acts on the one end and the other end pointing out of the edge of the table was banged upon. Also he asks: "Shall we do the experiment?" for which the students answer "Yeah." His boisterous nature, sense of humor and asking questions that draw the students' attention to the demonstration, may help them experience the emotional moments vicariously.

Visceral: The ruler finally breaks when the Dr. Quark spread a sheet of newspaper on the one end lying on the table and the other end pointing out of the table's edge was banged upon. The breaking was finally made possible because, as Dr. Quark notes, so much air totaling over "300 pounds" was acting on the paper which was holding down the ruler. It is likely that the students will experience a visceral sensation of awe as they might expect that the spread-newspaper would go flying in the act as the air 'sitting' on it was not visible to them.

Title of Video 18: Hailstorm! A Science Class Musical Drama



URL	**http://www.youtube.com/watch?v=jq54DBiTk1I**
Date posted/Poster	October 15, 2008/*galapagos2K6*[18]
Popularity	360 views (April 3, 2010)
Presenters	6^{th} grade students, Pudong Middle School, China
Approach	Choreography
Place of Presentation	Appears to be Auditorium
Target Audience	Middle School Students

[18] Not much information is provided on the activities of the website http://www.youtube.com/user/galapagos2K6, however, one Alfred owns it.

Description: The video shows the student-performers using their bodies and minds to create and interpret the process of radiation and convection which leads to the formation and precipitation of hail. The video shows 4 main stages in the drama activity: (1) dawn to noon; (2) heat causes convection; (3) cloud formation; and (4) hails journey. It uses sound and picture effects to enhance appeal of the dramatization and to help communicate ideas non-verbally. The video thus begins with some performers sitting on the bare floor to perhaps denote their state of inactivity because they have yet to be activated by the sun's energy. On the screen appears "Dawn emerges." Following, a curtain is pulled up and light enters the stage perhaps indicating sunshine. Additional performers join those already sitting, and some of them lie flat on the floor. It portrays that at "About 9 a.m." the sun's energy increases intensely as the day advances to noon time. "The Sun heats the Earth's surface" appears on the screen. A sound effect is used to simulate an idea of intense heating of the earth's surface through the sun's radiation and on the screen then appears "And Convection Begins…." Here, the video uses picture effects to simulate how the surrounding air particles begin to vibrate and finally rise (convection current) upon heating as a result of the sun's thermal energy supplied through the process of radiation. Performers demonstrate this idea as some of them wave their hands in a zigzag fashion, twisting their bodies, rising upward on their feet; while others show less action to indicate that perhaps they are not heated enough to cause them to rise up. After a moment, the message "As the Earth gets hotter, more rising warm air …" appears on screen. Performers in a similar display as the above, demonstrate this idea. Then follows the message, "Then clouds form from all the rising moist air." Some performers standing on the back counter to the stage mount what looks like three single-size student foam mattresses to simulate the idea of cloud cover or formation in the sky. The message, "The strong updrafts of warm air send rain to the top of the cloud where it freezes then falls back to the bottom of the cloud, but it is pushed back up by the updrafts and it freezes again. This happens many times and the hail grows with each new 'freezing cycle.' Finally, it becomes big enough to overcome the updrafts and falls to Earth as Hail!" appears. Performers demonstrate this idea in such a way that some of them in front of the counter give an object that looks like a tissue paper to those standing on the counter. This exchange process goes on for a while until a beeping is heard and the presenter in front of the desk throws down the tissue paper perhaps to signify the hail precipitation onto the earth.

Surprising/New/Wonderful: In the video, performers use their bodies and minds to create and interpret the process of radiation and convection which leads to the formation and precipitation of hail. The performative technique, which specifically uses choreographic approach to the teaching of the concept "Hailstorm," adopted in the video may help offer to a teacher-viewer a (new) way of teaching such abstract concepts.

Sense making: The video portrays to viewers through a choreographic dramatization that at dawn, particles of air that make up the earth's atmosphere are almost in a state of inactivity due to either less or no (thermal) energy supply from the sun. It perhaps helps the viewers make sense of the idea that, as the day grows, the sun's heat causes these air particles to vibrate, become warmed-up, and begin to rise to the sky–signifying the process of convection–and that as the warm moist-air meets the cold layer in the sky, clouds are formed, which in the end produces the hails. It is likely that, viewers' understanding of the concept performed herein may be profoundly enhanced by the on-screen explanations that intersperse the choreographic show. It also by extension may help the viewers especially teachers realize that the new pedagogical tool it offers is perhaps worth their own teaching.

Emotional moments: The video makes use of moviemaking software to create sound and picture effects that may cause the viewers to react emotionally. For example, the changing of pitch or tempo to the background music as well as the video effects in instances portraying how the sun's heating through radiation, initiates and enhances the process of convection which in effect leads to hail formation and precipitation unto the earth's surface. More so is perhaps the beeping that signals home the instance whereby the hail has grown or developed to such a size that its weight overcomes the updrafts and in consequence has to fall to the earth's surface: this is where one performer throws down the object they (those in front of counter) exchange with those standing on the counter.

Visceral: It is likely that the sound (pitch variation) and video (twisting) effects, as indicated under Emotional moments, that prominently characterize the processes that lead to the formation and overall precipitation of hails to the earth's surface may cause the viewers to experience a visceral sensation of awe as a comment posted by one of the viewers suggests: "awesome effects," (AlvinandJoe, 1 year ago).

Title of Video 19: Hip Hop Science Show

URL	http://www.youtube.com/watch?v=-snhY-Kzg4k
Date posted/Poster	May 27, 2009/*WRCBvideos*[19]
Popularity	1,017 views (April 3, 2010)
Presenter	David Carroll on *FMA Live*
Approach	Hip-Hop Science Show/ Experimental demonstration
Place of Presentation	Appears to be Auditorium
Target Audience	Middle school students

[19] Information on the video indicates that "One national performance tour called FMA, shows Ocoee Middle School students in Cleveland, Tennessee, just how fun science can really be ... through the beat of hip hop." The video is a News report by David Carroll for WRCBtv.

Description: The program is dubbed *Hip Hop Science Show.* Carroll indicates that, Sir Isaac Newton once noted that to every action there is a reaction, "and the students' reaction to an action filled science hip hop concert, about Newton's Laws of Motion, was very positive." In the first activity, an Ocoee middle school teacher sits in a Huber chair and makes a head-on collision with a "giant cream pie" which causes her a backward motion. Carroll reports that the program is part of a live professionally-staged multimedia hip hop concert illustrating Newton's Laws of Motion. He asks: "Did the student's learn any science from there?" Jonathan Crittenden, an 8th grader, has this to say: "I learned Laws of Motion, and, science career can be fun, as the dancers were cool, and entertainment is fun." Jason Robinson, a male teacher of the school also asserts that, he thinks the students learned many things not only about Newton's Laws of Motion but if for anything, "if we spark the kids' imagination and curiosity today, and those students' wanna be what they want to be when they grow up; science related fields, math related fields; that is where the future is." Carroll reports that the show is called *FMA Live!,* for force = mass x acceleration, and is fully funded by Honeywell and NASA. He indicates that a ten-person crew including three singers and dancers, spend a full day assembling the stage and then entertaining and educating kids … including wrestling. In the final activity, two teachers of nearly the same mass engage in a wrestling act on the stage. Eric Olson, an *FMA Live!* performer, explains that as they 'add' acceleration to the teacher with less mass, he creates a greater force which helps him to overcome the force exerted by his opponent and thus winning the fight in the end. Carroll notes that the program is designed to "capture the attention of middle schoolers and make science relevant to their lives" and that this award-winning show might have given some Ocoee students ideas about their scientific career. Robinson adds that, "if we can excite one of these students that are the next astronauts or engineers or chemists, then we did our job today."

Surprising/New/Wonderful: The Show may help the students learn more meaningfully as they explore the wonders of science in a more interesting and entertaining ways. This viewpoint is supported by Jonathan Crittenden, an 8th grader, who states: "I learned Laws of Motion, and, science career can be fun, as the dancers were cool, and entertainment is fun." It may be surprising to the students and other viewers in knowing that as the teacher-wrestler with less mass increased his acceleration he created a "greater force" and thus a bigger impact on collision which helped him to overcome his opponent who had a bigger mass.

Sense making: The first demonstration using the Huber chair and the "giant cream pie" may help the students to perhaps better understand from a real performative perspective, Newton's 3rd Law of Motion which basically states that to every action there is an equal and opposite reaction. Also, the wrestling show may help the students make sense of the applicability of Newton's 2nd Law of Motion in an everyday event such as the wrestling contest. The demonstration together with the explanation offered may help the students make sense of the reason the teacher with less mass was able to win the wrestling contest.

Emotional moments: The performers appear very passionate about their show to the students. They play live-band music, dance and perform live demonstrations such as the head-on collision, the launch of a miniature rocket, and the wrestling contest to educate the students on Newton's Laws of motion. It is possible that, the students seeing the Newton's Laws of Motion demonstrated and taught through an entertaining live-band hip hop show, may cause them to emotionally 'love' the scientific activities performed.

