THE IMPACT OF POPULAR AUDIO-VISUAL MEDIA ON THE SCIENTIFIC KNOWLEDGE OF ADOLESCENTS

A MASTER'S THESIS

BY

KHADIJAH MUMTAZ

THE PROGRAM OF CURRICULUM AND INSTRUCTION
BILKENT UNIVERSITY
ANKARA

MAY 2012

DEDICATION

To Ali and Asha.

May the trees have re-grown by the time you embark on such follies.

THE IMPACT OF POPULAR AUDIO-VISUAL MEDIA ON THE SCIENTIFIC KNOWLEDGE OF ADOLESCENTS

The Graduate School of Education

of

Bilkent University

by

Khadijah Mumtaz

In Partial Fulfilment of the Requirements for the Degree of
Master of Arts

in

The Program of Curriculum and Instruction
Bilkent University
Ankara

May 2012

BILKENT UNIVERSITY
GRADUATE SCHOOL OF EDUCATION
THE IMPACT OF POPULAR AUDIO-VISUAL MEDIA ON THE SCIENTIFIC KNOWLEDGE OF ADOLESCENTS
Supervisee: Khadijah Mumtaz
May 2012

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction.

Assistant Professor Dr. G. McDonald

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction.

Professor Dr. M. Sands

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction.

Assistant Professor Dr. J. Mathews-Aydinli

Approval of the Graduate School of Education

Professor Dr. M. Sands

ABSTRACT

THE IMPACT OF POPULAR AUDIO-VISUAL MEDIA ON THE SCIENTIFIC KNOWLEDGE OF ADOLESCENTS

Khadijah Mumtaz

M.A., Program of Curriculum and Instruction

Supervisor: Dr. G. McDonald

May 2012

Students learn and assimilate scientific information from a variety of informal sources, including television and movies. Since such forms of media often stretch the truth or present fiction as fact, it is possible that young adults develop a warped understanding of scientific information which may hinder (or aid) formal science education in a classroom setting. This study aimed to determine how science learned from informal audio visual sources affects knowledge gained in the classroom.

Further, it attempted to discern whether gender or age was a variable. The study was mixed methods in nature; a case study examined how grade 6-8 students from a private, international school in Turkey acquired scientific knowledge from a movie and a television show that contained concepts not related to the school's science curriculum. Additionally, grade 6-10 students, on rotation, watched a movie/television show in class that contained scientific information relating to the curriculum. Data from discussions and responses to key questions relating to the scientific content before and after the viewing of the movie/television show were used for analysis. This study found that students acquire knowledge from movies and television shows but are unable to relate this knowledge to information acquired in a classroom. However, the nature and extent of the information that students acquire from movies/television shows depends on age, gender and the scientific content itself.

Key words: Science, film, informal learning, misconceptions

ÖZET

BASİT HİKAYELERDE BULUNAN BİLİM ÖĞELERİNİN ÇALIŞILMASI

Khadijah Mumtaz

Yüksek Lisans, Eğitim Programları ve Öğretim

Tez Yöneticisi: Dr. G. McDonald

Mayıs 2012

Öğrenciler bilimsel bilgiyi, içinde televizyon ve sinemların da olduğu bir çok gayrıresmi kaynaktan alır ve benimserler. Medyanın bu türlerinde kimi zaman gerçekler çarpıtılabildiği ya da kurgu gerçek gibi gösterilebildiği için, genç yetişkinlerin, sınıf içerisindeki resmi bilim eğitimlerini aksatabilecek (ya da yardımcı olacak) yanlış bilim anlayışı geliştirmelerine sebep olabilir. Bu çalışma, gayrıresmi işitsel kaynaklardan öğrenilen bilginin, sınıfta öğrenilen bilgiyi nasıl etkilediğini belirlemeyi amaçlar. Sonrasında, cinsiyet ve yaşın bir değişken olup olmadığını ayıredilmeye çalışılmıştır. Bu çalışmanın özünde karna araştırma methodu kullanmıştır; vaka örneği Türkiye'deki özel bir uluslararası okulun 6.-8. sınıf öğrencilerinin, okulun fen müfredatıyla ilgisi olmayan kavramlar içeren bir filmden ve televizyon programından aldıkları bilimsel bilgiyi nasıl kazandıklarını araştırmıştır. Ek olarak, 6.-10. sınıf öğrencileri, müfredatlarındaki bilgilerle ilişkili bir film/televizyon programı seyretmişlerdir. Tartışmalardan ve film/televizyon programının seyredilmesinden önce ve sonra sorulan bilimsel içerikle ilgili anahtar sorulara verilen cevaplardan toplanan veriler analiz için kullanılmıştır. Bu araştırmada, öğrencilerin filmlerden ve televizyon programlarından bilgiyi kazandıkları ancak sınıfta öğrendikleri ile bu bilgiyi ilişkilendiremedikleri bulunmuştur. Bununla birlikte, film/televizyon programından kazanılan bilginin doğası ve boyutu yaşa, cinsiyete ve bilimsel içeriğin kendisine bağlıdır.

Anahtar Kelimeler: Bilim, gayrıresmi öğrenim, yanlış anlama

ACKNOWLEDGEMENTS

I would like to acknowledge the help and support of the numerous people, too many to mention individually, who contributed towards making this research possible. In particular, I would like to thank Hajrah, who reminded me of how she learned science, and thus laid the basis for this research.

Dr. McDonald, aka Gaby, was always there to discuss and problem solve at any time, at any place; I could not have asked for a better supervisor!

I would like to thank the administrators, faculty members, staff and students of the Bilkent Laboratory and International School, who supported me during this study. A special thank you to Christina, Jeff and Sila, who endured watching movies and television shows with their students during science lessons. I would also like to thank Dr. Emily Wilson, who painstakingly proof read and edited this tome. I could never have imagined that any two people could have an extended discussion about a lowly comma, but we did. The faculty members of the Graduate School of Education too provided support, guidance and encouragement at all times.

Finally, I am in debited to SAW, HM, SR and RKM, for knowing exactly what to say and when to say it.

TABLE OF CONTENTS

LIST OF TABLES

Table

Page

CHAPTER 1: INTRODUCTION

Introduction

The exponential pace of advancement in communication technology has caused changes in how we learn and gather information. Traditional sources of information have been replaced by the World Wide Web, which literally has the power to connect all parts of the planet. Such growth has caused profound changes in society, including the field of K-12 education. Teachers are finding that their students are far more technologically competent and have access to and are gaining knowledge from a variety of sources outside of school, some of which are verified but many are not.

This content knowledge, gained from informal sources, can no longer be ignored as it shapes a student's perception and information base about a particular topic before he/she walks into the classroom (Dhingra, 2003). It was the aim of this study to determine how scientific information, gained from informal sources, specifically affects knowledge students gained, both generally and that which is learned in the classroom.

Background

Advances in technology and the rise of the internet have dramatically changed the way people acquire and share information. Audiences now do not rely on one single source of information. No longer do members of the public read the same newspaper or watch the same television (TV) shows. Technology has allowed each of us to get information from sources that are most personalized to our needs and desires. Media groups now offer more choice in programs in order to remain ahead of the competition and reach out to a greater audience. Advancements in technology also allow us to acquire information in real time, at the exact instant that an event is happening, from a variety of sources, all customized to fit our individual needs (Reich, 2009).

The entertainment industry, too, has grown, and the choice in years past was significantly less than what it is now (Bakker, 2010). Globalization has enabled movies produced in Hollywood to be available everywhere (Frank, 2012), and one can now follow a favourite show in any corner of the world (where internet is available), at the time that one wants to see it (Reich, 2009).

In addition to increasing choice, all this has also served to raise the quality of programming that is available to the audience, as producers compete in a greater, more international market (Reich, 2009). The audience is now more discerning and is able to pick and choose from a plethora of the highest quality programs and movies in the international market. The popularity of shows such as *ER* and *X-Files*, and movies such as *Avatar*, mostly produced in North America and the United Kingdom (U.K.) and popular around the globe, all serve to remind us that the world has indeed become smaller (TV guide names top 50 shows, 2009; Guinness World Records).

It is also the case today, that such popular media now includes highly technical and theoretical concepts relating to science, politics and society among others, making each discipline more accessible and appealing to a non-academic audience. In fact, TV shows often follow or mimic current events, providing the audience with a new way of viewing an occurrence, whether political, social or otherwise, that has happened in the near past (Holbert, 2005). For science, TV shows like *CSI* and the *X-Files* have a cult following; they show science in action and expose the audience to dilemmas being faced by scientists and also include concepts at the cutting edge of the field (Cavanagh, 2009).

Increasingly, such shows and movies are also finding their way into classrooms and main stream formal education, given their mass appeal, easy access and content. Indeed, showing *CSI* in a classroom has been attributed with turning students on to science (Champoux, 1999). On the other hand, critics argue that science presented in popular media does more harm than good for it can create misconceptions in an ill informed audience. This is especially true for a young audience, who often do not think through concepts that they are presented with and may not work through the subtleties of how popular media deals with facts (Ongel-Erdal, Sonmez and Day, 2004).

Problem

It is clear from past studies that informal sources of learning, such as popular TV shows and movies, are impacting significantly on how and what young adults learn ("Informal Science Learning," 2009). Such (informal) methods of "information spread" means that when students walk into a science class, they may already have constructed a set of facts and assumptions based on shows and movies they have viewed at home. However, whether the knowledge acquired in this manner is fact or part of the magic of Hollywood, is unclear in the minds of young adults, as most do not bother to think through, or know no better than to believe the arguments or plausibility of what they have seen on TV (Berumen, 2008).

Thus, when such adolescents walk into a classroom, it may be the case that a previously learned set of information (acquired through informal means) affects what and how they learn. This may hinder or advance classroom learning and the influence may be dependent on gender, age, topic and source of informal method of learning.

Purpose

This study examined whether watching scientific concepts relating to a certain topic, as they are presented in popular, fictional audio-visual media, had any effect on the knowledge and understanding that students had about that particular topic.

Research questions

This study addressed the following main question:

- How does the viewing of non-academic audio-visual media containing scientific concepts impact students' knowledge of science?

A series of sub set questions were also examined:

  - Does non-academic audio-visual media containing science concepts impact girls' and boys' science content knowledge differently?
  - What role does age play on the impact (if any) that non-academic audio-visual media containing science concepts has on student knowledge?
  - How do students respond to non-academic audio-visual media that contains scientific concepts? Does gender and/or age of the student influence interest level in science?
  - How do teachers view the use of non-academic audio-visual media that contains scientific concepts in a formal classroom setting?

Significance

Audio-visual media designed for popular entertainment increasingly contains scientific concepts that are presented in ways that make the information accessible to an undiscerning audience. The science being presented often "looks good" and is put across in very convincing ways. Indeed, many Hollywood productions are now employing scientists to work as advisors on movie sets, to better walk the fine line between scientific accuracy and popular appeal. In most cases, however, scientific accuracy takes a back seat to other constraints such as film-ability, budgeting constraints and, most importantly, popular appeal (Kirby, 2003).

This 'movie science' may have a great impact on adolescents. Young adults are often avid movie/TV viewers and may not be mature and/or knowledgeable enough to break down what they see on screen. The story line, along with the science, is accepted almost without question, despite the fact that according to an estimate by Durnal (2010), forty percent of the science on the popular TV show, *CSI*, simply does not exist.

In addition, showing popular movies/TV shows is becoming a common way for teachers to engage their students in science as it is set in the real world. Following the popularity of TV shows such as *CSI*, forensics units are becoming fixtures in the science curriculum and educationists are working hard at finding ways in which these forms of popular culture can be used in the classroom setting (Tierweiler, 2006). In fact, forensics courses at the undergraduate level in many universities have witnessed a rise in enrollment following the airing of TV shows such as *CSI*, as more and more students are now considering a career in this field (Smallwood, 2002). Past research has also indicated that girls may be far more likely to consider a field in science, having watched women working in science on TV (Cavanagh, 2009).

Research has attempted to detail the impact and usefulness of these forms of popular culture, whether audiovisual or print, on formal science learning (Dubeck, Bruce, Schmuckler, Moshier & Boss, 1990; Berumen, 2008; Czerneda, 2006; Estes, 2003; Ongel-Erdal et al., 2004; Barnett, Wagner, Gatling, Anderson, Houle & Kafka, 2006; Dhingra, 2003; Barriga, Shapiro & Fernandez, 2010). While these researchers agree on the fact that such forms of popular culture do impact students' perceptions and knowledge about science, there is no consensus on whether this impact is positive or negative. Neither is there agreement on the value of using such forms of popular culture in formal education. Researchers in the past either examined the impact of showing a single movie relating to the curriculum to students at one particular grade level (Barnett et al., 2006) or examined perceptions of students on science learned through a variety of sources such as TV news and fictional TV shows (Dhingra, 2003).

The research being presented here was different in that it focused on examining how students of different ages responded to science contained in only one type of source - fictional audio-visual media. One part of the study included students viewing audio-visual media in which the scientific concepts related directly to the curriculum. This was done so as to examine if students were able to connect content from movies/TV shows to material being covered in class. A separate component involved a smaller group of students watching a TV show and movie that contained science not covered specifically by science courses, to examine whether students acquired scientific information from movies/TV shows that contained concepts unrelated to what was being taught in science classes in school.

Definition of key terms

Certain specific terminology was used in the course of this research and its presentation. The definitions of terms, as used by the researcher, are given below.

Audio-visual media, as used by the researcher, refers to fictional TV shows and movies. All the media used in this study was produced in North American or Europe, and was non-academic in nature.

IGCSE stands for the International General Certificate for Secondary Education, which is a two year curriculum set and examined by the University of Cambridge International Examinations (CIE). At the end of tenth grade, students have completed the IGCSE course work in school, and sit for external exams in all subjects, to obtain the IGCSE Certificate.

BLIS students at a particular grade level are broken down into three groups or 'sections'. A section, for the purposes of this research, refers to a group of students, generally 15-18 in number, who study together with the same teacher, and follow the same class schedule on a weekly basis.

PISA stands for Programme for International Student Assessment. These tests are evaluations of 15 year old students' academic performance, conducted every three years in OECD (Organizational for Economic Cooperation and Development) countries.

CHAPTER 2: REVIEW OF LITERATURE

The importance of informal educational experiences

Formal education and classroom learning only provide a small part of the overall learning experience, and informal educational experiences can change children's attitudes by appealing to their imagination and curiosity (Druger, 1988). Shaw and Dybdahl (2000) state that informal learning experiences may occur when children watch non print media or read newspapers, magazines or books. Kirikkaya, Iseri and Vurkaya (2009) break down informal education into two primary forms; planned activities such as field trips and unplanned activities such as those that occur in the playground.

Research indicates that informal learning experiences significantly impact on how students learn in a classroom. This can be either beneficial or detrimental as the exact nature of the interactions between formal and informal learning are complex and not fully understood. Teachers need to be aware that learning occurs informally and should make deliberate efforts to incorporate knowledge acquired informally into the classroom (Shaw & Dybdahl, 2000).

Not only do informal learning experiences change the knowledge base that students bring with them into the classroom but they also impact how students perceive different subjects. Kirikkaya, Iseri & Vurkaya (2009) found that students' perceptions about science in every day life changed depending on what they watched on television (TV). However, the exact nature of the change on perception depended on the students' own belief systems.

According to a report by the National Research Council as cited by Cavanagh (2009), informal learning experiences, such as educational TV shows, significantly increased scientific learning amongst female students and other minority groups who are under- represented in the field of science. Additionally, informal science learning may lead to more civic engagement on science issues such as environmental concerns, which are frequently covered in TV media. It can be inferred then, that information acquired informally can have a great impact on student learning and performance in school, as well as possibly influencing future career choices and helping students become better citizens.

The use of movies/TV shows in science classes

In an effort to excite students about science, teachers have increasingly been using such forms of popular culture in their classrooms. Educators are using TV shows and books in classes that, in the past, students only saw and read at home. Mostly, it is visual media being used such as movies and TV programmes. Champoux (1999) states that using movies can be an effective teaching tool as they communicate better with an audience and portray a greater sense of reality. Additionally, according to

Champoux (1999), students might be better able to process visual and audio media than printed material.

Tierweiler (2006) has noted that TV shows like *CSI* have caused an increasing number of forensics courses being taught at middle school level. Such TV shows are often incorporated into classrooms to teach not only science but also mathematics and language arts. However, the author points to ethical dilemmas of using crime to educate young people and also questions whether the graphic nature of the show makes it appropriate for use in a classroom setting.

Other researchers have examined the use of science fiction movies to teach science. Dubeck et al. (1990) found that teachers, after using non-academic movies in science classrooms were uniformly enthusiastic about the experience. In a different study, Dubeck and Tatlow (1998) advocated the use of the TV series *Star Trek: The Next Generation* to teach science as it is popular amongst students and also contains a great deal of scientific information. The researchers felt that the futuristic nature of the show may excite students about science and also help reverse some of the negative perceptions that students may have about the subject.

Ongel-Erdal et al. (2004) were more skeptical about the use of movies. They questioned whether movies could be used effectively, for though they may excite students and contribute to classroom discussions, movies may also create misconceptions about the nature of science and present information to students that is scientifically incorrect. However, Berumen (2008) recognized that the depiction of biological concepts in movies may not be accurate and that they may give students an incorrect or misguided view about science, but encouraged teachers to still use them as a teaching tool in classrooms. According to Berumen (2008), movies engage students in active learning and help facilitate critical thinking and investigative skills. Also, students can be taught to look at media with a more critical eye. Gardner, Jones and Ferzli (2009) supported the role of science teachers helping their students become critical thinkers and encouraged curriculum designers to include critical use of media as a tool to promote scientific literacy in a biology classroom. They argued that teachers must now ensure that students are learning material in ways that relate directly to their lives. Students should be taught in ways that allow them to recognize the issues that relate to science, specifically biology (Gardner et al, 2009). Czerneda (2006) stated that teachers should incorporate movies into their classrooms in other ways than just asking them to find flaws in how science is presented (within the movie). This may actually serve to turn students off science, negating the original purpose of exciting students' imagination and creativity (Czerneda, 2006).