Visceral: In the wrestling show, the teacher with less mass by 'increasing' his acceleration towards his contender with greater mass was able to win over him. It is possible that the students may experience a visceral reaction of awe as they might expect that the contender with a greater mass should overcome his opponent.

Title of Video 20: Dance of the Water Molecule from Fusion Science Theater

URL	http://www.youtube.com/watch?v=5p0P5SluDSU&feature=related
Date posted/Poster	May 27, 2008/*fusionsciencetheater*[20]

[20] Information on video indicates that *Fusion Science Theater* (FST) is a model of science education outreach that combines theater, science demonstrations, and kinesthetic dramatizations of science

Popularity	1,158 views (April 3, 2010)
Presenter	Female Adult
Approach	Experimental demonstration/Story-telling
Place of Presentation	Appears to be early-childhood school classroom
Target Audience	4-14 years

Description: The video dramatizes the concept of the boiling point of water. The presenter directs the activities on the stage as other members of the performing group dramatize the concept boiling point of water to the audience. Performing on the stage are seven artists–six children and a male adult. Each performer has the letter ‘O’ designed using a green cardboard and affixed to the front part of their shirt, and in each hand, letter ‘H’ of color blue. Beginning the main activity, the presenter tells the audience “Now we’re getting ready for the big performance.” she turns round to the performers and asks, “Are you ready?” Meanwhile, in front of the performers are two persons holding a rope at its ends to perhaps signify a boundary to the performers (this boundary represents for water molecule its outer surface membrane). She explains that as the music increases speed of its rhythm it would signify an increase in temperature (heating), until boiling point was reached. Transferring this idea, performers increase

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concepts. From their website, FST “creates outreach shows that combine theater, inquiry and participation to inspire and engage kids 4–14 years in science learning. Each show investigates an intriguing science question through demonstrations, guided-inquiry, and dramatizations that bring kids to the stage to model the science concept. Kids learn best when they get into the act!” (http://www.fusionsciencetheater.org/).

their rate of dance to be at pace with the speed of the music rhythm, causing their intermolecular distances to increase and thereby pushing against the boundary. Beginning the actual dance, the presenter welcomes the audience to the witness of the "dancing of water molecules." She introduces the performers saying, "Here we have beautiful water molecules, vibrating, rotating, moving short distances...." Performers dance to the music. The presenter asks the audience what would happen to the speed of the dancers as the music was building up speed. She answers: "Dancing faster!" adding that the water was getting hot and that they were going to do the "boiling music now." Immediately, the band goes "papapaah" signaling home the beginning of the boiling. The dancers begin pushing on the boundary, causing it to extend until a point where the presenter says, "Stop!" with the male adult performer responding: "We gonna blow!"

Surprising/New/Wonderful: Though there appears to be nothing much surprising in the activity, the performative approach the performers adopted to simulate the random movement of water molecules and its corresponding concept of boiling point may help a viewer-teacher in particular to perhaps learn a new thing in teaching abstract science concepts such as water molecules and what happens when water starts boiling.

Sense making: The presenter uses an increase in the rhythm of the background music being played to denote an increase in heating and for that matter a corresponding increase in the random interaction of the water molecules–the dancers or performers. On a signal of boiling point through the music, the performers dance their way pushing on the boundary, causing it to extend until a point where the presenter says, "Stop!" with the male adult performer responding: "We gonna blow!" The performative role-play technique used, coupled with the explanations given may help the viewers make sense of the random movement of water molecules and how the movement is largely increased during heating and more so as the water boils changing to vapor or gas. Though the significance of the letters ‘O’ and 2‘Hs’ may to indicate that each water molecule has one oxygen (O) atom and two hydrogen (H) atoms bonded together, the presenter does not explain the relevance of these symbols decorated on the performers.

Emotional moments: The presenter appears passionate about her presentation as several phrases she uses to connect the audience to her emotions suggest. For example, she indicates to the audience, “Now we’re getting ready for the big performance.” She turns round to the stage and asks, “Are you ready water molecules?” who in a quick response, answer “We’re ready!” She turns back to the audience and indicates that they are going to do something like “say, boiling and see what happens.” Next, she asks if the band is ready and orders them to start the music. She then turns round to address the audience saying “Well, ladies and gentlemen, welcome to the dancing of water molecules.” [Turns back to the stage] “Here we have beautiful water molecules, vibrating, rotating, moving short distances…” as the performers begin dancing. By performing her message as above indicated (intermittent story-telling/drama), the presenter perhaps helps the audience to share her feelings about the performative activity.

Visceral: The dance and music used in the performative science activity may help a viewer to viscerally react; for music and dance can enhance a visceral experience. Also, the demonstration perhaps helps a viewer realize a fit between heating and boiling of water.

Chapter Summary

This chapter has presented the findings of the study. In all, 20 YouTube videos with focus on middle school science teaching that uses performative approach to present a scientific concept were analyzed based on the categories, “Surprising/New/Wonderful,” “Sense-making,” “Emotional moments,” and “Visceral experiences.” It can be gleaned from the chapter that, while most of the videos satisfy the criteria for the categories “Surprising/New/Wonderful,” and “Visceral experiences,” the same cannot be said of the categories “Sense-making,” and “Emotional moments.” In the next chapter, these observations will become evidently clear as I discuss the findings by doing cross-case analysis.

Chapter 5: Discussion of Findings

Introduction

This chapter discusses the findings of the study in an attempt to help answer the three research questions underlying the study, and in relation to related literature. It begins by using 4 tables to present a cross-analysis of the 20 videos. Each table provides a snapshot of where the 20 videos selected for analysis and discussion fall in each of the categories “Surprising/New/Wonderful,” “Sense-making,” “Emotional moments,” and “Visceral experiences” that underlie the Gadanidis and Borba (2008) performance-arts lens. In part, the lens is being employed in this study for the purpose of finding out how its adaption might help improve science education particularly for middle grades and especially for those seeking to use performative teaching approach to science concepts, like the video resources on YouTube.

I have indicated under the research methods that, Gadanidis et al. developed their performance-arts lens based on Boorstin’s model of what makes for a “good movie”. It may be recalled that Boorstin (1990) identified a number of pleasures that good movies offer an audience, which I have paraphrased for a science education/movie context: (1) A good science movie offers the “joy of seeing the new and the wonderful” (p. 12) in science. As students watch the movie they guess what might happen next. However, if they are always correct in their guesses, the movie becomes predictable and boring. “Audiences want their overall expectations fulfilled–they want the hero to triumph and the lovers to be united–but moment to moment they want to be wrong (…) to be surprised.” (p. 50). For the teacher, “this means constantly creating expectations that (for the right kind of reasons) aren’t quite fulfilled” (p. 50); (2)

Although students want to be surprised, the surprise needs to make sense. If the science movie surprises without “a rational explanation” (p. 46) then students eventually stop attending; (3) Good science movies also offer emotional moments. Here students vicariously experience the human, emotional aspects of a science education experience, by putting their “heart in the actor’s body: we feel what the actor feels, but we judge it for ourselves. The tension between the two impulses–the urge to be the character and to judge him simultaneously–gives the vicarious experience grit.” (p. 67). In this way, the science movie resonates with students in a personal, emotional way. (4) Lastly, good science movies offer visceral pleasures. “The passions aroused are not lofty. They are the gut reactions of the lizard brain–thrill of motion, joy of destruction, lust, blood lust terror, disgust. Sensations, you might say, rather than emotions.” Visceral experiences make you feel that you are having “the experience yourself, directly” (p. 110).

In sum, viewing a “good science movie” or science performance through Boorstin’s perspective, we see that a science movie or performance is much more than simply “entertainment”. In fact, the four “pleasures” identified above, map nicely on some of the key ideas of constructivism. A good constructivist lesson (1) helps students experience the “new and the wonderful in science, in a way that create surprise or cognitive conflict; (2) it focuses on sense-making, by providing students with opportunities to understand and overcome their cognitive conflict; (3) it connects with students in a personal, emotional way; and (4) it affords opportunities for students to experience science concepts directly.

In light of the above indications, and in respect of the purpose of this study, I use 4 Tables–2, 3, 4 and 5–that summarily bring into focus the strengths and weaknesses of the 20 videos when looked at from the 4 (main) categories of the performance-arts lens. Following the Tables, I describe and interpret each of the four categories citing specific video examples from their respective sub-categories (indicated below).

In each Table, the Roman numeral in the horizontal row indicates the components of the videos on each main-category of the analytical framework. Also, in each of the 4 Tables, the specific sub-categories indicated emerged from the data analysis (or findings) of the 20 videos under the 4 main categories of the analytical lens. It is noteworthy that, a video may 'qualify' to belong to more than one sub-category of a given main-category due to its special features. The display of the video numbers in relation to the various sub-categories of each main-category makes this observation explicit.

For easy/quick reference, Table 1 provides the titles and numbers of all 20 videos.

Table 1: Summary Table showing the Numbers and Titles of the 20 Videos

Video Number	Title
1	How much sugar is in a can of soda?
2	Tea bag rocket science experiment
3	Dry ice fun–cool science experiments
4	Fun science experiments: How to build a water rocket

5	Milk of magnesia–cool science experiments
6	Fun with liquid nitrogen–cool science experiments
7	Steve Spangler on the Ellen show April 2008
8	Magic tricks–science facts
9	Density–science theatre 12
10	Newton's 3rd law–science theatre 09
11	Acceleration due to gravity
12	Gravity: The bigger they are the faster they fall?
13	Physics free fall project
14	Rockets and planets
15	Day and night
16	Dancing shadows
17	Slap stick science: "Air has weight" with Dr. Quinton Quark
18	Hailstorm! A science class musical drama
19	Hip hop science show
20	Dance of the water molecule from fusion science theater

In Table 2: Surprising/New/Wonderful, I have the sub-categories, "Uses everyday objects/simple tools or situations," and "Offers different/new/surprising perspective. Under this main-category of Surprising/New/Wonderful, findings from the videos show that, insofar as my analytical framework is concerned, presenters appreciably satisfy the criteria by trying to: (a) use everyday materials or simple tools as opposed to specially designed scientific apparatus, to help explain a scientific concept, and to surprise the viewer by showing science concepts in action in the world around them (rather than in a science lab with scientific tools/instruments); (b) and/or approach their presentation in such a way that it helps to generate "the new/surprise" perspective as they help the viewers explore the wonders and the wonderful 'world' of science.

Table 2: Surprising/New/Wonderful Category

Components of Surprising/New/Wonderful	I	II
	Uses everyday objects/simple tools or situations	Offers different/new/surprising perspective
Video Number	1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 (all videos)

In Table 3: Sense-making, I have the sub-categories, "Provides statements of facts without conceptual understanding; lapses, and "Explains with examples, and what is presented as surprise/new/wonderful makes sense." Boorstin (1990) explains that, to enjoy a movie, the surprising/new/wonderful must make sense to the viewer. In this main-category of Sense-making, findings from the videos reveal that, presenters try to: (a) explain a science concept but mostly based on scientific facts, and ignoring some key happenings or occurrences that are important for the understanding of the concept; or (b) do a 'good' job in their explanations so the surprising/new/wonderful experience, makes sense to the viewer.

Table 3: Sense-making Category

Components of Sense-making	I	II
	Provides statements of facts without conceptual understanding; lapses	Explains with examples, and surprise/new/wonderful makes sense
Video Number	1, 2, 4, 5, 6, 7, 9, 11, 12, 13	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 , 14, 15, 16, 17, 18, 19, 20

In Table 4: Emotional moments, I have the sub-categories, "Uses personal statements" to help connect the viewer to science experiences offered in the video;

"Uses guest" through which the viewer can vicariously experience the unfolding of scientific events and "Uses skit/drama/story-telling" to help the viewer experience science through the actors and their actions. Boorstin explains that, to experience emotional moments vicariously requires that the viewer encounters such an experience usually through the actor. Thus, in this main-category of Emotional Moments for analysis, findings from the 20 videos reveal that presenters use either: (a) mainly personal statements; (b) persons such as a host or students; or (c) drama/choreography/story-telling to help connect their emotions about the performative science activity to their viewers.

Table 4: Emotional Moments Category

Components of Emotional Moments	I	II	III
	Uses personal statements	Uses guest	Uses skit/drama/story-telling
Video Number	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20	3, 5, 6, 7, 17	1, 14, 15, 16, 17, 18, 20

In Table 5: Visceral Sensation, I have the sub-categories, "Sense of scientific fit and/or beauty," "Awe, fear and disgust," and "Quick change." Boorstin explains that visceral sensations such as fear, beauty, love, and lust are those that the viewer experiences directly by him/herself (not through the actor). Findings from the analysis of the videos indicate that under this main-category, "Visceral Sensation," the main sensations that showed up were sense of fit or beauty, awe, fear, disgust, and quick change.

Table 5: Visceral Sensation Category

Components of Visceral Sensation	I	II	III
	Sense of scientific fit and/or beauty	Awe, fear, or disgust	Quick change
Video Number	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 13, 15, 16, 20	1, 2, 4, 6, 7, 8, 12, 17, 18, 19	1, 2, 3, 4, 5, 6, 7, 14

Discussion of the Four Categories

This section discuses the 20 videos in respect of each of the four main categories "Surprising/New/Wonderful," "Sense-making," "Emotional moments," and "Visceral experiences" that underlie the analytical lens for the study. It uses the various sub-categories as identified in each main-category to discuss and interpret the findings of the videos when looked from the perspective of the analytical lens.

Surprising/New/Wonderful

The category of surprise/new/wonderful appears to be the goal for all the 20 videos. Findings from the video analysis as summarily presented in Table 2 above reveal that, presenters try to surprise viewers with science demonstrations, help them to discover something new and unexpected, and take them on in a voyage of the wonderful world of science. I refer to some examples of each of the two sub-categories identified under this main-category.

Sub-category I: Uses everyday objects/simple tools or situations.

All Videos–1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, and 20–except 3 and 18, fall under this category. In Video 3, *Dry ice fun–cool science experiments,* Spangler demonstrates how dry-ice (frozen carbon dioxide) generates spontaneous bubbles when in contact with a liquid. Dry-ice, being the main ingredient for that demonstration may not be viewed as an everyday object, hence its exclusion from this sub-category. Video 18, *Hailstorm! A science class musical drama* uses mainly choreography to communicate a scientific idea and therefore cannot be said to make the use of everyday objects in this sense, its approach of doing the communication. For the videos under this sub-category, findings indicate that the presenters try to use everyday objects or simple tools as opposed to specially designed scientific apparatus in their science concept video presentation. I cite three Videos–1, 4, and 9–to illustrate this sub-category.

In Video 1, *How much sugar is in a can of soda?,* Marshall Brain for example uses everyday objects (can of pop) in everyday contexts (a kitchen) to show that there are about 7 ½ teaspoons of sugar in 39 g, helping students or viewers realize that they would not normally (or knowingly) eat this much sugar. He also draws students' attention to the soda pop label, which clearly states that it contains 39 g of sugar, helping them be surprised with the fact that they may not have noticed this information or understood its meaning. Moreover, he points out that fruit juice of equivalent volume has the same amount of sugar. Also in Video 4, *Fun Science Experiments: How to Build a Water Rocket*, Kilbane uses an ordinary pop bottle, air pump, though with the help of a locking pin, to prepare his water rocket which, in an open field, he launches into air. Likewise, in Video 9, *Density–Science theatre 12,* Dr. Carlson tries to surprise the viewers by finding his volume using an ordinary garbage container and water. He also indicates that, a quick way to find the density of an object is to compare it to that of water which has a density of 1 g/mL^3 or 1 kg/l^3 and that if it floats then it has less density than water and if it sinks then it has more density than water. Other presentational videos in this sub-category use effectively similar (everyday) objects and approaches as the videos cited above to demonstrate their science concept.

Sub-category II: Offers different/new/surprising perspective.

All the 20 videos analyzed fit in this sub-category. As already pointed out, findings from the video analysis show that, the category of surprise/new/wonderful appears to be the goal for all the 20 videos. As we can see, the three videos examples (1, 4, & 9) discussed above, all try to offer ways that can potentially elicit in a viewer surprises regarding the approaches they use to communicate the scientific idea. Also, in Video 2, *Tea bag rocket science experiment,* the presenter potentially increases the surprise experience by lighting an empty tea bag which finally launches itself upwards like a rocket, for viewers might expect that the teabag simply burns and falls to the ground, as (visibly) there do not 'appear' to be any forces acting on the teabag. The presenter attributes the launch and the return of the tea bag rocket to the works of convection currents. Similarly, in Video 10, *Newton's 3rd Law–Science theatre 09*, Dr. Carlson demonstrates this law by for example spraying from an extinguisher, CO_2 gas in the forward direction causing the trolley to move together with him in the backward direction. He uses the law to explain that jet engine works on the same principle by grabbing air and throwing it backwards and that is what pushes an airplane forward. It is possible that viewers might think something different was responsible for the airplane's (fast) speed rather than pushing mere air backward.

In sum, under this main-category of surprising/new/wonderful, the presenters of the videos try to use everyday situations on their scientific concept in their bid to create 'surprises' and, as much as possible, use simple everyday tools or items to help explain a scientific idea, however abstract to viewers.

Sense-making

In this category of the lens, it appears there are a lot of sense-making gaps in many of the 20 videos. Also, this reveals that there are pedagogical opportunities missed. A glance at Table 3 gives an indication of how the videos fare on the components of measure. I refer to some specific videos of each of the two identified sub-categories to highlight their strengths and weaknesses in this respect.

Sub-category I: Provides statements of facts without conceptual understanding; lapses.