The use of print science fiction in science classes

The use of science fiction (or sci fi) as a form of literature is also encouraged by researchers. Burns (1994) advocated using science fiction literature in science classes as it allows students to discover content in other ways. Literature and science are both creative processes and their combination could help foster critical thinking skills. Students could also have experiences (through reading) that they might not have otherwise. Kilby-Goodwin (2010) suggested that the use of science fiction books in a science class would have the further advantage of improving reading and writing skills, which are seldom addressed in this type of classroom. The variety of science fiction in print media lends itself to school-wide use and according to a pilot study done by Kilby-Goodwin, as reported in 2010, students who participated in the project continued to read similar books long after they were required to do so.

Significantly, researchers have pointed to other benefits of using science fiction in science classrooms. Samuelson (1971) advocated the use of science fiction being made a mandatory part of the school curriculum because it helps prepare students for an unknown future. All the problems of tomorrow are not necessarily clear to us now, and students will need a strong sense of imagination if they are to look into the future. Science fiction allows students to think about possible future scenarios while further exciting their sense of imagination and wonder (Samuelson, 1971). Estes (2003) pointed out that science fiction often brings with it a "what would happen if" scenario, which allows students to use their knowledge in novel ways. Science fiction also highlights social, ethical and moral dilemmas related to science, which are often left out of traditional lessons (Estes, 2003). Nunan and Homer (1981) argued that science fiction could be used to show the evolutionary nature of science while highlighting the contradictions that are inherent to the discipline. As well, the use of science fiction would raise philosophical questions relating to the nature of science, which are often not covered in traditional classes (Nunan & Homer, 1981).

The impact of science contained in informal media

There is no consensus of what students or other members of the general public actually take away from media that contains scientific content. Barriga et al. (2010) examined the relative effects of context and gender, and found that both played a significant role in what the audience understood about the science being presented. According to their study, male viewers would be more likely to be influenced by mistaken science information if it was central to the plot, whereas women got more movie science correct if the science was peripheral to the story. Additionally, Barriga et al. (2010) suggested that men may be more confident about pointing out mistakes in movie science than women.

Kiernan (1996) found that greater TV viewage actually reduced what viewers learned about science. Durnal (2010) pointed out the distortion that has been created in the minds of the public because of shows such as *CSI.* Durnal (2010) states that only 40 % of the science presented in *CSI* is true, and that the portrayal of jobs is completely wrong. In his research, he detailed how jurors, prosecutors, defense attorneys and judges are all portrayed incorrectly in the show, leaving the public with a completely mistaken view of how the justice system functions. Durnal (2010) labeled this the "*CSI* Effect" and suggested that it may be the audiences' desire to see smart, sexy and omniscient people working for law enforcement that leads to the show's popularity.

Doherty (2003) went so far as to claim that shows like *CSI* have forever changed the genre of detective fiction on TV by completely removing the element of hypothesising, which (TV) detectives no longer practice. No longer do detectives pick up boxes of matches and wonder who or why it was left at the crime scene. Now, forensics' specialists collect and bag every item from a crime scene and send it to laboratories for analysis. Once the results are in, it is a relatively simple matter to match the evidence to a person and, as shows such as *CSI* remind us, the evidence is incontestable. It is unknown, however, whether the audience actively realizes this lack of prediction making; as well, the impact on students who study science and are taught the value of hypotheses is not confirmed. Kirby (2003) explained the reasons for such scientific inaccuracies in movie/TV media, for although scientists are often employed on movie/TV sets, there is a tension between the scientists and Hollywood as the latter has to consider film-ability, budget and drama. In most cases, scientific accuracy would take a back seat to what the audience would prefer seeing (according to the directors) and what could be made to look plausible within budget (Kirby, 2003).

Television viewing can have a significant impact on the academic performance of a younger audience. A study by Notten and Kraaykamp (2009) found that children who came from TV rich homes did worse in science as indicated by PISA scores than those who had fewer TVs at home. This finding was found to be true for all countries participating in the PISA tests. Interestingly, according to Notten and Kraaykamp (2009), possession of one TV set at home was beneficial to students;

however, ownership of more than one TV set at home negatively impacted children's performance in school.

Specific to the impact of science fiction movies on the understanding of scientific concepts, Barnett et al. (2006) found that even a single viewing of a movie could negatively impact students' understanding of a scientific phenomenon. According to another study carried out by Dhingra (2003), high school students' informal learning experiences, gained through watching TV, significantly impact their learning science in a formal setting. Zimmerman, Bisanz, Bisanz, Klein & Klein (2001) reported that reading science news in newspapers could be beneficial but depended heavily on the analysis of the journalist. Analysis of print media showed that key information such as funding issues and critical commentary was missing while the social context of the scientific news item was presented only in superficial ways (Zimmerman et al., 2001).

However, Smallwood (2002) argued that despite the incorrect depictions about science in TV shows such as *CSI*, the field of forensics is happy to welcome those who have been attracted to a career in forensics because of its depiction on TV and in movies. The author feels that these shows have the great advantage of attracting women to science, thereby negating any misconceptions that may arise from watching *CSI.* These conclusions were echoed by Cavanagh (2009) who cited a report by the National Research Council which showed that programs such as *CSI* have a positive effect on people who are considering science as a career, especially women.

Clearly, there is consensus amongst researchers that informal learning experiences such as TV and print media can significantly impact formal learning experiences that occur in a classroom. However, the exact nature of this interaction is not clear. There are those who advocate using such informal resources in a classroom, to reach out to students more and to engage young people in the field. Conversely, other research argues that incorrect scientific facts presented on screen or in fiction do more harm than good, and hinder (or even negate) what children may learn in school.

CHAPTER 3: METHOD

Research design

The aim of this research was to establish whether the viewing of popular (non-academic) audio-visual media containing scientific information had an impact on the scientific knowledge and concepts of students from grades 6-10. An exploratory mixed methods case study methodology was used for this research, as multiple methods of data collection were used to collect both qualitative and quantitative data. Data were collected in two separate components. The first component, a case study, focused on a very specific group of individuals (hereafter known as the Focus Group) and attempted to explore their responses to learning that may occur through informal sources of education. This research design was adapted from Barnett et al. (2006), where the researchers examined the impact on student understanding of Earth Science after showing one movie to a group of students. Students in the Focus Group for this study watched a movie and a television (TV) show that contained scientific information but was not related to (science) content that was covered as part of the Bilkent Laboratory and International School (BLIS) curriculum. This was done to examine if students learned material from a movie and a TV show that contained scientific information that the students may not have knowledge about.

The second component involved collection of both qualitative and quantitative data from science classes, and was based on a rotation devised by Taraban, Box, Myers, Pollard and Bowen (2007) to establish internal validity. Students from sixth through tenth grades were shown a movie or television show relating to the concepts covered during the previous unit on a rotating schedule. Data from questions asked of the students before and at the end of the unit were used to determine any changes in the conceptual understanding of these students. This component of the research also examined whether students were able to relate scientific information contained in the movies/TV shows to course work being covered in school. Qualitative data from 6 through tenth grade teachers in the form of discussions on their perceptions of the impact of informal audio-visual media was also gathered.

Context

The Bilkent Laboratory and International School (BLIS) is a private, English medium school located in a suburb of Ankara, Turkey. BLIS is affiliated with Bilkent University, which is one of the leading private universities of Turkey. BLIS caters to children of faculty members of Bilkent University as well as other children. Students at BLIS are predominantly Turkish, as well as those who are Turkish by citizenship but have spent significant time living abroad. The first language of almost all the students at BLIS is Turkish, with some students being bilingual and others for whom English is the first language. All lessons, with the exceptions of Turkish, Turkish Social Studies and Foreign Languages are taught in English; however, Turkish remains the language that most students use to communicate in amongst themselves.

All students in grades 6 through 8 at BLIS study general science, which leads up to the IGCSE curriculum being taught in grades 9 and 10. Different sections may be taught by different teachers, though the same curriculum is followed. Major assessments such as end of unit tests and exams are designed by all teachers teaching a particular grade level and the same test/exam is thus administered to students across a grade level.

General science classes specialize into chemistry, biology and physics at the ninth and tenth grade levels, with all students taking each of these sciences. Different teachers teach chemistry, biology and physics to the same students and follow the IGCSE curricula, preparing students for the external exam in each of these subjects administered by Cambridge University (UK), conducted in May of their tenth grade year. Exams and major assessments are identical for students at the same grade level in the same subject. During the BLIS 2011-2012 academic year, in grades 9 and 10, a subject specialist taught one grade level. So, for example, the entire ninth grade was taught by one chemistry teacher, and the entire tenth grade was taught by a different (chemistry) teacher. The same was true for physics and biology.

Participants

BLIS students of grades 6 through 10 ($N = 239$) and their science teachers ($N = 4$) participated in this study. Most students at BLIS are Turkish by citizenship. Many of these students have been attending BLIS since the primary years as turnover amongst Turkish students is low. A small minority of students in this grade range are international students, some of whom have also been students at BLIS since their early childhood years.

The teacher participants of this study were 75 % international, including the researcher herself. One teacher who participated in this study was Turkish. Out of the four teachers who took part in this study, one was a grade 6 through 8 general science specialist, while the other three also taught high school specialized science classes (biology, chemistry and physics).

The Focus Group was the first component of the research. This group consisted of students from grades 6 through 8. Students volunteered to be part of this activity, which was conducted during a designated time for extra-curricular activities, which is part of the students' weekly schedule. A presentation was made to all students from grades 6 through 8 about this activity, and all students from these grades were given an opportunity to participate. Twenty five students chose to be involved while the remaining students selected other extra-curricular activities such as Robotics or Drama.

The Focus Group study involved examining how students responded and learned from a TV show (session 1) and a movie (session 2). The numbers of students for each session varied slightly though most students were present for both session 1 and session 2. The details are given in Table 1. Due to scheduling restraints, students from grades 9 and 10 could not be part of the Focus Group.

Table 1

Breakdown of Students in the Focus Group

	Session 1	Session 2
Total students participating	$N = 24$	$N = 20$
Students participating by gender	Girls: 14 Boys: 10	Girls: 12 Boys: 8
Students participating by grade	Grade 6: 5 (3 girls, 2 boys) Grade 7: 11 (6 girls, 5 boys) Grade 8: 8 (5 girls, 3 boys)	Grade 6: 4 (2 girls, 2 boys) Grade 7: 9 (6 girls, 3 boys) Grade 8: 7 (4 girls, 3 boys)

For the second component, research was carried out in the classrooms in all sections of grades 6 through 10, with their teachers. Students were divided into three sections (A, B and C) at each of these grade levels at BLIS during the 2011-2012 school year. Details of the students at each grade level and their division into sections is given in Table 2.

Table 2

Details of Students from Grades 6 through 10 per Grade Level and Section

Grade		Section A	Section B	Section C	Grade total
10	Students	15	14	15	44
	Girls	11	7	8	26
	Boys	4	7	7	18
9	Students	15	14	15	44
	Girls	9	5	4	18
	Boys	6	9	11	26
8	Students	18	20	20	58
	Girls	9	8	7	24
	Boys	9	12	13	34
7	Students	16	16	14	46
	Girls	7	7	5	19
	Boys	9	9	9	27
6	Students	17	15	15	47
	Girls	7	7	8	22
	Boys	10	8	7	25

Division of students into these sections was organized by the administration at the start of the school year, and was based on subjects that students were taking, primarily foreign languages and social studies. Students were not tracked in any way for the core subjects (English, Math, Science and Turkish); thus, division of students into sections was not based on academic skills or performance. Once assigned, students stayed in their sections throughout the school year and therefore met with the same (science) teacher throughout the year.

The reason for the study being conducted utilizing students of grades 6 through 10 was that it is for the first time in sixth grade that students are taught by a science specialist teacher. Starting from sixth grade, students study science intensively, leading up to the IGCSE exams at the end of the tenth grade year. Thus, content knowledge in science gradually increases over a five year period, to match the students' own growth.

Instrumentation and data collection

Parental permission was sought from all the students' parents, to allow their sons or daughters to watch age appropriate TV shows/movies in the classroom or during the extra-curricular activity period for the Focus Group. There were no parents who objected to their children participating in this study.

The Focus Group watched one animated TV show and one movie during the seven week data collection period. The TV show and movie were specifically selected so as to include science content that was not covered at any particular grade level. The movie/TV show was shown once a week, on a Thursday afternoon, during the 40 minute time allocated for extra-curricular activities. All students who were part of this activity gathered in the school's Performance Hall, which is a space specifically designed for lectures and performances. This space is equipped with professional multi media equipment including a high quality sound system. Details of the Focus Group data collection are shown in Table 3.

Table 3

Details of the Focus Group Activity

	The Simpsons: Tomacco	*Indiana Jones and The Kingdom of the Crystal Skull*
Length of TV show/movie	22 min	122 minutes
Time taken to see the TV show/movie	1 week	5 weeks

Students in the Focus Group were asked closed ended questions on the content covered in the movie/TV show before the start of the movie/TV show. Students were instructed to answer the questions to the best of their ability, and to guess at answers to questions that they did not have knowledge about. These questions were designed and graded by the researcher and are given in Appendices A and B. Following the end of the TV show/movie, the same questions were asked again, followed by a group discussion. Due to time limitations, the Focus Group only watched one TV show (*The Simpons: Tomacco*) and one movie (*Indiana Jones and The Kingdom of the Crystal Skull*) over the data collection period.

The Simpsons: Tomacco episode was selected as the cartoon focuses on farming and genetic engineering on plants. The main character, Homer Simpson, decided to take up a career in farming, and the episode shows how he accidentally created a hybrid 'tomacco' plant from tobacco and tomato plants by feeding plutonium to his crops. The cartoon has taken liberty on several occasions with scientific facts, and presents numerous concepts incorrectly. *The Simpsons* is a popular TV show the world over, especially amongst young adolescents (Rucynski, 2011). As well, the content covered in this particular episode is not part of the BLIS 6 through 8 grade science curriculum. It was thus selected to help determine whether students' knowledge and understanding of science would be impacted by watching a TV show/movie that included content not covered in science classes.

Indiana Jones and The Kingdom of the Crystal Skull was selected for similar reasons. The movie relates the adventures of an archeologist, Dr. Indiana Jones, who embarks on a quest to find a crystal skull with supernatural powers. The movie is set in the 1950s, and thus contains many references to the Cold War going on at that time, between the United States and the Soviet Union. The movie shows concepts relating to many scientific disciplines, including archeology, nuclear technology, magnetism and the existence of aliens. It also takes several liberties with physics' laws of motion while remaining appealing to a younger audience. Archeology, nuclear technology, magnetism and aliens are not part of the BLIS 6 through 8 grade science curriculum, which is why the movie was selected.

A group discussion with the Focus Group was conducted by the researcher for both the TV show and the movie. This was done after the students had watched the TV show and movie. The discussion had the same unstructured format as used by Dhingra (2003), and questions as well as themes that were discussed are given in Appendix C. Responses to questions asked before and after the movie/TV show were used as a basis for the discussion. Through the discussion, the researcher attempted to understand if the students felt watching informal audio-visual media aided their understanding of science.

For the second component of this study, research was carried out in formal science lessons. For grades 6 through 8, the study was conducted in the general science lessons while for grades 9 and 10, owing to the specialization of the subjects, research was carried out in the physics class at the ninth grade level and the chemistry class at the tenth grade level, the latter of which was taught by the researcher herself. Data were collected during the school day over a 12 week period starting in September 2011 and ending just before winter break in December of the same year.

Before the start of the unit, all students at that particular grade level were given a questionnaire based on a format used by Barnett et al. (2006) in their research. This consisted of a series of multiple choice and short (closed ended) questions that asked students key questions relating to the science topic that was to be studied. The questions did not relate to any science content referred to in the movie/TV show to be seen later. Rather, questions were based on the curriculum and content of the unit to be studied. Students were asked to answer the questions to the best of their ability, and to guess at answers to questions that they did not have knowledge about. It was also clarified that responses to these questions would not contribute to any academic grade, and were simply being asked to determine prior knowledge about the upcoming topic. The number of questions ranged from five to 15 in number, and depended on the unit itself. Units with more content had more questions and vice-versa. The questions asked are given in Appendices D-G.

The purpose of asking the students these questions before the unit started was to determine the baseline knowledge of each student. The questions were designed by the researcher and the regular classroom teacher together, and had no bearing on the school grade of the student. The student responses were examined by the researcher and the responses to individual questions were recorded for later use.

The teacher then taught each unit according to his/her normal routine. At the end of the unit, one section from that grade level watched a movie/TV show related to the topic that was being studied (Table 4). Students watched the movie/TV show during class time. Following the viewing, all students, including those students who had not watched the TV show/movie, were asked the same questions from the start of the unit again. These responses were then compared to the original responses, from the start of the unit, to examine whether the viewing of the TV show/movie had an impact on students as compared to those students who did not watch the TV show/movie.

The time interval between the questions asked before the unit started and then again at end of unit test varied, depending on the grade, curriculum and content to be covered. On average it took 3.6 weeks to cover a unit. Table 4 gives exact time periods used to cover each unit at each grade level.

Following the end of the unit, there was a classroom discussion on the movie led by the classroom teacher. The themes for this class room discussion, adapted from Dhingra (2003) and Barnett et al. (2006), were discussed beforehand by the researcher and teacher, and followed approximately the same format for all the post movie discussions (Appendix C). Minor changes were made depending on the movie/TV show viewed by the class.

Each section at a particular grade level only saw one movie/TV show and participated in one classroom discussion during the data collection period. Other sections of the same grade level (who were not watching a movie/TV show in that rotation) used the extra time do other work set by the classroom teacher as end of unit tests are administered on the same day for all sections at the same grade level. Thus, all sections at the same grade level started a new unit at the same time.