Under this sub-category, analysis of videos shows that several of the videos contain instances where the presenters largely fail to provide a meaningful and convincing explanation on the scientific concept presented in a video. Videos that come under this sub-category are: 1, 2, 4, 5, 6, 7, 9, 11, 12, and 13. Table 3 at a glance reveals that, with the exception of videos 2 and 13 that are included only in this sub-category I, the rest of the videos in sub-category I are also included in the sub-category II. This shows that while, in one part, some presenters of videos under this sub-category I mainly state scientific facts that may not necessarily help with the conceptual understanding of a scientific concept, in another part, they try to explain well so the surprise/new/wonderful experience makes sense to the viewer. The examples below help illustrate this observation.

In Video 2, *Tea bag rocket science experiment,* the presenter indicates that the convection currents were responsible for the tea bag's take-off into air. He however does not explain why he makes the tea bag into a cylinder and mounts it in an upright position before lighting it on fire. He does not also explain why the tea bag was unable to launch itself into air immediately it was lit. These gaps may render a viewer wondering as it regards the conceptual understanding of the scientific concept performed. Likewise, in Video 13, *Physics free fall project,* Bross and Hearne indicate as a fact that free fall means nothing else but the gravity is affecting the object when it is falling from a height. They give the initial velocity of the object to be 0 m/s. They state that by throwing a ball from the top of a roof down to the ground, both the acceleration due to gravity and the distance traveled by the ball values ought to be negated. Basic physics principles, in this context, establish that this can be true if and only if the object is acting against gravity and not when in the direction of it. The presenters could have therefore re-worked their video and re-posted it especially when a comment by a viewer pointed out that those assumptions were not possible in or consistent with basic physics principles. Similarly, in Video 1, *How much sugar is in a can of soda?,* Marshall Brain shows to the audience how to experimentally calculate the amount of sugar in a bottle of soda. Though Brain mentions that one teaspoonful of sugar is “about” 6 g, he obtains his 39 g by counting 7 ½ teaspoonfuls, which totals 45 g. This may not make much sense to the viewer. Also in Video 5, *Milk of Magnesia–Cool Science Experiments,* here, Spangler connects the significance of the concept neutralization to reactions that normally take place in the human stomach, he does not answer his guest’s interesting question that, “does it [the reaction] work as fast in the stomach?” though he says they will have to consult a medical expert. This is a missed opportunity; the video could have been re-done to capture a reasonable answer to that question. One may argue that Spangler should not necessarily be a repertoire of knowledge, and more so, it was not a classroom-based learning. Indeed, it will be unwise by any stretch of imagination to hold of him an assumption of such. However, it may not be unreasonable to expect of him to find an answer to that interesting question given the fact that he was preparing the video demonstration to be posted on the Web for public use. And of course, if it were to be a classroom ‘blunder,’ I would have considered asking students to take it home as assignment, and to be revisited in the next science lesson. This would offer me the opportunity to hunt for the most appropriate answer to the ‘challenge’ question. Notwithstanding the strengths, similar ‘weaknesses’ show in Spangler’s videos 6 and 7 where he does not explain certain important happenings or occurrences such as what causes the formation of the “beautiful little cloud” of video 6, and the flashes of light generated in the water bottles as the alcohol was burning, video 7.

It can be seen that the videos under this sub-category could impact more effectively to viewers if the presenters were careful enough in either measurements of quantities or in offering reasonable explanations to some important occurrences that often crop up during the presentations on scientific concepts. Failure to address these observed ‘lapses’ leaves gaps in conceptual understanding as they may not help the audience to make good sense of the surprises, the new, and the wonders that mostly characterize the scientific video presentations.

Unlike a video in this sub-category that provides an ‘unconvincing’ explanation to a scientific concept, presenters of the videos in sub-category II (as illustrated below) do appreciably better on explanations of a scientific concept.

Sub-category II: Explains with examples, and surprise/new/wonderful makes sense.

Videos that fall under this sub-category are: 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, and 20. Findings from the video analysis indicate that unlike the videos in sub-category I which in some instances show some degree of lapses in measurements of quantities or in explanations either in a part of the presentation or the entire activity, the videos under sub-category II do comparatively better when looked at from the perspective of the analytical lens for this study. I cite examples of videos under this sub-category to illustrate this observation.

In Video 8, *Magic Tricks–Science Facts*, Friedhoffer explains that the 30 cm wooden ruler placed beneath a sheet of newspaper such that they (both) rest on the surface of a table with about a 5 cm piece of the rule pointing out of the edge of the table breaks upon banging on it because acting to hold it in place is a total air pressure of about 3000 pounds. His demonstration probably helps the audience perhaps to make sense of the fact that air pressure constitutes a tremendous amount of force. (In a related presentation, Video 17, *Slap stick science: "Air has weight" with Dr. Quinton Quark,* Dr. Quark uses three stages in his "Air has Weight" demonstration: first, he puts nothing on the ruler and it does not break as the girl bangs it down; second, he folds a piece of newspaper and puts it on the ruler, the girl bangs it down and it does not break; finally, he spreads onto the ruler a sheet of newspaper leaving just about a 5 cm piece pointing out of the edge of the table, the girl bangs it down and it breaks. Comparing Dr, Quark's approach to Friedhoffer's on air pressure, we can see that Dr. Quark's offers a more pedagogical potential than Friedhoffer who just straightaway, spreads the newspaper on the ruler and bangs on it.) On his demonstration of the principle of inertia, knocking off the cardboard tray causes the eggs to fall into the respective glass containers. His explanation that the demonstration is in conformity to Newton's First Law of motion might help the audience make sense of the surprise experienced in that activity (see viewers' reaction to this event under the Description section). In the final activity, his revelation that as he covers the leak on the plastic cup, no air could enter and that the air pressure acting outside was greater than that inside the cup and upon allowing air to enter through the leak both pressures equalized each other, may help the audience to make sense of why the water poured out the cup at his will. Also, in Video 10, *Newton's 3rd Law–Science theatre 09,* Dr. Carlson's four sets of demonstration of Newton's 3rd Law of motion might help the audience make sense of the concept action and reaction are equal and opposite forces. His explanation and demonstration of the concept using everyday situations such as pushing against an immovable wall, throwing of objects (as fast as one can), and relating it to an airplane's movement might help the audience to perhaps relate the idea to similar situations such as NASA's Space Shuttles and other similar ones in life.

A review of videos under the main-category of Sense-making shows that, in order to make the surprise/new/wonder that usually comes up with the demonstrations make much sense to the viewer (particularly students), reasonable explanations ought to be given to various issues that go with the demonstrations. I will offer suggestions on this when I attempt to answer the research questions in chapter six.

Emotional moments

In this category of the lens, most videos appear to fall short in satisfying the criteria thereof, though a few of them measure up quite satisfactorily. Findings from the video analysis indicate that, presenters mainly use personal statements, a guest or other means such as drama, skit, story-telling and so forth to help connect the audience to the emotions they portray as they make their scientific video presentations. Also, a video identified to belong to all the three sub-categories (e.g., Video 17) features in all the three components that emerged from the data under this main-category. Table 4 helps to capture this observation at a glance. I make reference to specific examples under the three sub-categories identified in Table 4 to show the weaknesses and strengths of the videos when looked at from the analytical lens.

Sub-category I: Uses personal statements.

Videos that come under this sub-category are: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and 20. Findings from the analysis of the videos reveal that unlike the sub-category II and III where presenters make effort to use other means to demonstrate to the audience their passion for their scientific presentation as indicated under the opening paragraph of emotional moments, presenters in sub-category I mainly use personal statements to do so. Two examples are videos 4 and 5.

In Video 4, *Fun Science Experiments: How to Build a Water Rocket,* Kilbane tries to connect his presentation to the audience in a personal way by using statements such as: "... I am going to show you how to make a very simple water rocket," "... this is basically our water rocket here," "We gonna keep it simple...." Also in video 5, *Milk of Magnesia–Cool Science Experiments,* Spangler connects the significance of the concept neutralization to reactions that normally take place in the human stomach, he does not however make use of say, someone who has had such an experience to tell exactly how it feels to be in that condition, or at least describe these feelings himself, in a dramatically convincing way; which is possible to do.

Performative approaches such as those indicated in Videos 4 and 5, more often than not, lack the ingredient required to help the viewers experience the emotional moments vicariously. This is usually the case in the sense that, dramatic arts usually use more than one character to help portray emotional moments. For example, if the video had someone that the presenter was talking to, and that person exhibited emotional reactions as the 'story' unfolded, it might create a better opportunity for the viewer to experience emotional moments vicariously. A good example is video 7 (explained below) where DeGeneres' emotionally reacts overtly to Spangler's demonstrations. She thus helps the audience to experience the ripples of her emotions vicariously.

Sub-category II: Uses guest.

Videos in this sub-category are: 3, 5, 6, 7, and 17. Findings from the video analysis show that presenters try to use other means as explained under sub-category I rather than mere personal statements to help the audience share their feelings about their presentations and for that matter (the audience to be able to) experience the emotions vicariously. Two examples are Videos 7 and 17.

In video 7, *Steve Spangler on the Ellen Show April 2008,* DeGeneres' reactions on the Show might profoundly help connect the audience emotionally. In fact, DeGeneres indicates that she does not want to find out, beforehand from Spangler what they will be doing on such Shows. This helps her profoundly experience the surprises (for the first time) that sometimes emanate out of the demonstrations which she often shows their effects on her visibly emotionally as the following indicate: (a) in the burning of alcohol demonstration, DeGeneres, quickly removes her hand from the opening of the bottle exclaiming, "Jesus, it's hot!" (with the audience laughing); (b) in the diaper (super absorbent), experiment, Spangler picks up the cup from DeGeneres' head, empties its content (liquid water) into her palms; it has turned to a solid. DeGeneres exclaims, "Wow, what did you have in there [in the cup]?" Spangler responds: "Nuclear waste [they all, including the audience, laugh];" (c) in the last activity, DeGeneres fires the potato 3000 shooter finding the target and the audience goes "wooow", amidst clapping of hands. The reactions of the viewers as above indicated show that they have experienced DeGeneres' emotions vicariously (i.e., the viewers becoming emotionalized through the guest's emotional reactions is profoundly enhanced). Also in Video 17, *Slap Stick Science: "Air has Weight" with Dr. Quinton*

Quark, Dr. Quark uses a 3rd grader in her "Air has Weight" demonstration. The reactions of the 3rd grader (guest)–laughing, smiling, banging and so forth–may profoundly help the students engage emotionally with the experience.

Sub-category III: Uses drama, skit, story-telling.

Videos that come under this sub-category are: 1, 14, 15, 16, 17, 18, and 20. Here, findings show that, presenters try to connect the audience to their (presenters) emotions by dramatizing the scientific concept or using a skit or story-telling approach in their presentations. It must however be pointed out that, in using drama, skit or story-telling in the scientific video presentation, a presenter may include the use of personal statements or a guest, or a combination of two or all the components of sub-category three–drama, skit or story-telling. I refer to specific examples.

In Video 15, *Day and Night,* Cordelia and Lang begin the activity by performing the song, "Twinkle twinkle little star …" choreographically. They use a story-telling approach that involves personal statements that help connect their viewers to their performative activity such as: "Did you know that the Sun is a star?;" "If the Sun is a star, then why do we see it during the day and not at night?;" "Here we are at night time. Wow, where did that day go?;" "Can you see the stars twinkling?" Such personal statements, together with the drama they attach to them as they tell the story of "Day and Night" may help increase the audience's emotional moments experience vicariously. Likewise, in Video 17, *Slap stick science: "Air has weight" with Dr. Quinton Quark,* Dr. Quark combines humor and drama as he makes his presentation to the students. He involves the students in his demonstration as he intermittently asks questions that elicit their thoughts on the science activity. For example he asks them if they think the ruler will break if no weight acts on the one end and the other end pointing out of the edge of the table was banged upon. Also he asks: "Shall we do the experiment?" for which the students answer "Yeah." His boisterous nature, sense of humor and asking questions that draw the students' attention to the demonstration, may help them experience the emotional moments vicariously.

In sum, it can be seen from the above discussed video examples that, for emotional moments in a perforamtive demonstrational activity to be enhanced, actors' and guests' reactions to unfolding events become paramount if not crucial. Similarly, teaching a scientific concept by telling a 'good' story, or using drama/choreography, skit and so forth might help in this context. This way, viewers' tendency to vicariously respond to the emotional moments is profoundly increased. It would be necessary as much as important that in planning a performative scientific activity we think beyond the box so as to explore more meaningful approaches and strategies that can potentially enhance emotional moments of the activities vicariously. However, let me quickly state that, the fact that DeGeneres does not want to find out in advance what they will be doing on the Show from Spangler is not to suggest that students should not make advance preparation by reading around the scientific topic or concept to be treated in their next science lesson. Rather, it brings to light potential instances that science teachers may have to critically consider when designing classroom science instructional activities where one objective of the instructional delivery is to target and enhance a vicarious emotional experience on the part of the students.

Visceral sensation

In this category of the lens, most videos satisfy the criteria as the demonstrations largely show one or more instance(s) that define(s) elements such as quick change, fear, disgust, beauty, sense of fit, awe and so forth which are the five identified sub-categories under visceral sensation. Table 5 helps to make the distribution of the 20 videos clearly explicit in terms of these elements of sensation that the videos largely portray. It however needs indicating that, insofar as these identified elements of visceral sensations are concerned, most of the 20 videos analyzed can be said to be inextricably interwoven. This is largely due to the fact that apart from a few videos that clearly portray just one or two elements of visceral sensation, most of the videos enhance a combination of these elements of visceral of sensation, hence their inclusion in other sub-categories of this main-category. I however make effort to refer to specific video examples of each of the identified three sub-categories to indicate this observation and also to show the weaknesses and strengths of the videos when looked at through the narrow yet acute lens of visceral category as embedded in the wider analytical performance-arts lens.

Sub-category I: Sense of scientific fit or/and beauty.

Videos identified under this sub-category are: 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 13, 15, 16, and 20. Findings from the analysis of the 20 videos indicate that the presentations under this sub-category try to offer a means that can be defined as denoting a fit of knowledge in scientific principles or beauty of scientific methods. Videos 10 and 16 are two examples that demonstrate a sense of scientific fit, while Video 2 demonstrates an example of beauty of scientific methods.

In Video10, *Newton's 3rd Law–Science theatre 09*, by Dr. Carlson, all the four different demonstrations he uses, bring about movements in opposite directions which, in fact, indicate a sense of scientific fit in respect of the Newton's 3 rd Law of Motion. Likewise, in Video 16, *Dancing Shadows,* by Cordelia and Lang, as the presenters dance in the light to the background music being played in the video, their respective shadows dance along doing exactly everything they do. However, they both lose their respective shadows in an area where there is no light. It is likely that, viewers might realize a visceral sensation of scientific fit in terms of the performers and their shadows in the light, and how they lose them in the dark area. Also in Video 2, *Tea bag rocket science experiment,* it is likely that the sudden take-off into air of the burning teabag in a rocketry fashion, and its momentarily return to the ground might help the viewers appreciate the beauty and potential of scientific methods, however simple.

It becomes evident from the preceding discussion that one way a performative scientific activity can help produce a visceral sensation in a viewer is through an effort to ensuring that an instructional delivery targets a fit amongst scientific concepts and principles, and, as well, target the beauty of scientific methods.

Sub-category II: Awe, fear, or disgust.

Videos that fall under this sub-category are: 1, 2, 4, 6, 7, 8, 12, 17, 18, and 19. Findings from the video analysis indicate that the scientific presentations of the videos under this sub-category create instances that potentially help to generate in a viewer a state of awe, fear, or disgust. Examples below help to illustrate these observed sensations.

In Video 12, *Gravity: The Bigger They Are The Faster They Fall?,* by Hardee and Dawkins, the release of the two balls (of significantly different masses–36.5 g and 142.2 g) on the overhead bridge at the 'same' time which hit the ground at the "exact same time" may potentially cause a sense of awe in viewers as they might expect that the difference in mass would affect the time each ball takes to hit the ground as a comment posted by one of the viewers suggests: "dude.... [I] just tried it ... it really works. [S]cience is weird ... thanx for the vid," (Bouncert, 1 year ago). Also in Video 7, *Steve Spangler on the Ellen Show April 2008,* DeGeneres (the hostess) removes her hand from the top of the water bottle during the alcohol burning demonstration exclaiming, "Jesus, it's hot!" This generates an impulse of fear. This observation or assertion is supported by the fact that DeGeneres suggests that "We don't wanna do this at, home, no!" On the same show, she overtly exhibits a state of fear when she asks Spangler, "Where are we shooting this thing [pointing a finger at the audience]?" when Spangler stated that the potato shooter he had built before the audience could fire at 60 miles per hour. Likewise, in Video 1, *How much sugar is in a can of soda?,* the brownish color of the sugary sludge obtained in the pot does not have the same appeal as a cold can of pop. Viewers might have a visceral reaction of disgust when they see that sludgy substance that is 'hiding' in a can of pop.

Sub-category III: Quick change.

Videos identified under this category are: 1, 2, 3, 4, 5, 6, 7, and 14. Findings from analysis indicate that the videos under this sub-category of visceral sensation are largely characterized by a quick change sensation that can potentially cause a viewer to react to it viscerally. Three examples are Videos 2, 3 and 7.

In Video 2, *Tea bag rocket science experiment,* the sudden change of state in which the solid tea bag burns into flames turning into smoke and ashes produces contrasting images which help the audience to potentially experience a sense of quick change. Also, in Video 3, *Dry Ice Fun–Cool Science Experiments,* the dry-ice upon contact with the liquids produces 'mountains' of bubbles containing CO_2 gas that denotes a quick change. Likewise, in Video 7, *Steve Spangler on the Ellen Show April 2008,* the liquid alcohol burns in the water bottles generating sparks of fire that flash for a moment before becoming extinguished; the burned alcohol also produces new products–water (vapor) and carbon dioxide gas–as indicated by Spangler; the liquid water poured into a cup turns into solid instantaneously, all denoting a quick change.