Table 4

Rotation of Research Conducted by Section at each Grade Level

Grade level		Topic 1	Topic 2	Topic 3
		Scientific Method	*Air and Water*	*Sulphur*
Tenth grade	Section A	Regular course work	Regular course work	Regular course work + *Dante's Peak*
	Section B	Regular course work	Regular course work + *The Simpsons: The Movie*	Regular course work
	Section C	Regular course work + *Sherlock: A Study in Pink*	Regular course work	Regular course work
Time (in weeks) spent on unit		2 weeks	5 weeks	3 weeks
		Motion	*Forces*	*Work, Energy and Power*
Ninth grade	Section A	Regular course work	Regular course work + *National Treasure II: Book of Secrets*	Regular course work
	Section B	Regular course work + *Unstoppable*	Regular course work	Regular course work
	Section C	Regular course work	Regular course work	Regular course work + *Back to the Future*
Time (in weeks) spent on unit		3 weeks	5 weeks	4 weeks
		Scientific Method	*Energy Flow and Food chains*	*Nutrient cycles and population size*
Eighth grade	Section A	Regular course work + *Sherlock: A Study in Pink*	Regular course work	Regular course work
	Section B	Regular course work	Regular course work + *Star Trek Voyage: Prey*	Regular course work
	Section C	Regular course work	Regular course work	Regular course work + *Day After Tomorrow*
Time (in weeks) spent on unit		2 weeks	3 weeks	5 weeks
		Scientific Method	*The Earth*	*Nutrient Cycles and Population Size*
Seventh grade	Section A	Regular course work + *Sherlock: A Study in Pink*	Regular course work	Regular course work
	Section B	Regular course work	Regular course work	Regular course work + *Ice Age 2*
	Section C	Regular course work	Regular course work + *Journey to the Centre of the Earth*	Regular course work

Time (in weeks) spent on unit		2 weeks	6 weeks	3 weeks
		Scientific Method & Measurement	*Rocks*	*The Earth and Beyond*
Sixth grade	Section A	Regular course work + *The Road Runner Cartoons*	Regular course work	Regular course work
	Section B	Regular course work	Regular course work + *Journey to the Centre of the Earth*	Regular course work
	Section C	Regular course work	Regular course work	Regular course work + *Dr. Who: Journey's End*
Time (in weeks) spent on unit		4 weeks	5 weeks	3 weeks

The movie/TV shows shown were selected for presenting concepts related to each unit in an age appropriate manner. *Sherlock: A Study in Pink*, watched by students in 10C, 8A and 7A, shows the detective solving a murder using the evidence presented to him, which is very much like the scientific method. *The Road Runner* cartoons, viewed by section 6A, show the laws of physics being defied, but nevertheless clearly depict the trial and error that is part of scientific endeavor.

The movie *Unstoppable*, viewed by section 9B, is based on the true life story of two train engineers who stop a train carrying hazardous material from derailing. This made it ideal for use in grade 9's first unit, Motion, as there were numerous references to speed and momentum within the movie. Section 9A saw a clip from the movie *National Treasure: Book of Secrets II*. The scene shows four people trapped on a giant platform held up by a pivot. As long as one person stood at each corner of the platform, it would remain balanced. However, as soon as any person tried to move or get off, the platform would unbalance, causing the people to fall off and die. The movie illustrates how the characters defy laws of force to get off.

Similarly, *Back to the Future*, seen by 9C, shows how a scientist figures out a way of going back in time using electrical power and a nuclear fuel. While this is not (yet) possible, the movie did depict concepts relating to power and energy in an interesting manner.

The Simpsons: The Movie was watched by grade 10B students as the cartoon movie focused on pollution, specifically air and water pollution, and ways of making the environment less polluted. However, the techniques of reducing pollution given in the movie are not actually possible or indeed ethical, and directly contradict ways of reducing pollution as listed in the tenth grade chemistry curriculum. Similarly, the movie *Dante's Peak*, seen by section 10C, about an erupting volcano, shows lakes and other water bodies being contaminated by oxides of sulphur from the volcano, and literally dissolving organic material in a matter of minutes.

For grade 8's second unit, an episode from *Star Trek: Voyager* was shown to students in section 8B. This series follows the path of a space traveling vessel lost in another galaxy. The vessel and its crew encounter many different alien species in their quest to get home. The series often highlights debates relating to science and the definition of a life form is a recurring topic. This particular episode showed the relationship between an (alien) predator and it's prey, which was content covered in the second unit of the eighth grade science curriculum. The movie *Day After Tomorrow* shows the dramatic scenes from the effects of very rapid climate change (over a few days), and alludes to nutrient cycles being affected, causing population decline. This movie was viewed by students in section 8C.

Grade 6B and grade 7C both saw *Journey to the Centre of Earth* for their second unit rotations, as the movie covered aspects of both units (Rocks for sixth grade, and The Earth for seventh grade). The movie depicts how three people fall into a crevice, all the way to the centre of the Earth, where there is a whole new world, complete with lakes, plants and creatures. These people then devise a way of returning to the Earth's surface by boiling the water at the centre of the Earth, and being lifted up by the steam. There were many facts presented incorrectly in this movie, both relating to the structure of the Earth, and what lies at its centre.

Grade 6C saw an episode of *Dr. Who*, which depicts planets disappearing. This episode related to the third unit of sixth grade, in which planetary systems were being studied. This particular episode of *Dr. Who* attributed the disappearance of planets to the work of evil aliens. Grade 7B, for the last rotation, watched *Ice Age 2*, an animated movie that showed how creatures in the Arctic had adapted to their very cold environments, and how climate change was forcing them to migrate. The unit covered adaptation to habitat, and also included how climate change could affect population of particular species.

The duration of each movie/TV show is not listed as some teachers showed only the relevant clips of the movie/TV show in class time. This is particularly true of ninth grade, where all sections only watched a portion (10-20 minutes) during each rotation.

For the Focus Group, results were analyzed only for those students who were both present for the questions before the movie/TV show, and then again after it had finished. For the second component, that is, research done in the classroom, students who were absent for the questions asked before the unit started, the end of unit questions or the viewing of the movie/TV show (if in the test section), were excluded from data analysis, details of which are given in Chapter 4.

A summary of the differences between the two components of this research are given in Table 5.

Table 5

A Summary of the Two Components of Research

The Focus Group	Classroom research
Grade six through eight students.	Grade six through ten students.
Research conducted outside of class time and involved a small number of students (N<25).	Research conducted in science lessons.
Students watched one movie and one animated TV show.	Students in every section at each grade on rotation watched one movie/TV show.
Content of movie/cartoon not related to curriculum.	Content of movie/TV show related directly to science course work.
Students asked questions relating to the moive/TV shows before and after viewing.	Students asked questions relating to the unit of study before and after the unit.
Involved examination of changes in responses of all students from before and after viewing the movie/TV show.	Involved examination of number of correct responses given by students who had watched the movie/TV show and those that had not.

Teachers who participated in the study and showed TV shows/movies in their classroom as part of this research were interviewed at the end of the data collection period. The interview was unstructured in nature, and themes were adapted from the discussion questions that students were asked (Appendix C).

Data analysis

For the Focus Group, the questions were examined and results were converted into percentages. As all the questions were closed ended, each response was given either a 1 (for correct answers) or a 0 (for incorrect answers). The number of questions left unanswered were also recorded and converted to percentages, to see whether students attempted more questions after the movie/TV show had finished than prior to watching it. The data allowed the researcher to examine whether students had gained information from the movie/TV show. Data were also organized by grade level and gender, to determine whether these two factors had an impact on whether and how students acquire knowledge from watching fictional audio-visual media. Themes from the discussion with the Focus Group were thus identified while answering the question of whether popular audio-visual media aids or harms formal science learning.

For research done in classrooms, students' understanding of the topic, and how a movie/TV show contributed (or not) to content knowledge was analyzed by examining student responses to questions at the start and at the end of the unit. Student responses were graded on a 0-1 scale. Correct answers were awarded a 1 and incorrect answers, a 0. These numbers were then converted into percentages. Data were examined by comparing average scores on questions before the start of the unit, and at its end at each grade level to see if the showing of a movie/TV show had an impact on the section that watched the movie/TV show as compared to the two sections that did not. The responses to the discussion questions were transcribed and organized by theme.

Themes were also identified from the discussions with the teachers, which were then analysed. The results from the collected data from both parts of the research are presented in Chapter 4.

CHAPTER 4: RESULTS

For this research, data were collected in two different components, the Focus Group and classroom research. The Focus Group participated in two sessions of data collection, whereas research done in the classroom followed the rotation given in Table 3 over a period of three months. As the research was essentially qualitative in nature, data, in the form of themes emerging from the discussion questions given in Chapter 3, were collected for analysis. However, questions were asked of the students, before and after watching a movie/television (TV) show, to provide a basis for the discussion that followed the viewing. Results from the questions as well as the discussions for both the Focus Group and the classroom research are given below.

Results from the Focus Group

Focus Group Session 1: *Tomacco*

The students ($N = 24$) watched an episode of *The Simpsons'* cartoon series, entitled *Tomacco,* in the first session. In order to set the basis for the post cartoon discussion, and for students to think about what, if any, impact informal media had on their knowledge of science, students were asked questions about material presented in *Tomacco* prior to watching it. Following the viewing of the cartoon, students were asked the same questions again, to lead into the discussion about the cartoon. Student responses to questions that related to the science content of the cartoon are given in Table 6.

Table 6

Details of Student Responses to Questions from Focus Group Session 1

		number of students who answered correctly		number of students who left question blank		number of students who answered incorrectly	
		Before viewing	After viewing	Before viewing	After viewing	Before viewing	After viewing
Q 1	What disease do raccoons have?	4	11	20	12	0	1
Q 2	What is fertilizer?	13	18	7	4	4	2
Q 3	Can tumbleweed and thistle be digested by humans?	10	16	8	2	6	6
Q 4	Does plutonium glow in the dark?	6	1	9	0	9	23
Q 5	Is it possible to genetically engineer plants?	10	16	12	6	2	22
Q 6	What substance in cigarettes is addictive?	9	8	6	3	9	13
Q 7	What is a duel?	10	16	13	5	1	21
Q 8	Do tomatoes grow above ground or are they a root (grow below ground)?	13	19	5	2	6	3

The data in Table 6 suggests that students acquired content knowledge from the cartoon. For Question 1, it is clear that there was an increase of knowledge after the cartoon had been seen; there was reference to the fact that raccoons have rabies in the episode. In *Tomacco*, Homer Simpson is also shown buying fertilizer from a shop, in order to promote plant growth, which could be why more students got the answer correct for Question 2 after watching the cartoon. For Question 3, it is interesting to note that more students knew that tumbleweed and thistle cannot be digested by humans following watching the cartoon, which clearly showed the Simpsons' family eating it. This gain in knowledge could be because students recognized tumbleweed and thistle as types of inedible plants from the cartoon, and then answered that it could not be eaten. Prior to the watching of *Tomacco*, students may have struggled with the terminology as English is a second language for a large proportion of the student body. It may be hypothesized that hearing unfamiliar terminology in context helped the students understand the content better.

Perhaps the most interesting change is response relates to plutonium (Question 4). Whereas 6 students got the answer correct before watching the cartoon, that plutonium does not glow in the dark, only 1 student got this correct following the viewing of the show. This may be because Homer Simpson is shown holding a piece of plutonium that is emitting a green light. In the episode, everything that the plutonium touches also takes on the green sheen.

Question 5 relates to genetic engineering of plants. In *Tomacco*, Homer is shown accidentally crossing a tomato plant with a tobacco plant, and creating a 'tomacco' plant that has characteristics of both tomatoes and tobacco. The episode often makes reference to tobacco, which might explain why more students got Question 6 incorrect after viewing of the cartoon.

Question 7 refers to a duel being fought between two characters, and it is clear that students learned the definition of a duel from the episode. While a duel is not part of any scientific study, this does show that students are learning content and knowledge that relates to other disciplines as well, including ideas and concepts that are not part of their daily lives. As the cartoon shows tomato plants growing above ground, it is not surprising that more students answered Question 8 correctly after having seen the cartoon.

Results by Grade Level

Responses to the questions were then sorted by student grade level, to see if age was a factor in whether and how students learned material from the cartoon. The results are given in Table 7.

Table 7

Average Percentage of Correct Scores of Questions from Focus Group Student Responses Organized by Grade Level.

	Over all average percentage ($N = 24$)	Average percentage for sixth grade students ($n = 5$)	Average percentage for seventh grade students ($n = 11$)	Average percentage for eighth grade students ($n = 8$)
Before viewing	51.54 +/- 22.59	34.07 +/- 0.83	47.14 +/- 24.62	68.52 +/- 15.08
After viewing	60.80 +/- 19.47	48.15 +/- 2.62	55.89 +/- 21.31	75.46 +/- 13.99

It can be seen from Table 7 that, on average, grade 8 students answered more questions correctly than students from grade 7, who in turn did better than students from grade 6. This is to be expected as students from grade 8 have not only studied more content, but are generally also more mature and analytical. However, the relatively high standard deviations on the average percent scores from grade 7 and 8, from before and after the viewing, indicates that there is large differential in the knowledge of students, as indicated by responses to these questions, within those particular grade levels.

Students from all three grade levels had answered more questions correctly after seeing the cartoon than before. However, it is the students from grade 6 for whom this gain in knowledge is statistically significant. The standard deviations show that these students, on average, did increase their knowledge base. Individual students from grade 7 and 8 may have gained knowledge from the Simpson's cartoon; however, on average, this gain is not of statistical significance, as can be seen in Table 7.

The data were then examined to see whether grade level was a factor in answering individual questions.

Table 8

Data by Grade Level for Questions Asked from Focus Group Session 1

		Number of students who answered correctly from Grade 6 $n = 5$		Number of students who answered correctly from Grade 7 $n = 11$		Number of students who answered correctly from Grade 8 $n = 8$	
		Before viewing	After viewing	Before viewing	After viewing	Before viewing	After viewing
Q 1	What disease do raccoons have?	0	2	2	3	2	6
Q 2	What is fertilizer?	0	2	5	8	7	7
Q3	Can tumbleweed and thistle be digested by humans?	0	3	6	7	4	6
Q 4	Does plutonium glow in the dark?	3	0	2	2	1	0
Q 5	Is it possible to genetically engineer plants?	1	1	4	6	4	8
Q 6	What substance in cigarettes is addictive?	1	0	3	3	5	5
Q 7	What is a duel?	1	2	4	7	4	6
Q 8	Do tomatoes grow above ground or are they a root (grow below ground)?	1	3	8	9	4	6

Data from Table 8 indicates that for Question 4, students from both grades 6 and 8 gained incorrect knowledge about plutonium, while for students of grade 7, there was no change. It was the same grade 7 students who got the question correct before and after seeing the cartoon, which indicates that these students had prior knowledge about the element plutonium.

For Question 6, students of grade 6 gained incorrect knowledge from *The Simpson's* cartoon, whereas the cartoon did not have an effect on students from grade 7 and 8. This may be because the episode continuously refers to tobacco, and not nicotine, which grade 6 students may have understood to be the correct answer. In looking at data from grade 8, it was the same students ($n = 5$) who answered Question 6 correctly both before and after the viewing of the cartoon, indicating that these students had prior knowledge about the active ingredient in cigarettes. For grade 7, two students out of the three who answered the question correctly after the viewing had also answered it correctly before they watched the cartoon, thereby also indicating prior knowledge.

For other questions, the content of which was presented correctly in *Tomacco*, students generally showed an increase in content knowledge. Students from grade 6 gained information about all questions, while students of grade 7 and 8, in some cases, showed no change. For example, in Question 2, students from grade 8 scored the same high results both before and after seeing the cartoon. This may be because fertilizers had been briefly touched upon during at the start of the academic year with reference to a field trip, before the collection of this data.

It is also interesting to note that grade 8 students did not show a greater level of prior knowledge for all questions. As shown in Table 8, for Question 3 and 8, students from grade 7 did slightly better than students of grade 8 before viewing the cartoon. Interestingly, both questions were about plants, so it could be that grade 7 students had learned this content in previous years while grade 8 students had not.

Results by Gender

Data obtained from the showing of *Tomacco* were then organized by gender, the results of which are shown in Table 9. Table 1 in Chapter 3 details the breakdown of the students by gender per grade level.

Table 9

Average Percentage Scores of Questions Organized by Gender from Focus Group Session 1

	Over all average percentage (N = 24)	Average percentage for girls (n = 14)	Average percentage for boys (n =10)
Before viewing	51.54 +/- 22.59	45.77 +/- 18.35	59.63 +/- 26.33
After viewing	60.80 +/- 19.47	55.56 +/- 13.07	68.15 +/- 24.89

The data in Table 9 indicates that the average knowledge being asked by the questions before viewing was greater for boys than the girls at the start of the research, though the difference is not statistically significant. While both boys and girls gained knowledge, as shown by the results above, the high standard deviations for both indicates that there was a great differential in how much students learned, though this differential was slightly reduced after watching the movie. It is unclear from this data whether the higher results achieved by boys was due to the particular students involved in the research, the difference in interest that boys and girls may have for *The Simpsons* or other factors such as language fluency or knowledge about American culture.

The data were then examined to see whether gender was a factor in the questions highlighted in Table 10.

Table 10

Details of Questions Organized by Gender from Focus Group Session 1

		Number of girls who answered correctly		Number of boys who answered correctly	
		Before viewing	After viewing	Before viewing	After viewing
Q 1	What disease do raccoons have?	2	6	2	5
Q 2	What is fertilizer?	7	10	6	8
Q 3	Can tumbleweed and thistle be digested by human?	7	10	3	6
Q 4	Does plutonium glow in the dark?	3	1	3	1
Q 5	Is it possible to genetically engineer plants?	6	9	4	7
Q 6	What substance in cigarettes is addictive?	3	3	6	5
Q 7	What is a duel?	4	10	6	6
Q 8	Do tomatoes grow above ground or are they a root (grow below ground)?	7	12	6	7

Generally, it can be seen from the data in Table 10 that both boys' and girls' knowledge increased after they had seen the cartoon, for questions for which answers had been presented correctly (Questions 1, 2, 3, 5, 7 and 8). The results from Question 6 (What substance in cigarettes is addictive?) are interesting. While there was no change in the responses for the girls before and after seeing the cartoon, girls' knowledge about this question was far less than boys'. One less boy answered this question correctly after having seen the cartoon as compared to before, possibly due to the incorrect information presented in *The Simpsons'* episode. As well, for Question 7, double the number of boys knew what a duel was before seeing the cartoon compared to the girls (Table 10). There was no increase in knowledge for the boys, but six more girls answered this question correctly after seeing '*Tomacco*' than before having seen it, as can be seen in Table 10.

Qualitative data

The discussion with the students following the viewing of *Tomacco* was based on the questions presented in Table 6. The discussion themes (Appendix A) and the corresponding answers are given below:

- Did you enjoy *The Simpsons*?

  Most students enjoyed the cartoon, and had seen this, or other episodes of *The Simpsons* before. There was only one student who said that he hadn't seen *The Simpsons* ever before.

- Do you think all the science presented in the cartoon was correct?

  Students generally felt that if science was presented in shows such as *CSI*, the content would be correct. However, they said that *The Simpsons* was a cartoon, and therefore had nothing to do with science. Students were able to point out what was incorrect in *Tomacco*, such as

    - Plutonium used to promote plant growth
    - Elephants shown to eat rats
    - Crossbreeding between plants such as tomato and tobacco is easily and instantly done
    - Tobacco eaten by animals
    - People depicted as having yellow skin
    - Cows shown to talk
    - Sheep with the ability to jump into helicopters
    - A rat shown as having as much hair as a sheep
    - Thistle and tumbleweed being eaten by the characters

  Students were surprised to find that plutonium did not glow in the dark, as was shown in the cartoon.

- How do you know whether the science presented in *Tomacco* was correct or not?

  Students thought that scientists could be asked whether it was correct or not. Students also felt that important facts, incorrectly presented on TV, would be corrected by school teachers in due time. The general consensus amongst students was that if science was presented incorrectly in the cartoon (such as plutonium not glowing in the dark), it was not important as they would never use plutonium in their daily lives.

- Are there any problems with using non-academic TV shows/movies in class to help with the understanding of a (science) topic?

  Students were skeptical of using *The Simpsons* in a classroom, for as one student said "It's only a cartoon". They felt that other shows, like *CSI*, were far better suited to be shown in an academic setting. However, they pointed out that content contained in non-academic TV shows and movies was often not covered in school.

Focus Group Session 2: *Indiana Jones and The Kingdom of the Crystal Skull*

The Focus Group watched *Indiana Jones and The Kingdom of the Crystal Skull* for the second session. Again, students ($N = 20$) were asked questions about material presented in the movie prior to watching it, in order to set the basis for the post movie discussion, and for students to think about what, if any, impact informal media had on their knowledge of science. Following the viewing of the movie, students were asked the same questions again, to lead into the discussion about the movie. Table 11 shows the responses that students had to questions before and after the viewing the movie.

Table 11

Details of Student Responses to Questions from Focus Group Session 2

		Number of students who answered correctly		Number of students who left question blank		Number of students who answered incorrectly	
		Before viewing	After viewing	Before viewing	After viewing	Before viewing	After viewing
Q 1	What is archeology the study of?	13	16	6	3	1	1
Q 2	What is a compass?	14	19	6	1	0	0
Q 3	Is gunpowder magnetic?	9	5	7	1	4	14
Q 4	If you were to talk about history, who would the 'reds' be?	0	4	11	6	9	10
Q 5	How do we get rid of nuclear radiation?	5	5	11	12	4	3
Q 6	What kind of explosion forms a mushroom cloud?	7	9	10	7	3	4
Q 7	What is quartz?	9	15	7	3	5	2
Q 8	What is quicksand?	7	13	11	2	2	5
Q 9	Are all crystals fragile?	13	17	6	1	1	2

As can be seen by the data in Table 11, students, in general, gained information from *Indiana Jones and The Kingdom of the Crystal Skull*. Question 3 is interesting to note as the movie showed gunpowder to be magnetic; 4 more students answered this incorrectly after watching the movie than before. On other questions, where information was presented correctly in the movie, students showed increase of knowledge, such as in Questions 1, 2, 6, 7, 8 and 9.

Question 4 does not relate directly to science. However, the movie referred to communists as the 'reds' on a number of occasions. Four students answered this correctly after having watched the movie. It was interesting to note that some students answered that the 'reds' were native Americans, which is a topic that is covered in the middle school International Social Studies programme.

For Question 5, there was no change in the knowledge, despite the movie showing that a man exposed to nuclear radiation was given a chemical shower and then deemed radiation free. It may be because of this that one student wrote, after viewing the movie, that anything that has been exposed to radiation can be made safe by washing it. It is interesting to note, however, that more students left Question 5 blank after having seen the movie than before. This could be because students did not understand concepts relating to nuclear radiation and felt more confused after having seen the movie.

It can also be seen from the data in Table 11 that far more students attempted to answer questions after watching the movie, even though they may not have answered the questions correctly. When asked the questions before the movie, five students did not answer any of the questions, and one student attempted only one question. These 6 students attempted more questions after they had seen the movie. This is also true of other students, who tried to answer more questions after having seen the movie (Table 11). It may then be hypothesized that students thought they had gained knowledge from the movie, and therefore were more confident in answering questions.

Results by grade level

Data from Focus Group Session 2 were then sorted by student grade level, to see if age was a factor in whether and how students learned material from the movie. The results are given in Table 12.

Table 12

Average Percentage Scores of Correct Responses to Questions from Student Responses Organized by Grade Level for Focus Group Session 2.

	Over all average percentage ($N = 20$)	Average percentage for sixth grade students ($n = 4$)	Average percentage for seventh grade students ($n = 9$)	Average percentage for eighth grade students ($n = 7$)
Before viewing	42.75 +/- 33.85	32.5 +/- 18.4	42.2 +/- 38.9	49.2 +/- 36.2
After viewing	48.75 +/- 16.84	43.75 +/- 6.29	45.55 +/- 14.0	55.71 +/- 22.99

From Table 12, it can be seen that though there was an increase in knowledge following the viewing of the movie, this increase is not statistically significant. The high standard deviations for students from all three grade levels before the movie was shown indicate that there were many students who did not answer a large number of questions or answered them incorrectly. This may be explained by the fact that 25 % ($N = 5$) of the students did not attempt any question prior to watching the movie. The average knowledge after viewing the movie did increase for all students, and the standard deviation also decreased. This indicates that more students answered more questions, and of these, more were answered correctly. However, due to the high standard deviation, this increase cannot be viewed as statistically significant, although a larger sample size may well show the trend more clearly.

It can be seen from the data in Table 12 that grade 6 students had the least knowledge on the content of the movie before watching and eighth grade students had the most knowledge. This pattern stayed the same after the viewing of the movie.

The data was then examined to see whether grade level was a factor in answering individual questions.

Table 13

Data by Grade Level for Questions Asked from Focus Group Session 2

		Number of students who answered correctly from Grade 6 *n* = 4		Number of students who answered correctly from Grade 7 *n* = 9		Number of students who answered correctly from Grade 8 *n* = 7	
		Before viewing	After viewing	Before viewing	After viewing	Before viewing	After viewing
Q 1	What is archeology the study of?	3	4	5	6	5	6
Q 2	What is a compass?	3	4	6	9	5	6
Q 3	Is gunpowder magnetic?	1	1	5	0	3	4
Q 4	If you were to talk about history, who would the 'reds' be?	0	0	0	2	0	2
Q 5	How do we get rid of nuclear radiation?	0	1	2	0	3	4
Q 6	What kind of explosion forms a mushroom cloud?	0	3	3	2	4	4
Q 7	What is quartz?	1	3	5	8	3	4
Q 8	What is quicksand?	1	4	3	4	3	5
Q 9	Are all crystals fragile?	3	3	5	8	5	6

From the results given in Table 13, it can be seen that grade 6, 7 and 8 students generally showed an increase in knowledge after having seen the movie, with some important exceptions.

For Question 3, where the movie showed gunpowder incorrectly as being magnetic, students in the sixth grade did not show a change in knowledge. However, more students in grade 7 got the answer wrong after watching the movie. For grade 8, slightly more students got the answer correct after having seen the movie, despite the movie showing incorrect information.

For Question 4, students in grade 6 did not learn who the 'reds' were from the movie. However, a few students from grade 7 and 8 seem to have gained this knowledge from the movie. It is also possible that these students understood who the 'reds' were after seeing the movie and the historical context it was set in. Grade 6 students may be too young to know about this period of history.

In Question 5, one student from grade 6 was able to explain how to get rid of nuclear radiation correctly after watching the movie, even though the movie showed this incorrectly; the reasons for this are unknown. According to the movie, a chemical shower was enough to get rid of radiation, which might explain why all the seventh grade students got this answer incorrect after watching the movie. For grade 8 students, there was a slight increase in the correct answers after the movie had been seen, despite the incorrect information presented in the movie.

It is interesting to note that on three out of the nine questions (Question 1, 2 and 8), all grade 6 students got the answer correct after watching the movie. This was not the case for grade 7 or 8 students. This may be because of the small number of grade 6 students ($n = 4$) in the Focus Group who had watched the movie carefully, and were thus able to answer the questions correctly.

From the data, it seems that seventh grade students were more influenced by incorrect concepts presented in the movie, as compared to sixth and 8 graders. However, reasons for this are unclear, as while eighth graders, being a year older, have greater knowledge and maybe less susceptible to Hollywood than the younger students, this does not explain why grade 6 students too seemed less influenced by incorrect concepts in the movie, as compared to students of the seventh grade. There may be other factors, such as students' ease with the American English that was spoken in the movie or the smaller sample size for grade six students that may have contributed to these results.

Results by gender

Data obtained from the showing of *Indiana Jones and The Kingdom of the Crystal Skull* were then organized by gender, the results of which are shown in Table 14. Table 1 in Chapter 3 gives the breakdown of the students by gender per grade level.

Table 14

Average Percentage Scores of Questions Organized by Gender from Focus Group Session 2

	Over all average percentage ($N = 20$)	Average percentage for girls ($n = 12$)	Average percentage for boys ($n = 8$)
Before viewing	42.75 +/- 33.85	34.58 +/- 33.67	55.0 +/- 32.29
After viewing	48.75 +/- 16.84	45.83 +/- 13.45	53.13 +/- 21.20

It can be seen from Table 14 that the average for girls before viewing the movie was lower than that of boys. The high standard deviation for the girls may be accounted for by the fact that four girls did not answer any questions before watching the movie. By contrast, after viewing the movie, every girl tried to answer more questions than before. For boys, it is interesting to note that the average number of correct answers was lower after watching the movie than before. However, the change is small and not statistically significant.

The data was then examined to see whether gender was a factor in how students answered particular questions.

Table 15

Details of Questions Organized by Gender from Focus Group Session 2

		Number of girls who answered correctly		Number of boys who answered correctly	
		Before viewing	After viewing	Before viewing	After viewing
Q 1	What is archeology the study of?	6	10	7	6
Q 2	What is a compass?	7	11	7	8
Q 3	Is gunpowder magnetic?	5	1	4	4
Q 4	If you were to talk about history, who would the 'reds' be?	0	1	0	3
Q 5	How do we get rid of nuclear radiation?	2	1	3	4
Q 6	What kind of explosion forms a mushroom cloud?	2	3	5	6
Q 7	What is quartz?	4	11	5	4
Q 8	What is quicksand?	3	6	4	7
Q 9	Are all crystals fragile?	7	10	6	7

The data above indicates that for some questions, there was a drop in learning for boys from before viewing the movie to afterwards, despite information having been presented correctly in the movie. This is true for Question 1 and 7, where more boys got the answers wrong after having seen the movie. In other questions, boys did better after having seen the movie. Interestingly, for Questions 3 and 5, where information was presented incorrectly in the movie, there was either no change in the knowledge (Question 3) of the boys or the number of correct answers increased despite it being depicted incorrectly in the movie (Question 5).

For girls, there was a drop for learning in Questions 3 and 5; for both these questions, the movie gave incorrect information. For all other questions, information had been presented correctly, and girls' answers after the movie show a gain of correct knowledge. It may be that girls retained and used information as it was depicted in the movie more than boys, thereby giving the results seen in Table 15

Qualitative data

The discussion with the students following the viewing of *Indiana Jones and The Kingdom of the Crystal Skull* was based on the questions given in Table 6. The discussion themes and the corresponding answers are given below:

- Did you enjoy *Indiana Jones and The Kingdom of the Crystal Skull*?

  About half the students said they enjoyed the movie. Two students said that they had seen the movie before. Others said that it was too long, and the ending was too boring.

- What concept in the movie related to topics that you have studied?

  There were varying responses to this, as students belonged to different grade levels. Grade 6 students said that they had studied fossils, which is what archeologists research (as taught in the sixth grade). The fact that all grade 6 students got the answer to this question correct could be because fossils are part of the second unit of the grade 6 course of study. Students in the Focus Group may thus have connected archeology to course work previously studied in class. One 6th grade student did wonder if archeology was as exciting as shown in the movie. Students from 7th and 8th grade generally felt that topics covered in the movie were not the same as those studied in classes. When prompted about topics such as magnetism, that may have been taught in school and that also appeared in the movie, all students felt that the content of the movie had nothing to do with what was taught in science classes.

- Do you think all the science presented in the movie was correct?

  Students felt that if there was science in *Indiana Jones and The Kingdom of the Crystal Skull*, it must be correct to have been shown in the movie. However, they realized that the movie had depicted many things that were inaccurate, such as:

  - Aliens and space ships
  - A fridge being shown intact after a nuclear explosion

   - Gunpowder floating in the air
   - Buildings floating above the surface of the Earth
   - Ants devouring humans in a matter of seconds
   - Gold and crystals being attracted to magnets
   - Crystal skulls controlling human and ant behavior
   - Cars and humans falling over waterfalls without any damage

- How do you know whether science presented in the movie is correct or not?

  There was no real consensus amongst students on how to tell whether the science in *Indiana Jones and The Kingdom of the Crystal Skull* was correct or not. The internet was suggested by a few. Students said that some things were obviously not correct such as those mentioned above; however, they were not bothered by more subtle messages that may or may not have been correct. Generally, students did not connect science (regardless of whether it was correct or not) to anything that they had studied in a classroom.

- Are there any problems with using non-academic TV shows/movies in class to help with understanding of a (science) topic?

  Generally, the students did not see any point in watching *Indiana Jones and The Kingdom of the Crystal Skull* in a science class, though they all agreed that it would make school a lot more fun if they watched movies such as these. When asked about using the movie to teach scientific concepts, most said that there was no science in the movie.

Results from classroom research

Research done in the classroom involved students from grades 6 through 10 (N = 239) and followed the rotation given in Table 4. Students at a particular grade level watched a non-academic movie/TV show that contained concepts relating to the unit they had just studied. Any impact that the viewing of the movie/TV show may have had on students' knowledge and understanding was documented by a discussion held after students had seen the movie/TV show. In order to guide the discussion, students were asked questions relating to the content of the unit under study before the unit was begun, and again after the movie/TV show was viewed, at the end of the unit. The questions given for each grade level for each unit are given in Appendices D through H. Results from these questions are presented by grade level. In Tables 15 through 22, a bold font signifies the section that watched the movie/TV show during that particular rotation.

Grade 6

The first three topics for the sixth grade course of study were Scientific Method and Measurement, Rocks, and The Earth and Beyond. The results from the questions asked, both before the unit started and from when it had ended (and viewing of movie if applicable) are given in Table 16.

Table 16

Results of the Questions Asked of Grade 6 Students Before and After Viewing the TV Show/Movie for the First Three Units of Study

Unit	6A		6B		6C	
	n = 16		*n* = 13		*n* = 15	
1	**Average score before viewing**	**50 % +/- 20.72**	Average score before unit	35.71 % +/-27.19	Average score before unit	41.33 % +/-24.21
	Average score after viewing	**57.5 % +/-20.44**	Average score after unit	58.57 % +/-26.9	Average score after unit	73.33 % +/- 17.02
	n =13		*n* =14		*n* = 15	
2	Average score before unit	33.33 % +/- 30.45	**Average score before viewing**	**27.78 % +/- 32.64**	Average score before unit	26.67 % +/- 25.11
	Average score after unit	58.98 % +/- 28.23	**Average score after viewing**	**55.45 % +/-37.09**	Average score after unit	50.00 % +/- 32.89
	n =14		*n* =10		*n* = 15	
3	Average score before unit	67.26 % +/- 21.20	Average score before unit	80.3 % +/- 16.37	**Average score before viewing**	**66.11% +/- 23**
	Average score after unit	83.97 % +/-17.19	Average score after unit	80.30 % +/-22.21	**Average score after viewing**	**78.89 % +/- 28.97**

Note. Bold font indicates the section that viewed the movie for that particular rotation.

The results from the data collected in grade 6 are inconclusive. The data indicates that the academic level of all three sections of grade 6, relating to the content of the questions asked, is on average very similar. All sections showed an increase in content knowledge after the unit had been taught, except for section 6B for unit 3, which showed no change (Table 16). The high standard deviation for all sections in all three units, both at the start of the unit and upon completion, indicates that there are great differences in the content knowledge of individual students within each section.

During the first rotation, students from section 6A watched *Road Runner* cartoons. The data suggests that students from this section had the greatest knowledge about Scientific Method and Measurement before the unit was taught, which might explain why students showed the least difference in knowledge from before the unit was taught, and when it was completed (Table 17). For the second rotation, section 6B watched the movie, *Journey to the Centre of the Earth*. Students showed a slightly greater increase in knowledge as compared to sections 6A and 6C. However, for the third rotation, it was section 6C that watched an episode of *Dr. Who* and they showed the least knowledge about the unit when it had finished. This may also have been influenced by the fact that sections 6A and 6B are taught by one teacher, and section 6C was taught by a different teacher, though the curriculum being followed by all sixth grade students and the end of unit test was the same.

Table 17

Average Percentage Difference Between Answers to Questions from Before the Start of the Unit and After the Unit Completed for 6th Grade

	Unit 1 Scientific Method	Unit 2 Rocks	Unit 3 The Earth and Beyond
6A	**7.5 %**	10.9 %	16.7 %
6B	22.8 %	**13.7 %**	0 %
6C	32.0 %	10.0 %	**12.8 %**

Note. Bold font indicates the section that viewed the movie for that particular rotation.

No conclusions may be drawn from the above data due to the high standard deviations both before the start of the unit, and at the end of the unit, which indicates that there is a great differential in the knowledge (relating to the questions asked) of students within a section and thus there is no significant difference between the data sets. There, it cannot be conclusively said that students in section 6B were influenced by *Journey to the Centre of the Earth*, that accounted for their greater change in learning as indicated by Table 17 during the second rotation. Similarly, for the first and third rotations, the section that watched the TV show/cartoon did not perform significantly differently than those that did not watch the TV show/cartoon.