In summary, it can be seen that, most videos create potential instances that may help the viewer to profoundly experience the sensations such as fear, disgust, awe, sense of fit, or beauty by him/herself–that is viscerally as the foregoing discussion indicates. The findings of the analysis of the 20 videos as they relate to visceral sensation help us understand or to be cognizant of what constitutes visceral sensation on one hand, and what ways or means to help generate them in a viewer on the other hand. It needs indicating that, visceral, which means direct experience, can have different levels or intensity of the experience encounter. For example watching a teabag rise into air as it burns is very different from actually doing the experiment yourself.

Summary of Findings

It can be seen from the discussion on the four tables that: (1) The category of Surprise/New/Wonderful appears to be the goal for all the 20 videos. Findings from the videos reveal that presenters try to surprise viewers with science demonstrations, help them to discover something 'new' or take them on in a voyage of the wonderful world of science; (2) Under the category of Sense-making, it appears there are a lot of sense-making gaps in the 20 videos, some videos do better than others. Also, this reveals that there are pedagogical opportunities missed; (3) Under Emotional moments category of the lens, most videos appear to fall short in satisfying the criteria thereof, though a few of them measure up quite satisfactorily; and (4) Under Visceral sensation experiences category of the lens, most videos satisfy the criteria as the demonstrations largely show one or more instance(s) that define(s) elements such as quick change, fear, disgust, beauty, sense of fit, awe and so forth which form the sub-categories under visceral sensation.

Discussion of Findings

This section of the chapter attempts to elaborate on each of the four main-categories of the analytical lens in relation to literature and my research questions.

When we look at the nature of science performances as depicted on YouTube videos from the perspective of the Gadanidis and Borba (2008) performance-arts educational lens, it can be seen that most of the videos provide opportunities that can potentially help the viewer to profoundly experience a surprise, discover something new and/or worthy of learning, or to see or appreciate the wonders of science in its exploration of nature, and helping with the understanding of science concepts. A significant number of studies on science education suggests that such science performances (on YouTube) can enhance understanding of school science concepts (see, e.g., McCann, Marek, Pedersen, & Falsarella, 2007; Odegaard, 2003; Waters & Straits, 2008; Zembylas, 2005).

The Surprise/New/Wonderful category as discussed around the sub-categories of Table 2 indicates that, approaching the science teaching using a performative technique may help offer opportunities for students to learn in a much more interesting and engaging way. When science classroom instructional activities are organized and strategized in ways that create and enhance surprises, and students are helped to explore the surprise-filled or oriented activities in ways that make learning fun and relevant to their lives (Lacina & Hannibal, 2009), then it is not unreasonable to expect that their interest in science related fields of study will be developed. This viewpoint is supported by Jason Robinson, a male teacher of Ocoee middle school (see Video 19) who asserts that, the students learned many things not only about Newton's Laws of Motion but "if we spark the kids' imagination and curiosity today, and those students' wanna be what they want to be when they grow up; science related fields, math related fields; that is where the future is." Jonathan Crittenden, an 8th grader of the school indicated that he learned Laws of Motion and that science career can be fun, "as the dancers were cool, and entertainment is fun." A problem is that there appears not to be a 'good' cause for concern amongst science educators to help chart this supposedly course in science education. It is concerning when O'Neill and Barton (2005) state that "research in this area has consistently shown that around *middle school* student engagement in science wanes" (p. 292). Yet, it is not unusual in a debate where many science educators ask and continue to look for ingredients and strategies that should be added to science instruction in making it more pleasing for students to "digest" (Wickman, 2006).

Vitale and Romance (2006) have observed that the continuing goal of science education research is the generation of pedagogical knowledge that can be used to improve meaningful understanding of science concepts by students. Findings from the videos as discussed above have revealed potential innovative, creative and entertaining ways that can be used as an important step towards meeting this challenge–meaningful understanding of science concepts by students. This is in support of science education literature that advocates for a performative teaching approach such as drama, play, experimental demonstrations, choreography and so forth to science concepts especially at the elementary and middle grades (see e.g., McCann, Marek, Pedersen, & Falsarella, 2007; Odegaard, 2003; Waters & Straits, 2008; Zembylas, 2005). Perhaps, Nelson and Landel (2006) have put the point well when they state that, "[e]ffective teaching of all students by effective teachers is the key" (p. 215), which also may translate into meaningful understanding of science concepts to students. It is imperative that teachers consider teaching/learning approaches that help to position and define them as "effective" science teachers. One way may be structuring science instruction in ways that can potentially create 'surprises' as most of the 20 videos on YouTube analyzed show. Interesting is that, some teachers have started using these YouTube scientific video presentations in their classrooms and assert that they help students understand the scientific concepts with a relative ease (see Video 10, Sense-making section).

It is important that, for these informative science performances such as those videos analyzed and being discussed to become valuable venue for professional development (Everhart, 2009), and a good resource for other users, care must be taken to ensure that they are largely error-free so as to make much sense to a viewer. I am aware that, though generally, duration for YouTube videos is relatively several times shorter than that of a typical classroom lesson, this time difference should not be the reason for certain obvious 'shortcomings' on the part of the former. As Boorstin (1990) suggests, the surprise encounter or experience must make sense to the viewer. Unfortunately, as Table 3 (on Sense-making) above reveals, a good number of the science videos analyzed do little in many instances in explaining clearly unfolding happenings or scientific 'events' that often crop up as the presenters tackle a particular concept. A typical example is a situation in videos 6 and 7, where Spangler does not explain certain important happenings or occurrences such as what causes the formation of the "beautiful little cloud" of Video 6, and the flashes of light generated in the water bottles as the alcohol was burning, Video 7. Other problematic issues include a presenter's failure in being more careful to avoid measurements lapses in their presentations as Video 1, *How much sugar is in a can of soda?,* by Marshall Brain, and Video 9, *Density–Science theatre 12,* by Dr. Carlson indicate. Such lapses are at variance and incongruent with Vitale and Romance's (2006) viewpoint that the "purpose of the field of science education is applying the methods of scientific inquiry to advance pedagogical knowledge of how students gain a meaningful understanding of science content and the nature of science processes of science to establish knowledge that, when applied, results in science being taught more effectively" (p. 330). Teaching science "more effectively" in this context requires that whether designing a science video for classroom use or for the purpose of posting it on the Web or elsewhere as a resource for public use, it is well thought-out and effectively presented so that it can be more beneficial to (all) users. An in-depth presentation of concept in one video may better serve a good cause than a superficial presentation that involves several concepts in a single video.

On the category of emotional moments, as much as some videos show that the presenters try to use personal statements as perhaps a means of satisfying or meeting the category's demands, much more needs to be done to help the audience potentially experience vicariously emotional moments. Bentley and Watts (1986) advocate for a need to emphasizing the appeal of science. Noteworthy is that, most commonly, in science education research, aesthetics values are treated under the rubric of affect, attitudes, motivation, or emotions as Wickman (2006) puts it. What is more, "there are numerous scientists and science educators who today point out the importance of aesthetics more specifically in learning science and warn against the existential risks involved in eschewing aesthetics (see e.g., Lemke, 2001; Watts, 2001). As Table 4 (on Emotional moments) at a glance reveals, videos that involved other persons or drama in the science demonstrations, offered more opportunities for viewers to connect emotionally to the performed science concepts. A good example that typically illustrates and elucidates this category almost perfectly is DeGeneres' reactions elicited by experiencing the surprises for the first time as captured in video 7.

On the visceral category, almost all videos do appreciably well. This may largely be due to the fact that most of the videos try to create surprises that can have a direct effect on a viewer's reaction to that incident of the surprise which may be expressed in a form of an experience of a quick change, fear, awe, sense of fit or beauty. Teaching approaches such as experimentation that help students to experience science directly, as the video analysis reveals, offer more opportunities for enhancing visceral experiences. As Irving (2006) notes, “[h]ands-on activities where students manipulate objects and create artifacts in the classroom offer compelling strategies for many science concepts” (p. 14). Most of the video demonstrations when replicated in classroom learning hold the potential for promoting strategies that help enhance visceral experiences due to their surprise inclinations. It needs pointing out that these are videos and students are viewing them passively. They may produce visceral sensations in the students who watch them but not necessarily make sense to them. It is therefore important that the videos be richly designed to ensure that they help viewers especially target-students make sense of each piece of them for their (students’) academic development.

Analysis of the 20 videos has revealed that, the Gadanidis and Borba (2008) performance-arts lens though holds a potential for helping to develop a model, or at least an approach, for designing and more importantly, presenting performative science videos whether for classroom purposes or for posting on the Web for use by others, a degree of inconsistency appears to exist particularly between the two categories “Emotional moments,” and “Visceral sensation experiences.” I noted this inconsistency under analysis and deem it necessary to revisit it to help highlight what I consider, from the perspective Boorstin (1990), as refinements geared towards the sharpening/polishing of the lens to enhance its optimum pedagogical impact educationally.