Grade 7

The first three topics for the seventh grade course of study were Scientific Method, The Earth, and Nutrient Cycles and Population Size. The results from the questions asked, both before the unit started and from after it had ended (and viewing of movie if applicable) are given in Table 18

Table 18

Results of the Questions Asked of Grade 7 Students Before and After Viewing the TV Show/Movie for the First Three Units of Study

Unit	7A		7B		7C	
1	*n* = 16		*n* = 16		*n* = 14	
	Average score before viewing	**42.5% +/- 27.71**	Average score before unit	56.25 % +/-42.38	Average score before unit	44.38 % +/-37.59
	Average score after viewing	**68.75% +/- 28.12**	Average score after unit	63.77 % +/-38.38	Average score after unit	68.57 % +/- 43.62
2	*n* = 13		*n* = 16		*n* = 14	
	Average score before unit	55.12% +/- 31.09	Average score before unit	41.14 % +/- 34.58	**Average score before viewing**	**61.90 % +/- 37.83**
	Average score after unit	73.71% +/- 19.80	Average score after unit	72.39 % +/- 25.62	**Average score after viewing**	**76.19 % +/- 19.10**
Unit 3	*n* = 12		*n* = 16		*n* = 11	
	Average score before unit	52.77 % +/- 17.67	**Average score before viewing**	**52.08 % +/- 12.5**	Average score before unit	77.78 % +/- 12.12
	Average score after unit	73.14 % +/- 31.39	**Average score after viewing**	**67.36 % +/-30.10**	Average score after unit	65.66 % +/- 31.42

Note. Bold font indicates the section that viewed the movie for that particular rotation.

The data suggest that the knowledge of all three sections was approximately the same, though students from section 7C are marginally stronger on the content asked by the questions for all three units. All three sections showed an increase in knowledge at the end of the unit for all three units. However, the high standard deviations on answers to questions both at the start of the unit and at the end of all three units indicates that there are large variations in the content knowledge of individual students within each section and the difference between the sections is not statistically significant.

Examination of data from the seventh grade shows that for unit 1, the section that watched the movie, 7A, showed very similar changes in knowledge at the end of the unit as compared to section 7B and 7C. For unit 2, section 7C watched *Journey to the Centre of the Earth*, and showed the least improvement as compared to section 7A and section 7B. Although this difference is not statistically significant, it is interesting, as the *Journey to the Centre of Earth*, showed many scientifically inaccurate facts. Questions 10, 11 and 12 in particular relate to information presented inaccurately in the movie.

Q 10: What is the Earth made of?

Q 11: If you were to dig towards the centre of the Earth, what would you find? You may use diagrams to aid your answer

Q 12: What is at the very centre of the Earth?

Table 19

Details of how the Students in Section 7C Responded to Questions 10-12 as Compared to Students in Sections 7B and 7C, who had not Watched the Movie.

	% of students who answered Question 10 correctly			% of students who answered Question 11 correctly			% of students who answered Question 12 correctly		
	Before unit	End of unit	Δ	Before unit	End of unit	Δ	Before unit	End of unit	Δ
7A	84.62	92.31	7.69	84.62	76.92	-7.7	38.46	69.23	30.77
7B	93.75	100	6.25	87.5	81.25	-6.3	37.5	56.25	18.75
7C	**100**	**85.71**	**-14.3**	**92.86**	**92.86**	**0**	**64.29**	**78.57**	**14.3**

Note. Bold font indicates the section that viewed the movie for that particular rotation.

It is interesting to note that more students from section 7C, who watched the movie, answered Question 10 incorrectly as compared to the other two sections when asked the same question. This indicates negative learning after viewing the movie though student responses to questions from section 7C in no way referred to the movie content.

There was no difference in students' responses from 7C to Question 11 from before the unit and after having seen the movie. This is of note because the movie, *Journey to the Centre of the Earth*, contained completely fantastical notions of what lies at the centre of the Earth. The other two sections, 7A and 7B, appear to have 'lost' knowledge, as related to the questions asked, over the time period that the unit was taught in, the reasons for which are not clear.

Section 7C showed the lowest gain in knowledge on Question 12, as compared to section 7A and 7B. The movie showed a sea at the centre of the Earth, and while students from 7C did not state that the Earth contained a sea at its centre, they also showed the lowest gain in knowledge of the correct answer, which is that the centre of the Earth is made of solid metals (Table 19).

For unit 3, the results are inconclusive, as section 7B, the section that watched *Ice Age 2*, showed intermediate gain in content as measured by responses to the questions asked, when compared to section 7A and 7C, who did not watch the animated movie (Table 18). Section 7C again showed a negative learning between the time the unit started and when it finished, and the movie had been seen. Question 6, which asked where all energy from the Earth ultimately comes from, was a problem for this section. Many students answered the centre of the Earth though this may be a residual effect from unit 2, when this section watched *Journey to the Centre of the Earth*, which claimed that all energy came from the Earth's centre.

Qualitative analyses of answers to questions showed that students from section 7B, who had watched the movie, used examples from it. Numerous students used the example of a woolly mammoth (one of the lead characters) to explain adaptation to the environment. Overall, the movie, *Ice Age 2*, seems not to have caused any misconceptions in the minds of the students as related to scientific concepts. However, the watching of the movie did not cause students from section 7B to learn more material either, as indicated by Table 18.

Grade 8

The first three topics for the eighth grade course of study were Scientific Method, Energy Flow and Food Chains, and Nutrient Cycles and Population Size. The results from the questions asked, both before the unit started and after it had ended (and viewing of movie if applicable) are given in Table 20.

Table 20

Results of the Questions Asked of Grade 8 Students Before and After Viewing the TV Show/Movie for the First Three Units of Study

Unit	8A		8B		8C	
1	*n* = 18		*n* = 19		*n* = 19	
	Average score before viewing	**55.55% +/- 23.89**	Average score before unit	56.84 % +/-25.62	Average score before unit	49.47% +/-26.99
	Average score after viewing	**90.00 % +/- 11.38**	Average score after unit	68.88 % +/- 33.93	Average score after unit	71.57 % +/- 43.97
2	*n* =17		*n* = 20		*n* = 20	
	Average score before unit	65.68% +/- 33.45	**Average score before viewing**	**60.00 % +/- 26.02**	Average score before unit	63.33 +/- 31.93
	Average score after unit	88.72 % +/- 15.14	**Average score after viewing**	**87.50 % +/- 15.44**	Average score after unit	76.67 % +/- 17.75
3	*n* = 17		*n* = 20		*n* = 17	
	Average score before unit	44.38 % +/- 25.14	Average score before unit	41.36 % +/- 21.34	**Average score before viewing**	**35.84% +/- 15.66**
	Average score after unit	68.98 % +/- 24.12	Average score after unit	60.00 % +/- 29.15	**Average score after viewing**	**68.93 % +/-22.51**

Note. Bold font indicates the section that viewed the movie for that particular rotation.

It can be seen from Table 20 that the academic level of all three sections is, on average, very similar to knowledge related to the questions asked. All three sections showed gain in knowledge at the end of the unit for all three units. However, the high standard deviations on answers to questions both at the start of the unit and at the end of the unit for all three units indicates that there are large differences in content knowledge of individual students within each section.

Data in Table 20 indicate that there was a statistically significant difference between the section that watched the movie/TV show and those that did not, during each rotation. However, each section of eighth grade was taught by a different teacher, who had a different style of teaching. There were also other variables, such as the length of movie/TV programme shown, the actual content of the unit and the students in each section. Therefore, it cannot be said that the difference between the section that watched movie/TV show and those that did not watch it was due only to the movie/TV show.

Similarly, for unit 2, section 8B watched an episode of *Star Trek: Voyager* while students in 8A and 8C did not. However, all three sections performed very similarly to each other, given the high standard deviations. This is also true for the third unit when students in section 8C watched the movie *Day after Tomorrow* while students in 8A and 8B did just regular course work.

Grade 9

The first three topics for the ninth grade physics course were Motion, Forces, and Work, Energy and Power. The results from the questions asked, both before and after the unit (and viewing of movie if applicable) are given in Table 21.

Table 21

Results of the Questions Asked of Grade 9 Students Before and After Viewing the TV Show/Movie for the First Three Units of Study

Unit	9A		9B		9C	
1	*n* = 11		*n* = 16		*n* = 13	
	Average score before unit	77.79% +/- 14.21	**Average score before viewing**	**74.98 % +/-17.96**	Average score before unit	59.83% +/-23.32
	Average score after unit	95.96 % +/- 6.60	**Average score after viewing**	**86.80 % +/- 15.76**	Average score after unit	92.31 % +/- 7.69
2	*n* = 14		*n* = 12		*n* = 13	
	Average score before viewing	**32.14% +/- 22.58**	Average score before unit	37.5 % +/- 26.72	Average score before unit	28.84 % +/- 25.26
	Average score after viewing	**74.10 % +/- 27.24**	Average score after unit	59.37 % +/- 31.94	Average score after unit	56.73 % +/- 28.76
3	*n* = 13		*n* = 14		*n* = 15	
	Average score before unit	25.38 % +/- 21.46	Average score before unit	39.28 % +/- 26.56	**Average score before viewing**	**35.3% +/- 32.2**
	Average score after unit	86.15 % +/- 10.75	Average score after unit	70.33 % +/- 11.1	**Average score after viewing**	**89.33 % +/- 12.64**

Note. Bold font indicates the section that viewed the movie for that particular rotation.

It can be seen from Table 21 that the academic level of all three sections was, on average, very similar regarding knowledge related to the questions asked, although section 9C is consistently slightly lower as compared to 9A and 9B. All three sections showed gain in knowledge at the end of the unit for all three units. It can also be seen that more knowledge is acquired by all three sections during units 2 and 3, perhaps indicating that students had studied Motion in previous years whereas Forces (unit 2) and Work, Energy and Power (unit 3) were both new topics. However, the high standard deviations on answers to questions both at the start of the unit and at the end of the unit for all three units indicates that there is a large difference in the content knowledge of individual students within each section.

Table 21 suggests that students were not influenced by the viewing of a movie/TV show that contained ideas relating to the topic they had just studied. This is not unexpected, as for all three rotations, due to time constraints, students only viewed short segments of the movies rather than the entire movie as in other grade levels. The questions (designated by the 9th grade physics teacher) were mostly numerical in nature, while the movie clips shown did not refer to any mathematical problems. It is therefore unsurprising that students did not refer to the movies shown or learn from them.

For the third rotation, unit 3, it appears as if section 9B showed the lowest gain in knowledge at the end of the unit. However, this is due to a deviation in data collection. The questions were only asked from students in this section a month after the unit had been completed. A two week semester break also occurred during this interval. Thus, the students' lower performance could be attributed to having forgotten material that was learned more than a month previously.

The data in Table 21 shows Section 9A always showed a statistically significant difference in scores from before the unit started and when it had finished, regardless of whether the students in that section had watched a movie or not. Similarly, there was a statistically significant difference between the knowledge measured at the start of the unit, and what students had learned when the unit had been completed for unit 1 (Motion) and unit 3 (Work, Energy and Power) for section 9C as well. For Section 9C, the gain in knowledge for unit 3 (Forces) was close to being statistically significant (Table 21). However, these differences in knowledge cannot be solely attributed to the showing of the TV show/movie and could be because the knowledge of students in sections 9A and 9C was similar to each other, as opposed to the knowledge of students in 9B, which seemed more varied.

Grade 10

The first three topics for the tenth grade chemistry course were Scientific Method, Air and Water, and Sulphur. The results from questions both before the unit started and after it had ended (and viewing of movie if applicable) are given in Table 22.

Table 22

Results of the Questions Asked of Grade 10 Students Before and After Viewing the TV Show/Movie for the First Three Units of Study

Unit	10 A		10 B		10 C	
1	*n* = 13		*n* = 11		*n* = 14	
	Average score before unit	66.15% +/- 26.42	Average score before unit	61.81 % +/-35.44	**Average score before viewing**	**62.85% +/-33.27**
	Average score after unit	98.40 % +/- 3.57	Average score after unit	94.56 % +/- 4.96	**Average score after viewing**	**97.12 % +/- 3.14**
2	*n* = 14		*n* = 12		*n* = 14	
	Average score before unit	58.75 % +/- 14.97	**Average score before viewing**	**71.66 % +/- 26.41**	Average score before unit	60.71 +/- 24.1
	Average score after unit	72.14 % +/- 32.02	**Average score after viewing**	**81.66 % +/- 31.13**	Average score after unit	82.14 % +/- 30.53
3	*n* = 13		*n* = 14		*n* = 15	
	Average score before viewing	**57.98 % +/- 31.02**	Average score before unit	59.23 % +/- 26.60	Average score before unit	56.41 % +/- 31.57
	Average score after viewing	**57.39 % +/- 34.05**	Average score after unit	73.07 % +/- 22.50	Average score after unit	67.30 % +/- 21.90

Note. Bold font indicates the section that viewed the movie for that particular rotation.

It can be seen from Table 22 that the academic level of all three sections was, on average, very similar regarding knowledge related to the questions asked. All three sections showed gain in knowledge at the end of the unit for all three units, except section 10A for unit 3. However, the high standard deviations on answers to questions both at the start of the unit and at the end of the unit for all three units indicates that there are large differences in content knowledge of individual students within each section.

In grade 10, there was no real difference between the students that watched the movies and those who did not for the first two units (Table 22). For unit 3, Sulphur, students from section 10A did not perform as well when asked questions at the end of the unit, as compared to students from the other two sections, as can be seen in Table 22. One question is of particular interest here. Question 9 asked students whether strong and concentrated acids dissolve organic material such as bones, and whether this process occurred rapidly. Details of each section's responses to Question 9 are given in Table 23.

Table 23

Percentage of Students Who Answered Question 9 Correctly

	Before unit	At end of unit	Δ
10A	**69.23**	**46.16**	**-23.08**
10B	60	70	10
10C	41.67	33.33	-8.34

Note. Bold font indicates the section that viewed the movie for that particular rotation.

Strong and concentrated acids can dissolve organic material like bones over time though this process is not rapid. This was discussed in classroom discussions with all three sections. The movie which section 10A watched included a scene in which a woman fell into a highly acidic lake, which caused her bones to dissolve in a matter of minutes. This may account for more students in section 10A changing their answer to the incorrect one following the viewing of the movie. This may also account for the fact that students in section 10A overall showed a slight decrease in knowledge from when the unit started. No student made reference to the movie/TV episode shown for any of the three units while answering the questions. However, section 10C too showed a decrease in knowledge, even though they had not seen the movie. Thus, although the movie possibly had an influence on the knowledge and understanding of the students, doing poorly on the questions at the end of the unit cannot solely be attributed to the viewing of a movie that depicted science incorrectly.

Qualitative data

Due to limited classroom time being available for this research and other factors such as different teachers and changes to the school schedule, discussions following the end of the movie/TV show were only held consistently for grade 10. At other grade levels, discussions were not held after the viewing of the movie/TV show, given sufficient time allocation or held within the section that had watched the movie/TV show. Thus, these results are excluded from the research.

Discussions on the movies shown to the tenth grade students were based on certain questions relating to the themes given in Appendix C, and are given for each unit.

Unit 1: Scientific method and Sherlock: A Study in Pink

- Did you enjoy *Sherlock: A Study in Pink*?

Students generally enjoyed the show, though some had difficulty in understanding the English, as it was often very rapid and in a British accent, to which students are not accustomed. Students were amused by how crazy Sherlock was depicted to be in the show. One student mentioned that the acting abilities of the actor playing Holmes could be better.

- What concepts in *Sherlock: A Study in Pink* are related to the unit we just studied?

Students did not make the connection between Sherlock Holmes' method of solving problems based on evidence, as shown in the show, to the scientific method studied in class. When prompted about this, some admitted that while Sherlock Holmes may have been following a method shared by scientists, the show was more about showing how problems can be solved, which is a skill not based in a particular discipline. One student said that the show contained no science as it had no graphs.

As Sherlock was constantly jumping to conclusions in the show, all students decided that he could not be a scientist. As well, in the show, Sherlock Holmes reached conclusions without proof and did not do tests, in a laboratory setting, which is something students felt 'real' scientists would always do. It was also pointed out that Sherlock's hypotheses were based simply on what he saw, and therefore could not be considered scientific. Generally, students felt that Sherlock Holmes, as depicted in *A Study in Pink*, may have known a lot of science, but he was not a scientist following the scientific method.

- Did *Sherlock: A Study in Pink* help your understanding of the unit we just studied? Why or why not?

As students did not see the link between the scientific method and *Sherlock: A Study in Pink*, they all uniformly found the show unhelpful to their studies. This is also supported by data in Table 21 for unit 1, which shows that students from Section 10C (that watched *A Study in Pink*) were not influenced by the show.

- Are there any problems with using non-academic TV shows/movies in class to help with the understanding of a (science) topic?

Students felt that Hollywood helped them to see science in a different way, and that Hollywood's influence on them had been great. It was mentioned that TV shows are more appealing and their effect is more long lasting than documentaries. A student pointed out that the actors (on TV shows/movies) are better looking as well. One student mentioned that she had learned concepts of mitosis and meiosis from a TV show. Another student said *Fringe*, a popular TV show based on unexplained science had helped him 'un-hate science'. Thus, students felt that non-academic shows could be an important teaching tool, and could also help inspire students to consider future careers in science.

When prompted about any problems associated with using such non-academic shows as a formal teaching tool, students felt that content in such movie/TV shows was for people who could understand the message. A few students mentioned that the influence of popular TV shows/movies was not always correct as portrayal (of what jobs entail and science) is not accurate, which could be disappointing.

- Do you think content in non-academic movies/TV shows is always correct?

Students felt that content of such movies/TV shows may not always be accurate as it is often simplified for a non-academic audience. They agreed that TV shows and movies which showed space travel, alternative dimensions and aliens were obviously inaccurate, but that in such cases, the inaccuracies were very blatant. A student also mentioned that action movies often took liberties with the laws of physics.

- Do you think all the science presented in *Sherlock: A Study in Pink* was correct?

Generally, students were silent on this. A few students mentioned that they weren't sure whether blood actually splattered in the way it was shown in the show, but guessed that it probably did.

- How do you know whether science presented in movies/TV shows is correct or not?

Students suggested using the internet to find out. However, there was the general idea amongst students that if you're an intelligent person, you just know whether something is correct or not. Students seemed to differentiate between the 'average person', who wouldn't know or may not try to find out, and people like themselves, who most likely would be able to tell if something was inaccurate, or could find out if needed. Some students said the 'average' person did not question content on movies and TV shows, and that this was dangerous. Others, however, felt that not questioning the content of movies/TV shows was not harmful as such media always transmitted at least some information, and that some information was better than none. Movies/TV shows also introduced the terminology of a discipline to the 'average' person.

Unit 2: *The Simpsons: The Movie*

- Did you enjoy *The Simpsons: The Movie*?

All students seemed to enjoy the cartoon movie. They felt it was funny because it contained real life satire. While students agreed that they probably only understood half the jokes as the cartoon is so culturally North American, the stereotypes presented were exaggerated and blatant enough for them to notice.

- What concepts in *The Simpsons: The Movie* are related to the unit we just studied?

Students made the connection between the various environmental concerns that the movie had alluded to and those that had been studied in class during the Air and Water unit. Students were able to point out water and air pollutants that the cartoon movie had shown, that were also part of their curriculum.

- Did *The Simpsons: The Movie* help your understanding of the unit we just studied? Why or why not?

Students felt that watching the movie did not aid their understanding of the topic, but that they had been more interested in the content as presented in *The Simpsons: The Movie* as compared to when the same content had been covered in class. Students said the science in the cartoon was 'a bit thin' as it was only a cartoon. Also, the cartoon was making fun of an issue (the environment) that people already do not take very seriously.

- Are there any problems with using non-academic movies/TV shows in class to help with the understanding of a (science) topic?

Students felt that movies such as *The Simpsons* were informative but not scholarly. One student said that *The Simpsons: The Movie* contained a comical warning about global warming and this was effective as it was so exaggerated. Students said that there was no problem using non-academic shows in the classroom as such shows were entertaining and created interest amongst the students about a particular topic. According to students, the impression given by such shows was more long lasting than a lecture or regular course work. A student suggested that the underlying science factors contained in the movie/TV show might stay in the minds of students, and may create the desire to learn more.

- Do you think content in non-academic movies/TV shows is always correct?

Students agreed that everything shown on TV or in movies was not always correct. They felt that it was difficult to draw the line between science and science fiction. The TV show *Fringe* was mentioned again. Students mentioned that *Fringe* showed science in a plausible way, which was bad because it is confusing and shows the wrong side of science. One student said that the line between fake and real science needed to be more evident as it would lead to more understanding.

Students felt that incorrect science in movies/TV shows was not a problem because it was better to show exaggerated or incorrect science than nothing at all. Popular TV shows and movies reach out to a far greater audience than documentaries, and create opportunities for younger children to become interested in science. Conversely, one student did say that what is shown could be dangerous as 'it might cause someone to believe he's superman and jump out of the window'.

- Do you think all the science presented in *The Simpsons: The Movie* was correct?

Students were easily able to pick out scientific concepts presented in the cartoon movie that were incorrect. These included:

  - Glass domes being put over cities to limit environmental pollution
  - Waste from pigs causing a lake to become toxic
  - Sink holes allowing people to pass from one place to another
  - Acid reacting with glass instantaneously
  - The existence of many-eyed monsters (students suggested that such monsters may exist but we have no evidence of this currently)

- How do you know whether science presented in movies/TV shows is correct or not?

Students felt that you 'just know' whether something is correct or not. When pressed, they suggested the internet to find out, or asking a scientist. Some students suggested that everything seen in movies or on TV should be doubted. Others felt that it depended on what was being watched. *The Simpsons*, for instance, was a cartoon, so anything mentioned in it should not be taken seriously. Hollywood movies, by contrast, were thought to be more reliable.

Unit 3: *Dante's Peak*

- Did you enjoy *Dante's Peak*?

Students said the movie was 'okay'. None of them had seen it before, and one student said that she would never see it again either.

- What concepts in *Dante's Peak* were related to the unit we just studied?

Some students made the connection between oxides of sulphur (as studied in class) with the acidic lake that was formed as a result of a volcanic eruption. However, most students expressed surprise at this, and had not realized that the lake had become acidic because of sulphur oxides from the volcano.

- Did *Dante's Peak* help your understanding of the unit we just studied? Why or why not?

After all the students had made the connection between the oxides of sulphur causing an acidic lake, they became quite animated about whether what was shown in the movie was actually possible. Students felt that their knowledge about the exact contents of the tenth grade chemistry course curriculum had not increased. However, they had been unaware of the fact that natural phenomena, such as volcanic eruptions could produce acidic oxides of sulphur.

- Are there any problems with using non-academic movies/TV shows in class to help with understanding of a (science) topic?

The students in this section were somewhat ambivalent about the use of non-academic TV shows/movies in a classroom setting. Some suggested that "it would be okay" or "more fun than listening to a lecture", but the researcher was unable to get a proper discussion started on this point.

- Do you think content in non-academic movies/TV shows is always correct?

Students said it was not possible for all the content in movies/TV shows to be accurate, given the wide spectrum of subjects and topics these movies/TV shows contain. However, there was the general feeling that if the movie was about 'real life', than the contents would be accurate. A student brought up the example of movies such as *Schindlers List* and *The Red Baron*, that were set in the past and mostly accurate in their historical detail and content (according to students' perceptions).

- Do you think all the science presented in *Dante's Peak* was correct?

Students said they did not know that much about volcanoes as they had never studied these or other such geological phenomena. They assumed that what was shown in the movie was correct as it 'looked right'. They were unsure about whether a body of water would become as acidic as quickly as shown in the movie, and whether the acidity would be high enough to dissolve organic matter such as bones in a few minutes, as was depicted. There was some debate about this, and when the researcher pointed out that this was something the class had discussed during the previous lesson, one student argued that though it may not be likely, it could happen, in which case the movie was not strictly inaccurate. Some students also wondered whether the robot shown in the movie existed, and whether people actually studied volcanoes in the manner that was shown.

- How do you know whether science presented in movies/TV shows is correct or not?

It was generally the opinion of the students that you cannot actually know whether the science or other content in movies/TV shows was correct unless it was researched. Most students suggested the internet. One student felt that eventually, a good education would allow you to filter through incorrect information.

Results from teachers interviewed

Discussions were held with the teachers ($n = 3$) after completion of the classroom research. The interview was unstructured in nature; themes for the discussion were adapted from those used with students, given in Appendix C. The main points from the teacher interviews are given below.

- Can movies/TV shows help students understand science better? Why or why not?

Generally, teachers felt that movies/TV shows containing science can excite students about the subject, and spark their curiosity and imagination. It was felt, however, that students would also have difficulty in recognizing science presented incorrectly in movie/TV shows, and therefore movies/TV shows may not necessarily help students understand the subject better. All three teachers stated that students of this age did not analyse the information being shown to them, and there was thus a danger of students gaining incorrect knowledge.

All three teachers felt that showing movies/TV shows in a formal classroom would only be useful if there was an analytical discussion following the movie/TV show, in which the teacher helped clarify differences between fact and fiction. However, the three teachers interviewed said that they did not often use movie/TV shows in class. One teacher pointed to a lack of time. Additionally, one teacher also said that he would only show movies/TV shows if it contained scientifically accurate information, as he did not want students to gain erroneous information.

- Do you think all the science presented in movies/TV shows is correct?

Teachers generally agreed that movies/TV shows contained science that was incorrect. They felt that, as adults, they did not need to know exactly which information was presented inaccurately in movies/TV shows, for they automatically viewed such media with skepticism.

CHAPTER 5: CONCLUSION

Overview of the study

This research study aimed to examine the effects of non-academic audio-visual media on the scientific knowledge of students' in grades 6 through10. Research was conducted at a private school in Ankara, Turkey, over the course of four months. Data, in the form of interviews, group discussions and responses to questions were gathered from 239 students and their four teachers, of which the researcher herself was one.

The research was done in two components, the first with a group of students from grades 6-8 who had volunteered to participate in this research project as part of their extra-curricular programme at school. This group, called the Focus Group, met once a week, and watched a television (TV) show and a movie containing scientific information that was not directly related to any material being covered in the grade 6 through 8 science curriculum. Students were asked questions regarding the scientific content contained in the TV show and movie before and after they had seen it. Responses to these questions were used to guide the discussion held with the students after the viewing of the TV show and movie, the results of which were organized thematically.

CHAPTER 5: CONCLUSION

Overview of the study

This research study aimed to examine the effects of non-academic audio-visual media on the scientific knowledge of students' in grades 6 through10. Research was conducted at a private school in Ankara, Turkey, over the course of four months. Data, in the form of interviews, group discussions and responses to questions were gathered from 239 students and their four teachers, of which the researcher herself was one.

The research was done in two components, the first with a group of students from grades 6-8 who had volunteered to participate in this research project as part of their extra-curricular programme at school. This group, called the Focus Group, met once a week, and watched a television (TV) show and a movie containing scientific information that was not directly related to any material being covered in the grade 6 through 8 science curriculum. Students were asked questions regarding the scientific content contained in the TV show and movie before and after they had seen it. Responses to these questions were used to guide the discussion held with the students after the viewing of the TV show and movie, the results of which were organized thematically.

The second component of this research project was conducted in science classes for grades 6-8 and in physics classes for grade 9 and chemistry classes for grade 10. Students at each grade level, divided into three sections, watched a movie or TV show on rotation, that contained content directly related to their course of study. All students were asked questions regarding the content of the unit that they were about to study before the unit started; at the end of the unit, one section watched the TV show or movie that contained some content related to the unit, while the remaining two sections did not. All students were then asked the same questions again, and changes or differences in responses amongst the sections were noted. These questions were then used as a basis for discussion that the regular classroom teacher had with the students regarding the scientific content of the movie/TV show. These discussions were organized thematically to identify emerging patterns.

Results from the Focus Group component of the research were examined by gender and grade level to see if these factors had an impact on how students understood the scientific knowledge contained in the movies/TV shows and their ability to relate this information to science in the classroom. Results from the classroom were only examined by grade level. General trends were identified and related to past research.

A discussion was also held with the teachers who participated in the research, about their perceptions of the use of non-academic TV shows and movies as a teaching tool.

Discussion of the findings

Findings from this research have been presented as responses to the questions that the research set out to answer.

The Focus Group component of this study shows that students' scientific knowledge was impacted by the viewing of a TV show or movie, which contain scientific content. Results in Table 6 show that students learned information from watching *The Simpsons: Tomacco*, both scientific and otherwise. Table 6 also details that more students attempted more questions after having seen the cartoon than before, suggesting that they felt that they knew more after they had seen the cartoon, as compared to before. This trend is also seen from results (Table 11) of the second Focus Group session that watched *Indiana Jones and The Kingdom of the Crystal Skull* over a five week period.

As the scientific content of both *The Simpons: Tomacco* and *Indiana Jones and The Kingdom of the Crystal Skull* is not specifically part of the grade 6-8 science curriculum, it is of interest that students generally believed the information presented in this cartoon and movie without questioning it. Some of the content of *The Simpsons: Tomacco* and *Indiana Jones and The Kingdom of the Crystal Skull* which students were questioned about was presented accurately, such as the fact that tomatoes do grow above ground and that quartz is a crystal. However, other content was shown incorrectly, such as the gunpowder in *Indiana Jones* which was shown to be magnetic. Following the viewing of the movie, more students accepted that gunpowder may be magnetic without applying previously learned knowledge (magnetism is part of the Elementary School curriculum) to what they had just seen.

It is also interesting to note that on responses to questions, students especially believed abstract concepts about which they may have no previous knowledge, such as radioactivity. Radioactivity was included in both *The Simpsons* and *Indiana Jones*. In *The Simpsons*, plutonium was shown to glow in the dark. More students said that plutonium does not glow in the dark before watching the cartoon than after, indicating that students had accepted the misinformation presented in the cartoon without hesitation (Table 6). By contrast, in the same cartoon, the characters were shown to be eating thistle and tumbleweed; more students understood that this was not possible after they had seen the cartoon and had recognized tumbleweed and thistle as types of grasses that cannot be digested by humans, than before watching the cartoon.

In this latter case, where students acquired knowledge about grasses, it could also be that as English is the second language of most of the students at Bilkent Laboratory and International School (and therefore for most of the students who participated in the Focus Group) that the students were unfamiliar with the words thistle and tumbleweed when asked about these before watching the show. After having seen the cartoon, the students may have associated the words with the grasses shown, and thereby been able to answer the question correctly. Research indicates that cartoons can be used effectively to acquire or improve skills in a different language (Jylha-Laide, 1994). Rucynski (2011) in fact advocated the use of *The Simpsons* cartoon series in teaching non-native speakers English. He suggested that the global popularity of the cartoon means that students in other cultures may already be familiar with the context, and thereby learn English more easily (as they are not focusing on getting to know the characters).

In *Indiana Jones and The Kingdom of the Crystal Skull*, a nuclear explosion resulting in a mushroom cloud was shown, and the lead character, Dr. Indiana Jones, was given a chemical shower to get rid of the explosion's radioactive effects. Students were less confident about attempting the question on how to get rid of nuclear radiation after having seen the movie than before seeing it (Table 11). This was the only question in session 2 of the Focus Group where fewer students attempted the question after having seen the movie than before. As well, more students seemed unable to relate a mushroom cloud to a nuclear explosion after having seen the movie (which depicted this quite clearly) than before. Barnett and Kafka (2007) suggested that fictional movies are particularly effective in blurring the lines between fact and fiction for phenomena that the audience may not have seen. Thus, students, who have most likely never seen a radioactive substance or a cloud formed by a nuclear explosion, may believe the information in *The Simpsons: Tomacco* and *Indiana Jones and The Kingdom of the Crystal Skull* as depicted.

Similar conclusions may be drawn from the data collected from the second component of the research done in science classes, though the trends are not as strong as those seen in the Focus Group, due to limitations and lack of control in the data collection technique. The movie/TV show seen by the students contained knowledge that directly related to content that was being covered in their science class. It can be seen from Table 21 that 10th grade students who watched *Dante's Peak* were influenced by incorrect concepts presented in the movie, and thus showed the lowest increase in learning as compared to the two sections that had not seen the movie. Similarly, from Table 15, it can be seen that 6th grade students who had watched *Journey to the Centre of the Earth* too showed the lowest gain in knowledge as compared to their peers who had not seen the movie.

Thus, it can be said that students learn information (or misinformation as the case may be) from the movies and TV shows they see, irrespective of whether the content of the movie/TV show directly relates to content being studied in school or not. This is in keeping with research done by Barnett et al. (2006) who found that students could acquire knowledge from a movie even after a single viewing. Ongel-Erdal et al. (2004) questioned the use of movies as a teaching tool for this very reason, as students may easily learn misconceptions from viewed movies/TV shows. As well, this study found that students do not relate knowledge learned in the classroom to what is being depicted on screen. Gordon and Eifler (2011) suggested that this could be because young people in particular do not have the critical thinking ability with which to watch movies/TV shows, and that the power of Hollywood special effects is such that the images presented on screen would be far more persuasive than anything in real life. These researchers suggested that students be given tools and strategies for comprehending the form and content of the information contained in TV shows/movies, and relating it to their every day lives.

The fact that students are unable to relate classroom learning to what they see in movies/TV shows is also indicated from the results of the discussions that were held with the students after the end of the movies/TV shows. After watching *The Simpsons: Tomacco*, students were uniform in their opinion that there was no science in *The Simpsons* (despite the cartoon containing concepts of genetic engineering, radioactivity and plant growth). When asked if they had learned any science from the cartoon, students said that there was no science to learn from *The Simpsons*. While a few students were able to connect concepts from *Indiana Jones and The Kingdom of the Crystal Skull*, such as the field of archeology relating to fossils (as had been mentioned in the sixth grade BLIS science course), most students felt that content of the movie (such as magnetism) was not the same as that which they had ever studied in school. When asked about any scientific content in the movie, students again said that there was no science to learn from the movie.

For content in movies that related directly to information being covered in the classrooms, discussions held with the 10^{th} grade students also indicated similar patterns. During the discussion, students were unable to connect Sherlock Holmes' problem solving techniques to the scientific method even when prompted. As well, most students did not connect the content of *Dante's Peak* to the entire unit they had studied on sulphur and its oxides. In fact, in this case, students who saw the movie accepted that acids can dissolve human bones in a matter of minutes (as shown in the movie) despite a discussion on this being held in class prior to the viewing of the movie, in which it was explained by the teacher that even the most concentrated of acids would probably not be able to react with bones that quickly. When reminded about this during the end of movie discussion, students were more inclined to argue that an extremely strong and concentrated acid could, in theory, dissolve bones in a matter of minutes, than remember what was learned during class. Again, this could be because, as suggested by Gordon and Eifler (2011), the images presented in *Dante's Peak* were so persuasive and different to that which been covered in class that students were unable to make the connection between the content of the movie and that of the lessons on the oxides of sulphur.

Students who viewed *The Simpsons: The Movie* were able to understand the cartoon related to environmental concerns that had just been studied during the previous unit. Tenth grade students were skeptical of any science presented in the cartoon, and some also took note of the fact that the cartoon made fun of the rather serious issues relating to the environment. Some students felt that it was improper to jest about environmental issues, which is also supported by a report by the National Research Council, as cited by Cavanagh (2009) that argued that informal science may lead to more civic engagement on science issues such as the environment.

It is of interest to note that 10th grade students were skeptical of any science presented in the animated cartoon movie *The Simpsons: The Movie*, yet students from this same grade level were willing to believe content presented in the (non-animated) movie *Dante's Peak*, despite the fact that material that was presented incorrectly in the movie had been directly covered in class. While no research was found that examined the perceptions of 10th grade students specifically to cartoons as compared to non-animated movies, there has been work done in the past on how children perceive and learn from cartoons. Grace (2005) cites the work of Hodge and Tripp (1986), who demonstrated that most children can distinguish between reality and fiction in cartoons by the age of 6. This would indicate that students of the tenth grade level, who are much older, would have no trouble distinguishing between what was real and what was not in the cartoon *The Simpsons: The Movie.* However, this may not be the case when considering scientific content in a cartoon.

Research done with elementary school students indicates that children of this age are unable to discern between science and pseudo-science in cartoons (Fisch, Yotive, Brown, Garner & Chen, 1997). These researchers pointed to previous research that suggested that even college students may have difficulty differentiating between real science and that which is not, though this work was done on audio-visual media other than just cartoons (Crelinsten et al. 1991; Fleming, 1998; as reported in Fisch et al. 1997). It may be, as Gordon and Eifler (2011) suggested, that students were unable to see through the skillfully created imagery presented in the movie *Dante's Peak*, but were able to do this in an animated cartoon *The Simpsons: The Movie*. In this particular case, as all the science in *The Simpsons: The Movie* was not plausible, students at the tenth grade level had no trouble classifying it as such.