To recall, I indicated that, the Gadanidis and Borba (2008) lens is not well-defined, particularly as it regards a clear-cut distinction between what explicitly constitutes emotional moments category, and that of visceral sensation category. The fact is, some common emotions are expressed in a form of anger, fear, love, sadness, grief, jealousy, hurt, disappointment, and joy. The observed problem is that some of these elements that define emotional moments also fall in the visceral category. Boorstin explains that while we feel the visceral sensations directly by ourselves, for the emotional moments, we do so through the actor. I cite two examples of the analyzed videos to help make clear this difference:

(a) The rocket launch event of Video 4, *Fun Science Experiments: How to Build a Water Rocket,* creates a sense of fear, for some people–this is visceral; for they experience the fear sensation themselves due to their individual personal perceptions of objects that suddenly display such take-offs, for example missiles or such weaponry. On the other hand, if there's an actor in the video expressing their fear through, say drama, we can experience their fear vicariously (whether we fear the rocket or not)–this would be an emotional moment.

(b) In Video 7, *Steve Spangler on the Ellen Show April 2008,* DeGeneres indicates that she does not want to find out from Spangler before the show starts what they will be doing on such shows. In the burning of alcohol demonstration, DeGeneres quickly removes her hand from the opening of the bottle exclaiming, "Jesus, it's hot!" (with the audience reacting to it amidst laughter). DeGeneres might hate that 'punishing' experience; she might entertain fear of it, be scared of it, and may dislike having such an encounter again as she states "We don't wanna do this at home, no!" If the viewer expresses his/her sensations (fear, dislike) out of or through DeGeneres–the actress' emotional experiences, then he/she (viewer) has experienced it vicariously. However, if the viewer experiences those sensations directly, based on his/her personal emotional self, then that defines the experience as visceral.

It needs pointing out that, the most daunting challenge I encountered using the Gadanidis and Borba (2008) performance-arts lens is the difference I have indicated above. To help improve the lens requires that the differences be looked at/into critically and closely to see how best to deal with the 'inconsistencies' that appear to cloak what should be a fairly distinctive boundary between emotional experiences and visceral sensation experiences. Nonetheless, the various sub-categories identified from the data of this study, as displayed in the four Tables–2, 3, 4, and 5–used in the discussion above, can serve as a first step in helping to develop the Gadanidis and Borba lens into a clear-cut teaching model.

Chapter Summary

The chapter has discussed findings from the 20 video analyses in line with the four main-categories underlying the Gadanidis et al. (2008) educational performance-arts lens. Based on the respective sub-categories of each main-category of analysis, it established that while most of the videos were strong in terms of satisfying the criteria that defined the Surprise/New/Wonderful and Visceral Sensation categories, a sizable number of the videos were weak in the other categories of Sense-making and Emotional moment experiences. The chapter also touched on the difficulty encountered in using the Gadanidis et al. educational performance-arts lens for this study, and suggested a way to deal with an identified inconsistency between Emotional moments category, and Visceral sensation category. The next chapter concludes the study. It answers the research questions set for this study, draws implications from findings and suggests recommendations particularly for future research.

Chapter 6: Conclusion

Introduction

This chapter begins by answering the research questions for this study. Next, it provides implications of findings for science education and suggests recommendations particularly for future research.

Answering the Research Questions

The first research question for this study asks that, in what ways do science performances as depicted on YouTube videos address the criteria for good educational performances laid out by the Gadanidis and Borba educational lens?

As already discussed under chapter five, when we look at the nature of science performances as depicted on YouTube videos from the perspective of the Gadanidis et al. (2008) educational performance-arts lens specifically being developed for mathematics education, it can be seen that: (1) most of the videos provide opportunities that can potentially help the viewer to profoundly experience a surprise, discover something new and/or worthy of learning, or to see or appreciate the wonders of science in its exploration of nature, and helping with the understanding of science concepts; (2) although presenters of the videos largely attempt to explain the scientific concepts they present in the videos, in many instances gaps in conceptual developments as well as inadequate or incorrect explanations or measurements of quantities (see e.g., Videos 1, 5, 6, and 7) do characterize these video presentations; (3) unlike videos in which presenters used mainly mere personal statements (see e.g., Videos 2, 4, and 5) as a way of helping to connect the viewers to their passions and emotions about their presentations, those presenters that involved other persons such the host/hostess (see e.g., Videos 7 and 17) or use drama, student or moviemaking effects (e.g., picture, sound, etc.) offered more potential instances that can help a viewer experience the emotional moments vicariously; (4) most of the videos offered potential opportunities that may help a viewer experience sensations such as quick change, fear, love, hate, sense of fit, beauty and disgust, viscerally (i.e. directly).

The second research question this study seeks to answer is, what does the lens tell us about creating a 'good science' performance and for that matter, how might science performative videos be improved? As we can see, addressing the first research question answers the second in part: to create a 'good science' performance requires that all the four categories "Surprising/New/Wonderful," "Sense-making," "Emotional moments," and "Visceral experiences" are essentially considered critically as parameters that are interwoven and ought to be intricately connected when designing science performative videos, whether for personal classroom use, or for the purpose of posting them on the Internet as a resource for use by others. A significant proportion of science education literature indicates that most science concepts appear to be abstract and taught from books (see e.g., Chiappetta & Koballa, 2006; Fang, 2006; Irving, 2006; Koc, 2009; Uce, 2009), particularly from the perspective of elementary and middle school students making it difficult for them to understand scientific concepts. Bybee (2006) notes that what students learn is directly influenced by how they are taught. Moreover, the "domain of science education research, using the processes of science, focuses upon the development of pedagogical knowledge that improves teaching science content and process" (Vitale & Romance, 2006, p. 331). Using the lens can thus guide us to richly design and develop science videos before posting them on the

YouTube or other publicly available sites on Web so as to help optimize their educational benefits for users. In so doing, we in disguise help improve science education; for the more richly developed, interesting and meaningful the videos are, the better they would be to engage the users extrinsically so that their inner-drive for science related careers might be given a positive-push, and be enhanced. Despite the second question being a-near-answered one, I will still advance its merits briefly. It can be gleaned from the 4 tables under the Discussion chapter that:

(a) Under the New/Surprise/Wonderful category, almost all the videos fare appreciably well; they try to create instances that have the propensity to generate streams of surprises to the viewer, attempt to offer a new/innovative/creative/interesting way of teaching a science concept, and helping with the understanding of the wonders of science through experimental demonstrations or activity, role-playing, choreographic dramatization, story-telling and drama, and so forth. The lens thus suggests that as science educators and their researcher community continues to look out for ways that may be more pedagogically appealing to students as Vitale and Romance (2006) put it, in our quest to enhance effective, meaningful and a holistic science education for all students, we begin to consider such inputs from the arts curriculum. By this means, our focus on issues involving research into science pedagogy and its related discourses though widens, it also becomes more encompassing and probably more enhancing educationally.

(b) Under the Sense-making category, a lot more needs to be done so that the surprises that science demonstrations try to create will in the end make sense as

Boorstin (1990) suggests, so as to help capture profoundly, the attention of the viewer. How therefore do we do this; the following suggestions might help:

(1) Presenters must endeavor to connect the concept to the viewer's knowledge (O'Neill & Barton, 2005; Walker & Wilson, 1991) as much as possible. For example, if the video is for a specific classroom use, then students' characteristics such as class level, age and previous knowledge become key considerations. If it is for posting as a resource on the Web, then this factor not only becomes important but even more necessary in the sense that viewers irrespective of specific attributes, would want to watch and understand. It can be argued that, it is the understanding (of the videos) that serves as the wheels of a vessel on which the enjoyment of the video largely thrives.

(2) They should use analogies that help to strengthen and concretize a viewer's understanding of the performed concept. A good example is video 1, *How much sugar is in a can of soda?,* by Marshall Brain.

(3) They should try to provide meaningful explanations for key ideas and happenings/occurrences as the performative activity unfolds. For example why the "beautiful little cloud," the "flashes of light" and so forth.

(4) They should give specific examples of the performed concepts that are, if possible, readily available in nature and easily understood. Also, how is the concept applicable in our everyday contexts and by extension, more scientifically oriented realms–astronomy, medicine, or industrial? Video 9, *Density–Science theatre 12* by Dr. Carlson, may be a good example worth emulating.

(c) Under the emotional moments, the table reveals a lot of weaknesses insofar as the objective is to creating 'good science' performances under the guise of the underlying performance-arts lens. However, there appear to be some good examples that can guide the course of developing science videos to appreciably meet the criteria herein. DeGeneres' nervousness, culminating into her emotionally expressed moments in Video 7, *Steve Spangler on the Ellen Show April 2008,* offers us a good example. Another good example is Video 3, *Dry Ice Fun–Cool Science Experiments,* where the children emotionally react both verbally and non-verbally to the 'eruptions' of the bubbles that characterize the 'dry ice fun.' However, let me quickly indicate that I am not suggesting that every science concept teaching approach should lead to the generation of profound emotional experiences. The clarion call is that efforts can be made especially when we want to approach science teaching from the perspective of the lens–an alternative searchlight for exploring perhaps a more pedagogically interesting and meaningful science learning experience by all stakeholders for the singular purpose of improving student learning through engagement (O'Neill & Barton, 2005; Moreno & Tharp, 2006).