By examining the data collected for this research, it can therefore be said that non-academic audio-visual media containing scientific concepts does have an impact, albeit small, on student's knowledge of science, whether that knowledge is directly being taught in a classroom or not. This is in keeping with past research done by Barnett et al. (2006) who found that a movie containing scientific information could impact students' understanding about a particular concept. Additionally, students seem unaware of the fact that they are learning scientific information (or misinformation) from the TV shows and movies seen, as the knowledge acquired through informal methods (such as through TV shows and movies) is not being related to classroom knowledge by students of this age range. Therefore, the research done by Shaw and Dybdahl (2000) becomes all the more important, as these researchers suggested that teachers must actively incorporate knowledge acquired informally within the formal domain of a classroom, to break down any misconceptions that students may be gaining.

Impact of student age

The data were also organized by grade level, to see whether age was a factor in how students learned information from TV shows and movies. From data collected from the Focus Group, it can be seen that generally 6^{th} grade students gained the most information from the cartoon and the movie, though this increase is not statistically significant in all cases. Students of grades 7 and 8 also learned material from the movie, though perhaps not as much as grade 6 students (Table 8 and Table 13). This is not surprising as younger students would be expected to have relatively less knowledge and would therefore be able to learn more from the TV show and the movie. Following the viewing of *Indiana Jones and The Kingdom of the Crystal Skull*, all grade 6 students answered some questions correctly, although these results could be skewed due to the relatively smaller number of sixth grade students who participated in the research (as compared to the greater number students from the seventh and eighth grade who participated).

It is interesting to note that the grade 8 students did not necessarily have the most knowledge about scientific content of the TV show/movie, as would be expected. This may have been because of the particular students who participated in the research. It could also be that changes in the science curriculum at BLIS in recent years and the gradual implementation of the Primary Years Programme (PYP) while these students were in elementary school has meant that seventh grade students have studied certain concepts that students of the eighth grade had not.

Students from grade 6 were also more likely to accept incorrect information from *The Simpsons: Tomacco* episode, such as information relating to tobacco (Table 8). This could be because grade 7 and 8 students had prior knowledge about nicotine and tobacco, possibly learned through the pastoral care programme being taught at

BLIS, which addresses issues relating to smoking with the older grade 7 and 8 students.

Observations made by the researcher during the Focus Groups sessions showed that younger students were far more involved in the TV show and the movie than the grade 7 and 8 students. Sixth graders were more likely to sit towards the front of the raked Performance Wing seating, bringing them closer to the screen. In addition, these students were less likely to talk during the screening than grade 7 and 8 students who seemed to be discussing either the content of the movie or other matters during the time that the cartoon and the movie were being shown. This may also account for the grade 6 student absorbing more content from the cartoon and movie than students of grade 7 and 8.

It was noted that older students were more vocal in the discussion following the viewing of the cartoon and the TV show. However, it could be that younger students were less likely to voice their thoughts in the presence of their older peers. Comments made by older students were more insightful and analytical, which is unsurprising. Younger students pointed out more obvious things that were presented incorrectly in *The Simpsons* and *Indiana Jones and The Kingdom of the Crystal Skull* such as people being yellow and buildings floating over the surface of the Earth. However, it was grade 6 students who related the field of archeology to fossils, possibly because fossils were part of their second unit of study in sixth grade, and it had been mentioned in class that archeologists study fossils. Grade 7 and 8 students, by contrast, were better able to point out more subtle concepts in both the cartoon and the movie that had been presented incorrectly.

Research tells us that as children reach their teenage years, they are able to think in more abstract and analytical ways, and they are also able to process information faster. Younger children, by contrast, have less of an ability to see the abstract, or to analyze. This has to do with the gradual development of the brain (Crane & Hannibal, 2009). Students from grade 6 are just entering their teenage years, and therefore, their ability to analyze and process information would be less developed than that of eighth grade students. This would support findings of this study, where the younger students were less analytical about what they had seen. When combined with the findings presented by Fisch et al. (1997), it may be said that younger students were less analytical in their thinking, as shown in this research, and therefore had a harder time distinguishing between fact and fiction.

When considering research conducted in the science classes, no patterns could be seen in the data examined over the five year age range, for whether (and how) age was a factor in how students learned science from informal sources. This could be because of the number of variables present, such as different teachers teaching the same course and deviations in the data collection methodology. Additionally, data from the discussions held with grade 6 through 9 students could not be used. Thus, this component of the research does not indicate whether age was a factor in how science learned through movies and TV shows affects knowledge gained in a formal classroom setting.

Data gathered from the tenth grade (all sections taught by the researcher), however, indicate that students did learn content from the TV show and movies shown. The data again showed that students of this age did not connect the content of what was being shown on screen to that which was being studied in class (Table 22) perhaps being unable to process the information as suggested by Gordon and Eifler (2011). It is interesting to note that students of this age were able to appreciate the satire presented in the cartoon movie *The Simpsons: The Movie* and were dismissive of any scientific content that was contained in the cartoon movie. However, when watching *Dante's Peak*, which is not a cartoon and uses all the glamour and special effects that Hollywood is known for, students were far more accepting of scientific content that the movie depicted than what a cartoon movie had portrayed, even though the concepts presented were ultimately wrong. This result concurs with the work of Barnett et al. (2006), which found that students do learn from watching movies. It also highlights the point that Ongel-Erdal et al. (2004) make, that movies and TV shows create misconceptions in the minds of students that formal education may not always be able to counter.

Tenth grade students did not make the connection between *Sherlock: A Study in Pink* and the scientific method. This could have been because, although Sherlock Holmes is shown to be following a method of problem solving during *Sherlock: A Study in*

Pink, his method was not in the clearly defined steps that were taught in class. In addition, some students struggled with the British English of the TV show, and had difficultly following the hypotheses based on evidence that Sherlock Holmes makes in the show. While hypothesising is taught in all grades in science courses at BLIS, it may be that students did not understand that a hypothesis made about an outcome of an experiment based on data actually is similar to a hypothesis made using evidence from a crime scene. This would lend weight to the suggestion put across by Doherty (2003), who said that TV shows such as *CSI* had removed the element of hypothesizing about a crime. While students did not watch *CSI* for this research, it could be, as Doherty (2003) suggested, that students were not aware of the hypotheses that Sherlock Holmes was forming in *Sherlock: A Study in Pink.* This is validated by results from the discussion with the students after they had seen the show where they said that Sherlock Holmes was jumping to conclusions based on what he saw (rather than formulating hypotheses).

Research suggests that students in the middle of their teenage years (grade 10 students) should have sufficiently developed their mental abilities to be able to carry out more abstract tasks such as hypothesizing, based on evidence, and to think analytically (Crane & Hannibal, 2009). Indeed, this skill is taught in all science courses, and students are asked to formulate hypotheses for their own annual science fair projects at BLIS. Thus, they should have noticed Sherlock Holmes stating his hypotheses in *Sherlock: A Study in Pink.* It is unclear from the present research whether the students not being able to see the element of hypothesis making in

Sherlock: A Study in Pink was due to their difficulty in following the language of the show, a lack of mental application or, as Doherty (2003) suggested, the fact that the genre of TV detective fiction is changing in that TV detectives no longer make hypotheses.

It can be concluded, then, that age is not a factor in the scientific content that students learn from informal sources such as TV shows and movies, though the exact information that students learn from the movie/TV show and their ability to analyze it may depend on age. Younger students are susceptible to learning what is shown on screen, not having the necessary analytical skills to break down the information that is shown (Crane & Hannibal, 2009). Older students, too, can succumb to the charm of Hollywood, if it is presented in a convincing manner. The effect was so great, in fact, that tenth grade students 'unlearnt' some of the material that had been taught in class, choosing to believe what was shown in *Dante's Peak* over what had been delivered during class room lessons (Table 22). This is supported by research done by Kirby (2003) who pointed out that scientists are being employed by Hollywood for this very purpose - to make the science in TV shows and movies seem plausible even if not necessarily correct. Fisch et al. (1997) also cited previous research to show that even college students may have difficulty understanding real science from pseudo-science, if the content is portrayed in a convincing manner.

This is especially significant when considering the research of Durnal (2010), who found that 40 % of the science on shows such as *CSI* simply does not exist. Whereas teachers may be able to break down some of the knowledge acquired by students through informal ways, this is not always possible. Thus, young people may continue to have misconceptions about science due to watching movies/TV shows throughout their school careers, as age does not seem to be a factor in students' acquiring information through movies. This was also argued by Ongel-Erdal et al. (2004) who were skeptical about the use of movies as a teaching tool because of the misconceptions they may cause in the minds of students.

Impact of student gender

Results were also analyzed to see if student gender was a factor in whether and how students learned science from informal sources. This is especially important as past research (Barriga et al., 2010; Cavanagh, 2009) indicated that gender can play a role in how students view science and learn it from informal sources, such as TV shows and movies.

Results from the Focus Group indicate that boys learned more information than girls, although the difference between boys and girls was not statistically significant. It also seems that the boys had more knowledge than the girls about the information shown in the cartoon and movie before watching them (Table 9 and Table 14). It is unclear, however, whether the difference in results were due to the particular girls and boys who were part of this study, the content of the movie and cartoon or are a general trend for a greater population.

It is interesting to note that for *The Simpsons: Tomacco*, far more boys than girls knew what a duel was. While a duel is not related to science in any way, it is of interest that as dueling might be considered quite a masculine concept, more boys knew what this was. Past research indicates that boys are more aggressive in play and their play is more violent than that of girls (Dominick and Greenberg, 1971; Sobkin, Abrosimova, Adamchuk & Baranova, 2005). In view of this, it could be hypothesized that boys were far more likely to fight, and therefore know what a duel is. Similarly, many more boys knew that the addictive substance in tobacco was nicotine before watching the cartoon than girls. Again, it could be that at this age, boys would be far more likely to be curious about smoking than girls. Research done by Can et al. (2009) in Turkey showed that more adolescent boys than girls smoke. Additionally, research conducted on grade 8 students in Canada indicated there were more male smokers than female smokers at this age (van Roosmalen and McDaniel, 1992). While these studies was not specific to BLIS or even Ankara, the greater incidence of smoking in adolescent boys in Turkey could explain why boys knew more about smoking than girls, when asked during the course of this research.

Similarly, for *Indiana Jones and The Kingdom of the Crystal Skull*, boys generally did better on answering questions than girls, both before and after seeing the movie. This was especially true for Questions 5 and 6, relating to mushroom clouds and nuclear radiation (Table 15). It could be hypothesized that the science concepts presented in the movie were mostly related to physics, a discipline that is traditionally seen as masculine as compared to chemistry and biology (Durham &

Brownlow, 1996; Murphy &Whitelegg, 2006) This may be why the boys not only knew more about these concepts before they watched the movie, but also why they gained more information about these concepts from the movie as compared to the girls.

In fact, research done by Durham and Brownlow (1996) found that in TV cartoons, other than *The Simpsons*, male characters were often depicted using science and technology, and being aggressive, whereas female characters, when using science and technology, were more likely to use it for a greater good. This could explain why girls generally did less well on questions relating to physics for not only was the content masculine, but there was no 'good' female lead character, who was using science to solve problems.

In addition, girls were more susceptible to believing incorrect information from *Indiana Jones and The Kingdom of the Crystal Skull* than boys (Table 15). More girls believed that gunpowder was magnetic after watching the movie than before, whereas there was no difference in the knowledge of the boys. Similarly, more girls got Question 5 wrong after watching the movie, believing that nuclear radiation can be easily got rid off, than boys, who showed a gain in knowledge for this question after watching the movie, despite the information being presented incorrectly (in the movie). Again, the fact that these concepts were related to physics, could be why the girls' believed what was presented on screen, whereas the boys had prior knowledge about magnetism and radiation.

Work done by Barriga et al. (2010) showed that men were more likely to spot mistakes in movie science if the science was central to the plot, whereas women were able to see errors in movie science more easily if the science presented was peripheral to the plot. The results of this study do not echo the findings of Barriga et al. (2010), who conducted their study on adults, and also just showed segments of movie, rather than entire movies. This study also did not distinguish between whether the science was central or peripheral to the plot. Therefore, direct comparisons cannot be made between the findings of Barriga et al. (2010) and this study.

It is interesting to note here that a different study questioned the difference between science and technology (Fisch et al., 1997). These researchers examined how young children's perceptions of science varied when they viewed educational and non-educational cartoons. Their results indicated that students under the age of 11 had difficulty differentiating between science and pseudo-science, and also did not differentiate between an educational and non-educational cartoon. Fisch et al. (1997) state that children as young as these have difficulty with the difference between science and technology. However, it may be the case that even older students do not see science and technology as being different, and that attempts to understand how students learnt science from a movie or TV show may actually be measuring students understanding of technology. While this was not a limitation in this present study (as the movies/TV shows shown had very little technology), further research would need to be done to understand how students view the differences between science and technology.

Observations made by the researcher during the showing of the movie and cartoon to the Focus Group made it clear that the girls viewed this activity to be a far more social event than the boys. The girls were generally chattier during the time that the cartoon/movie was being shown. As well, they were far less inclined to take the questions seriously or to think through their answers. In fact, many of the girls said that they did not know answers to any of the questions asked, and had to be encouraged by the researcher to even guess at an answer.

This difference between girls and boys' demeanor and attitude toward the activity could be because girls at this age are often extremely social, and tend to get involved in activities in intimate groups (Simpkins, Parke, Flyr, & Wild, 2006). The researcher also observed that it was a group of friends who had signed up to be part of this research, and therefore were a lot more talkative and animated, perhaps paying less attention to what was happening on screen. The boys, on the other hand, tended to sit alone and even when they did sit with friends, they talked less amongst themselves. This might explain why the boys generally showed more knowledge after the cartoon and movie as they had been paying more attention.

However, during the discussions held after the cartoon and the movie, it was generally the girls who were more vocal than the boys. The girls were far more expressive about their opinions, which they were less willing to discuss than to state. By contrast, the boys were willing to debate points and accept another's point of view. Again, it is unclear whether this is because of the particular girls and boys involved in this research or if this is a general trend amongst a greater population. It could also be said that as the movie and cartoon both did not contain strong, good, female lead characters, that the girls were less interested in the movie and cartoon, and therefore less willing to discuss it.

Results of this research are thus different to those done in the past, which attribute girls becoming more interested in science because of TV shows like *CSI* (Cavanagh, 2009). Data in Tables 9 and 13 indicate that girls acquired information (and misinformation) from the movie and the cartoon, though the difference in girls and boys learning from the cartoon and movie was not statistically significant. Qualitative observations made by the researcher suggested that the girls were less interested in the cartoon and movie, based on their willingness to discuss the movie/cartoon and the amount of attention they paid when the movie/cartoon was being shown. However, it must be noted that *Indiana Jones and The Kingdom of the Crystal Skull* did not contain a strong female character who was shown in a positive light. Similarly, in *The Simpsons*, the female character Lisa, who is shown to be fond of science, is not as prolific or appealing as the male characters. This may also have contributed to the girls being less interested in the cartoon and movie as there was no character that they could clearly identify with.

Student perceptions

Observations made by the researcher during this study indicate that students were very excited about watching a TV show or movie during their class time. That the movie or TV show contained science that could help the students' knowledge and understanding about a particular content area was never mentioned by the students.

Following the discussions held with the Focus Group, it can be hypothesized that the animation of *The Simpsons: Tomacco* led students to believe that the show contained no science. This was similar to what the grade 10 students felt, after watching *The Simpsons: The Movie*. This is of interest as both *Tomacco* and *The Simpsons: The Movie* contained scientific concepts. While tenth grade students were able to pick up on some of these concepts, it was generally the case that the students did not take the cartoon seriously. In contrast, students from both the Focus Group and tenth grade were far more likely to believe a non-animated movie/TV show (Tables 6, 11 and 22). This could be because a great deal of thought had gone into making the science look plausible in the non-animated movie and TV show, as indicated by Kirby (2003). Additionally, cartoons may be viewed as meant for children and thus not academic in nature (Mitchell, 1995).

Students from the Focus Group were not bothered by the fact that information could be presented incorrectly in movies or TV shows. It was generally thought that concepts that were presented incorrectly were not important to daily life, or that in due course, a teacher would correct the misconceptions. Additionally, these students did not connect any information from the cartoon or the movie to classroom content. Students mostly felt that if there was science in *The Simpsons* or *Indiana Jones and The Kingdom of the Crystal Skull,* then that science was completely different to what they studied at school. It is thus not surprising that these students did not see the point in watching such a movie or cartoon in class (other than for sake of enjoyment) for they felt there was no science in them.

Grade 10 students (the only grade level from whom the discussion questions were analysed) were, as expected, far more analytical than the grade 6 through 8 students who were part of the Focus Group component of the research. Tenth grade students felt that movies and TV shows that centered around science helped them see the discipline in a different way, and that they became more motivated about considering a career in science. This is validated by past research (Dubeck et al., 1990; Dubeck & Tatlow, 1998) that suggests that such movies and TV shows can help excite students about science.

Students at the grade 10 level too did not seem concerned about any erroneous information presented in movies and TV shows. It was generally felt that if one was educated, one would be able to see through the mistakes. Students did feel that for "other people", presumably those who were lesser educated, such movies and shows could create misconceptions, but that this didn't really matter as such content was rarely part of every day life. A few students felt that job portrayal may not be accurate, and could be disappointing for students who were seriously considering careers based on having watched a movie or TV show. This was also observed in the Focus Group component of the research when one student commented that he did not know that archeology was such an exciting job, following the viewing of *Indiana Jones and The Kingdom of the Crystal Skull.* However, according to Smallwood (2002) such misconceptions could be unimportant as the field of forensics specifically is happy to have students excited about it, despite the fact that shows such as *CSI* do not accurately portray what forensic scientists do. According to Smallwood (2002), forensic scientists are willing to deal with potential disappointments, such as differences in job responsibilities, once students have actually joined the field as professionals. It is unclear, however, how other disciplines address disappointments faced by young people who realize that jobs are not what TV shows/movies made them out to be, or whether this is even of concern.

It can be said that, generally, students did not connect information gained informally to that acquired through classroom teaching. As well, while students could pick up on the more blatant erroneous information presented in the movie and TV shows (dependent on age), more subtle inaccuracies would most likely go unnoticed, but this, in the minds of students, was not a major concern. Older students felt there was value in using TV shows and movies that contained science in the classroom as a tool to motivate students, but not necessarily to learn from. This is in keeping with previous research, which suggested the use of fictional audio-visual media as a tool to motivate and encourage students in the domain of science (Berumen, 2008; Cavanagh, 2009; Dubeck & Tatlow, 1998).