(d) Under visceral experiences, most videos do appreciable well; for the surprises that the demonstrations often create bring to their fold, elements of sensations such as quick change, fear and beauty which expressly define visceral sensations.

In summary, answering the research question what does the lens tell us about creating a 'good science' performance and for that matter, how might science performative videos be improved, brings to the fore that, we can create 'good science' performance in our efforts to improve science education by critically considering what makes for a good movie (Gadanidis, Borba, Hughes & Scucuglia, in press), hence, the importance of the four discussed categories identified by the Gadanidis and Borba (2008) performance-arts lens.

The third and very final question for this study asks that, how well does the lens developed by Gadanidis and Borba be adapted for use in future studies seeking to investigate science performance?

It needs re-emphasizing that, Gadanidis and Borba (2008) performance arts-lens is simply an educational lens that seeks to analyze what makes a good mathematics performance or story for classroom purposes, based on Boorstin's (1990) categories for analyzing film. In doing this, they have set out a clear criteria. Embedded within the criteria are the four categories: "Surprising/New/Wonderful," "Sense-making," "Emotional moments," and "Visceral experiences," that underline their near-developed theoretical framework, already discussed under the two preceding questions. Suffice it to say, to adapt any model for use in a particular situation perhaps requires that we find out its eligibility and compatibility for the proposed situation, at least, on a pilot study. This is what this study has specifically sought to do.

The preceding indications of what the lens is set out on doing notwithstanding, to ensure effective adaptation of the lens, science videos must not be created as if to emphasize what may be seen as certain categories of the lens; rather, equal or appreciable weightings as much as possible, ought to be put on all the four categories for optimum impact in science education. It can be said that, the surprise/new/wonderful and sense-making categories are already part of science teaching and learning practices. Nonetheless, much more can be done to make them help student engagement and learning. What appears to be lacking is the aesthetic dimension which can be viewed as encapsulating the emotional moments and visceral sensations. The Gadanidis and Borba (2008) performance-arts lens can help us find a way of addressing this lack, which in effect will promote sound science pedagogy. In fact the lens, given its multipronged perspective, in connection with the four categories, appears to capture every breadth and depth of all the 20 analyzed science videos. It helps to reveal weaknesses of the videos especially as it relates to "Sense-making" and "Vicarious Emotional experiences."

It is interesting that a lens coming from Hollywood movies–which one might expect to be superficial in its significance and purpose in the strict sense in the academic realms–helps us uncover Sense-making gaps in school science videos. On the other hand, as the Gadanidis et al. educational lens is not a fully developed one for detailed analysis of pedagogy; the sub-categories that emerged from the data analysis and their relevance as well as usefulness to this study can help steer the course towards developing the lens further.

As we search for pedagogical knowledge and skill and other classroom teaching/learning strategies to engage students in science education, "[t]he final determinant of success in our effort to improve science education will be measured by the quality of science programs delivered to our students and student outcomes" (Rhoton & Shane, 2006, p. xiii). Looking at the interface of the science and arts education curricula for elementary and middle grades, and harnessing the valuable potentials of the arts as this study has done in part, may be an important step towards a holistic science education program that enhances student learning more effectively.

Significant Findings

For the purpose of proposing implications of the findings of this study for science education, I re-state them as identified under Discussion chapter.

(1) The category of Surprise/New/Wonderful appears to be the goal for all the 20 videos. Findings from the videos reveal that presenters try to surprise viewers with science demonstrations, help them to discover something new particularly pedagogically or take them on in a voyage of the wonderful world of science; (2) Under the category of Sense-making, it appears there are a lot of sense-making gaps in the 20 videos, some videos do better than others. Also, this reveals that there are pedagogical opportunities missed; (3) Under Emotional moments category of the lens, most videos appear to fall short in satisfying the criteria thereof, though a few of them measure up quite satisfactorily; and (4) Under Visceral sensation experiences category of the lens, most videos satisfy the criteria as the demonstrations largely show one or more instance(s) that define(s) elements such as quick change, fear, disgust, beauty, sense of fit, awe and so forth which form the sub-categories under visceral sensation.

Implications of Findings for Science Education

Science education research is still making efforts in its goal at looking for the generation of pedagogical knowledge that can be used to improve meaningful understanding of science concepts by students (Vitale & Romance, 2006). Viewed from this disposition of science education research, it may be necessary to give much more attention to considering alternative teaching approaches that can help create 'surprises' to students in the learning of scientific concepts. In this study, the 20 videos analyzed used performative teaching approaches such as drama, experimental demonstrations, choreography, magical tricks and so forth, with most videos strategically combining several of these approaches to delivering on a science concept. The study has established from analysis of findings that, the afore-identified approaches help to profoundly create surprises to a viewer. The way forward to structuring school science instruction to potentially create educationally meaningful surprises to a learner therefore not only becomes paramount in this consideration, but also a critical challenge. Gadanidis et al. (2008) educational performance-arts lens adapted for this study can direct our efforts at meeting this challenge. In the event where research in this area has "consistently shown that around *middle school* student engagement in science wanes" (O'Neill & Barton, 2005, p. 292), it becomes more imperative a pressing need to look into pedagogy of school science teaching particularly at this levels of study to help salvage the dire situation from getting out of hand.

More specifically, the Gadanidis et al. educational performance-arts lens holds some potential of providing us with a tool regarding how we design videos on scientific concepts either for the purpose of a particular classroom use, or for the purpose of posting it on the Web for public use. In either case, it can be speculated that presenters of the videos analyzed in this study are of the disposition to helping a viewer understand a scientific concept (better) and, more importantly, to create opportunities for a viewer to realize that science is interesting, "fun and worth studying" (Friedhoffer, Video 8). It however needs pointing out that a presenter would need a good understanding of a science concept in order to be able to address key scientific ideas during the presentation.

It is a common knowledge, particularly amongst science teachers, that school science is replete with many concepts that can be taught through alternative performative approaches. Be it biology, chemistry, physics, and others that usually integrate to define a school science curriculum for a particular level of study, such as middle school, it is evident that a need for teaching approaches using experimentation and demonstration on many concepts is unavoidable. To put it more concretely, almost every school science concept has two sides to it: the theoretical component or aspect, and that of the practical. In particular, the practical aspects of school science concepts if well structured, hold the potential for triggering educationally meaningful surprises and understanding to a student. The Gadanidis et al. performance-arts lens can help us structure and present scientific concepts in ways that can impact meaningfully on student school science engagement.

Recommendations

Based on the implications of findings of this study, the following recommendation for science educators or researchers, science video posters/presenters, Gadanidis et al., and direction of future research may be suggested:

(1) Science education researchers, particularly those concerned with pedagogy, may need to consider the input the four categories–Surprise/New/Wonderful, Sense-making, Emotional moments, and Visceral sensation–underlying Gadanidis et al. educational lens of what makes for a good math story or movie might make to school science teaching. I have indicated under the Discussion chapter that,

already, Surprise/New/Wonderful and Sense-making categories, without doubt, can be said to be key considerations to effective science teaching, especially from the constructivist approach to teaching. What appears to be lacking from the perspective of this analytical lens is ways to approach teaching to ensure that Emotional moments and Visceral sensation experiences are potentially fulfilled. Adding this dimension of research to our critical discourses on pedagogy, we might begin to explore tactile ways to enhancing Emotional moments and Visceral sensation experiences in a learner. This way, we might begin to see potential ways that make for a 'good science story' experience.

(2) Likewise, if individuals who either post or present a science video on the Internet for public use would closely consider the findings from this study, they might see ways to design and present a video on scientific concepts so that it can enhance an increased impact positively to the viewer. It follows that, knowledge of what Gadanidis et al. educational performance-arts lens suggests in meeting the criteria for the four categories of what makes for a good math story, and for that matter a 'good science story' would be helpful.

(3) There is a need to consider a way of re-developing the two categories: Emotional moments and Visceral sensation experiences of the Gadanidis et al. educational performance arts-lens. At present, as I have already noted under the Discussion chapter, sensations such as love, fear, hate, beauty and so forth can be experienced by a viewer under both categories. However, according to Boorstin (1990), the instances that produce these sensations are different. It is necessary

that, these instances are clearly spelt out in the analytical framework (on pedagogy) being developed by Gadanidis et al. for mathematics education.

It however needs indicating that, I am not recommending the use of these videos as a replacement for active learning in classroom situations. My goal was to analyze them from the perspective of the Gadanidis et al. (2008) educational performance lens and to understand their educational value; what is done well, and what not or needs improvement as I explored particularly the pedagogical affordances of these videos to science education.

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