Perceptions of teachers

Four teachers took part in this research, of which one was the researcher. From discussions with the teachers, it became apparent that such fictional TV shows and movies were not used regularly in the classroom at BLIS as a teaching tool. This despite previous research advocating the use of movies and TV shows that relate to curricular topics as a teaching tool (Barnett & Kafka, 2007; Berumen, 2008; Champoux, 1999; Dubeck & Tatlow, 1998; Gardner et al., 2009).

One teacher pointed to time constraints and another said that she did not think movies/TV shows were a valuable teaching tool, and only showed them as substitute lesson plans, when she needed to be absent. One teacher said that he would only show movies/TV shows that contained scientifically accurate information as he did not want his students to have misconceptions about a topic. This is in keeping with Ongel-Erdal et al. (2004), who suggested that such audio-visual media created too many misconceptions in the minds of students to be effective. However, other researchers (Champoux, 1999; Czerneda, 2009; Berumen, 2008; Dubeck et al., 1990;) advocate the use of movies/TV shows in classes, as these can excite students, generate interest in science and help relate classroom knowledge to the practical application of science in the real world. The researcher herself has used movies and TV shows at the eighth and ninth grade levels, showing segments of the show and asking students to point out all erroneous information. This is a method advocated by Berumen (2008), who suggested that this type of activity improves critical thinking amongst students.

All teachers, including the researcher, felt that showing any kind of movie/TV show would only be useful if there was a discussion that followed so that students may work through the material presented under the guidance of the teacher. This is supported by previous research, which says that showing movies and TV shows can be an effective way of teaching critical skills, but this can only happen if teachers discuss the movie/TV show with their students, making clear the differences between fact and fiction (Berumen, 2008; Gardner et al., 2009). Researchers have pointed to other benefits of using TV shows and movies in classes, other than motivating students and teaching critical thinking. Marcus and Stoddard (2007) suggested that movies also build empathy amongst students, and present historical events in ways that may be unfamiliar to students.

Implications for practice

The findings of this study suggest that students may learn information, related to science and other subject areas, from the TV shows and movies they watch. This is in keeping with previous research which has examined the effects of non-academic media on students' knowledge (Barnett et al., 2006; Dhingra, 2003; Shaw & Dybdahl, 2000). However, students do not break down the information that they have just acquired and also do not question it, accepting that if it looks plausible, it must be.

This research also indicates that students of this age do not connect information that is presented in TV shows and movies to material that they may be studying in school currently, or may have studied at some point in the past. This may be the most important implication of this study, as it shows that students do not use knowledge acquired in a classroom in other areas (outside of the classroom). Connections must be made by teachers between what is being taught and the greater world. Barnett and Kafka (2007) suggested that with proper discussion, TV shows and movies can be used to bridge the gap between theory and practice. Even without the use of fictional audio-visual media, teachers must work hard to ensure that they are contextualizing the course content that is relevant to students, and in ways that students understand and are able to apply outside of classroom settings.

The implications of this on a classroom teacher are vast. While it is not possible for every teacher to keep up with every TV show or movie that is being watched by students, it certainly seems that teachers need to be aware of the informal sources that students are gaining their information from. Knowledge of popular culture would be beneficial to teachers, as most students of this age range watch the latest movies or TV shows. This would be beneficial as teachers would not only be able to relate to the lives of students, but also be able to break down misconceptions that students may be gaining from TV shows and movies, if the opportunity arises.

Shaw and Dybdahl (2000) suggested that deliberate efforts should be made to connect information obtained through informal means to formal classroom learning.

This would mean that teachers need to be aware of these informal sources and refer to as well as link content from popular TV shows and movies to classroom discussions where appropriate.

Findings from this research also suggest that students watching TV shows or movie containing science may start becoming more interested in science. This must be capitalized on by science teachers. The excitement and motivation that students gain from movies/TV shows could also be utilized upon further. Teachers may invite professionals linked to certain topics to not only show how science is used in real life, but also to answer students' questions about that career and help dispel incorrect portrayals of job descriptions created by TV shows and movies.

As well, while it is highly unlikely that the classroom can be made to look like the set of *CSI*, teachers may consider using scientifically accurate content from these TV shows/movies when teaching. Past research has already noted the increase of forensics units at middle school level (Tierweiler, 2006) following the success and popularity of *CSI*. Classroom teachers may consider developing other units based on other popular TV shows and movies to teach content that students may otherwise find dull.

While the majority of the teachers who participated in this research did not use informal TV shows and movies as a teaching tool, past research indicates that these (TV shows and movies) may be used effectively, if the teacher breaks down the movie/TV show after it has been seen (Berumen, 2008; Gardner et al., 2009). Movies/TV shows may also be used to point out scientifically inaccurate information given in the movie or in other, more creative ways, to not turn students off science (Czerneda, 2006). Teachers may be made aware of these findings and be encouraged to incorporate movies/TV shows into their lessons.

This study suggests that girls are less likely than boys to be interested in science, or in movies that contain scientific information. As the lack of women in science or science related fields has been and to some extent continues to be of concern, girls, in their school years, must be encouraged in science lessons, through the use of role modeling, after school clubs and other co and extra-curricular activities. Durham and Brownlow (1996) have pointed out that there are few cartoons that show men and women using technology and science equally. Using movies and TV shows, that show lead female characters in positive roles, who are actively using science, may also further inspire girls to consider careers in science.

Additionally, research examined for this study highlights the importance of media literacy amongst young people (Grace, 2005; Gordon & Eifler, 2011). Students must be taught how to view media with a critical and analytical eye, and understand the various pressures upon this industry, that influence how and why it presents content the way it does. These researchers suggest focusing on the audio-visual and electronic media, as this is most prevalently used by students, but could also be expanded to include print media. Whether media literacy would be taught as part of core subjects such as science, history and language arts, or as a separate course all together would require further research and discussion with school administration.

Implications for further research

This research indicates that more work must be done in the field of the effects of movies/TV shows on students' knowledge and understanding of particular concepts. As the sample size of the Focus Group study was small, the research could be redone with a greater number of students, to verify the results. In addition, the classroom research was centered around three topics at each grade level. This could be extended to include more topics, in order to see the effects of content on student learning from informal sources of information. Research should also be conducted on the scientific content of non-academic TV shows and movies, and these results be made available to educators and teachers.

Additionally, more research is needed on what role age and gender play on how and what students learn from TV shows and movies. The effects of gender are particularly important, as this study suggests that girls learned less information, but retained more incorrect information, than boys from a movie (Tables 9 & 13). This could be further studied by using a greater sample of students, and a wider choice of movies and TV shows that include strong female lead characters.

Comparative studies could be carried out on whether and how students learn science from non-fictional documentaries as compared to fictional movies/TV shows.

The influence of language as a factor in whether and how students learn science from fictional TV shows/movies could also be examined. Comparisons could be made between native English speakers with those for whom English is a second language.

As well, research could also be done using fictional and non-fictional print media, to examine whether and how students learn science from these sources. The role of age and gender could also be studied.

Limitations

As this research was done at a small, private school, the student participants, especially in the Focus Group component were few. Additionally, these students had volunteered to be a part of the research, which could indicate bias towards TV shows and movies. Therefore, any trends identified are in fact tentative only and based on a small sample size. The research should be repeated with a larger group of students, over a longer time period, using a greater variety of movies and TV shows to be able to generalize results.

Lack of controls when data were collected meant that much of the data from the second component of classroom research could not be used for analysis. The research could be repeated when a particular grade level was taught by the same teacher to eliminate changes in data caused by differences in teachers and teaching styles. The researcher (or one teacher) could hold all the discussions following the end of the movie/TV show to ensure uniformity. Additionally, the format of all questions asked (before and at the end of the unit) could be made the same. TV shows/movies would also need to be shown in their entirety, which was not always the case in this study.

The Focus Group watched only one animated TV show and one movie. *The Simpsons: Tomacco* was watched during a single forty minute session whereas the movie, *Indiana Jones and The Kingdom of the Crystal Skull* was viewed over a five week period. These variations in the time taken to see the movie/TV show may have upset the narrative structure of the movie for students.

As well, students in grade 6 through 10 at BLIS have varying fluency in the English language. While all students take all their subjects (except Turkish, Turkish social studies and foreign languages) in the medium of English, it is nevertheless true that there exist great differences in how comfortable students are with speaking, listening and understanding English. As all the TV shows and movies included in this research project were in English, some of which contained characters with heavy (non-Turkish) accents, students may have struggled to listen to and understand each word.

For further studies, the students' individual language skills would need to be taken into account.

Also, the researcher herself conducted the research in the tenth grade and eighth grade classes, and the Focus Groups. Discussions with students from the tenth grade and Focus Groups could have been influenced by the researcher's own views about the science in the informal audio-visual media. Additionally, the researcher is female and a chemistry teacher, which, too, could influence students' perceptions about women in science. It is assumed that these influences were consistent throughout the data collection and that their effects can therefore be ignored. However, further research may be carried out by someone other than a classroom teacher, to eliminate these biases.

All research could be done in venues where the quality of screen projection and sound were equal. There were problems in certain classrooms as the speaker systems and/or projectors were not of a high quality, which meant that students may not have understood what was being said.

REFERENCES

Bakker, G. (2010, February 05). *The economic history of the international film industry*. Retrieved from http://eh.net/encyclopedia/article/bakker.film

Barnett, M., Wagner, H., Gatling, A., Anderson, J., Houle, M., & Kafka, K. (2006). The impact of science fiction film on student understanding of science. *Journal of Science Education and Technology, 15*(2), 179-191.

Barnett, M. & Kafka, A. (January/February 2007). Using science fiction movie scenes to support critical analysis of science. *Journal of College Science Teaching, 36*(4), 31-35.

Barriga, C.A., Shapiro, M.A., & Fernandez, M.L. (2010). Science information in fictional movies: effects of context and gender. *Science Communication, 32*(1). Retrieved from http://scx.sagepub.com/content/32/1/3 doi: 10.1177/1075547009340338

Berman, R., Taylor, J., Biller, K., Braga, B. (Producers), & Braga, B. (Director). (1997). *Star Trek Voyager* [Television series]. USA: Paramount Television.

Berumen, M.L. (2008, December). "Life" in movies. *The Science Teacher*, *75*(9), 26-31.

Brooks, J. L., Groening, M., Jean, A., Scully, M., Sakai, R. (Producers), & Silverman, D. (Director). (2007). *The Simpsons: The Movie* [Animated motion picture]. USA: Gracie Films, Film Roman, Rough Draft Feature Animation, 20th Century

Fox Animation.

Burns, J. E. (1994, October). One for the books. *The Science Teacher, 61*(7), 38-41.

Can, G., Topbas, M., Oztuna, F., Ozgun, S., Can, E., & Yavuzyilmaz, A. (2009). Factors contributing to regular smoking in adolescents in Turkey. *Journal of School Health, 79*(3), 93-97.

Canton, N., Gale, B. (Producers), & Zemeckis, R. (Director). (1985). *Back to the Future* Motion picture. USA: Amblin Entertainment.

Cavanagh, S. (2009, October 28). Forensics courses becoming fixtures in classrooms. *Educational Week, 29*(9).

Collinson, P. (Producer), & Harper, G. (Director). (2008). *Dr. Who: Journey's End* [Television series]. UK: BBC.

Crane, J., & Hannibal, J. (2009). Developmental psychology: *Cognitive development. Psychology course companion.* Oxford: Oxford University Press.

Champoux, J.E. (1999). Film as a teaching resource. *Journal of Management Inquiry, 8*(2). Retrieved from http://jmi.sagepub.com/content/8/2/206 doi: 10.1177/105649269982016

Czerneda, J. E. (2006, February). Science fiction & scientific literacy. *The Science Teacher, 73*(2), 38-41.

Dhingra, K. (2003). Thinking about television science: how students understand the nature of science from different program genres. *Journal of Research in Science Teaching, 40*(2), 234-256.

Doherty, T. (2003, October 24). Cultural studies and 'forensic noir'. *The Chronicle of Higher Education, 50*(9), B15-B16.

Druger , M. (1988). Preface. In M. Druger (Ed.), *Science for the fun of it. A guide to informal science education* (pp. 7-9). Washington DC: National Science Teacher's Association.

Dominick, J. R., & Greenberg, B. S. (1971). *Girls' attitudes towards violence as related to TV exposure, family attitudes, and social class* (Report No. 4). East Lansing: Michigan State University.

Dubeck, L.W., Bruce, M.H., Schmuckler, J.S., Moshier, S.E., & Boss, J.E. (1990, May). Science fiction aids science teaching. *The Physics Teacher*, 316-318.

Dubeck, L.W., & Tatlow, R. (1998). Using Star Trek: The Next Generation television episodes to teach science. *Journal of College Science Teaching, 27*(5), 319-323.

Durham, S., & Brownlow, S. (1996, March). *Sex differences in the use of science and technology in children's cartoons.* Paper presented at the Annual Meeting of the Southeastern Psychological Association, Norfolk, Virginia.

Durnal, E.W. (2010). Crime science investigation (as seen on tv). *Forensic Science International*, *199*. Retrieved from www.elsevier.com/locate/forenciint doi:10.1016/j.forsciint.2010.02.015

Emmerich, R., Gordon, M. (Producers), & Emmerich, R. (Director). (2004). *The Day After Tomorrow* [Motion picture]. USA: Centropolis Entertainment.

Estes, S. (2003, November). Science fiction in science class. *Book Links*, *13*(2), 34.

Frank, S. (2012). Claiming Hollywood: Boosters, the film industry, and metropolitan Los Angeles. *Journal of Urban History. 38*(1), 71-88.

Fisch, S.M., Yotive, W., Brown, S. K. M., Garner, M. S., & Chen, L. (1997). Science on saturday morning: children's perceptions of science in educational and non-educational cartoons. *Journal of Educational Media, 32*(2-3), 157-167.

Forte, L. (Producer), & Saldanha, C. (Director). (2006). *Ice Age 2* [Animated motion picture]. USA: Blue Sky Studios.

Flynn, B, (Producer), & Brevig, E. (Director). (2008). *Journey to the Center of the Earth* [Motion picture]. USA: Walden Media

Gardner, G. E., Jones, M. G., & Ferzli, M. (2009). Popular media in the biology classroom: viewing popular science skeptically. *The American Biology Teacher*, *71*(6), 332-335.

Grace, D. J. (2005). Media literacy: What, why and how? *Educational Perspectives, 38*(2), 5-8.

Groening, M. (Producers), & Silverman, D. (Director). (2010). *The Simpsons: Tomacco* [Animated television series]. USA: Gracie Films, 20th Century Fox Animation.

Gordon, C. B., & Eifler, K. E. (2011). Bringing eyes of faith to film: using popular movies to cultivate sacramental imagination and improve media literacy in adolescents. *Catholic Education, 15*(1), 28-53.

Highest Box Office Film Gross. In *Guinness World Records*. Retrieved from http://www.guinnessworldrecords.com/world-records/10000/highest-box-office-film-gross

Holbert, R.L. (2005). A typology for the study of entertainment television and politics. *American Behavioral Scientist, 49*(3), 436-453.

Hurd, G. A., Singer, J., Herzberg, I. (Producers), & Donaldson, R. (Director). (1997). *Dante's Peak* [Motion Picture]. USA: Universal Studios.

Informal science learning. (2009, March). *The Science Teacher*, 14-15.

Jones, C. (Creator). (1945-2011). *The Road Runner* [Animated television cartoons]. USA: Warner Bros.

Jylha-Laide, J. (1994). Learning by viewing: cartoons as foreign language learning materials for children-as case study. *Journal of Educational Television, 20*(2), 93-109.

Kiernan, V. (1996, August). *Media exposure and knowledge about science.* Paper presented at the meeting of the Association for Education in Journalism and Mass Communication, Anaheim, California.

Kilby-Goodwin, K. (2010, summer). Putting the "Science" in "Science Fiction". *The Science Teacher*, 60-62.

Kirby, D.A. (2003). Scientists on the set: science consultants and the communication of science in visual fiction. *Public Understanding of Science, 12*. Retrieved from http://pus.sagepub.com/content/12/3/261 doi: 10.1177/0963663503123005

Kirikkaya, E.B., Iseri, S., & Vurkaya, G. (2009). High school students' thoughts about science on television programmes. *Procedia Social andBehavioral Sciences, 1*. Retrieved from www.sciencedirect.com doi: 10.1016/j.sbspro.2009.01.163

Marcus, A. S., & Stoddard, J. D. (2007). Tinsel town as teacher: Hollywood film in the high school classroom. *The History Teacher, 40*(3), 303-330.

Marshall, F., Lucas, G., Kennedy, K. (Producers), & Spielberg, S (Director). (2008). *Indiana Jones and The Kingdom of the Crystal Skull* [Motion Picture]. USA: Lucasfilm Ltd.

Mitchell, T. L. (1995). *"Kids' stuff": Television cartoons as mirrors of the American* *mind.* Canyon, Texas.

Murphy, P., & Whitelegg, E. (2006, September). Girls and physics: continuing barriers to 'belonging'. *The Curriculum Journal, 17*(3), 281-205.

Notten, N., & Kraaykamp, G. (2009). Home media and science performance: a cross national study. *Educational Research and Evaluation*, 15(4), 367-384.

Nunan, E.E, & Homer, D. (1981). Science fiction and teaching. *Science Fiction Studies*, *8*(3), 347-350.

Ongel-Erdal, S., Sonmez, D., &Day, R. (2004). *Science fiction movies as a tool for revealing students' knowledge and alternative conceptions*. Paper presented at NARST, Vancouver.

Reich, B. (2009, Summer). Education policy journalism in a new media age. *New England Board of Higher Education, 24*(1), 20-23.

Rucynski, J. Jr. (2011). Using "The Simpsons" in EFL classes. *English Teaching Forum, 49*(1), 8-17.

Samuelson, D. (1971, November). *A proposal for the mandatory use of science fiction in the general curriculum.* Paper presented at the meeting of the National Council of Teachers of English. Las Vegas.

Shaw, D.G., & Dybdahl, C.S. (2000, Summer). Science and the popular media. *Science Activities*, *37*(2), 22-31.

Simpkin, S. D., Parke, R. D., Flyr, M. L., & Wild, M. N. (2006). Similarities in children's and early adolescents' perceptions of friendship qualities across development, gender, and friendship qualities. *The Journal of Early Adolescence, 26*(4), 491-508.

Smallwood, S. (2002, July 19). As seen on TV. *The Chronicle of Higher Education, 48*(45), A8-A10.

Sobkin, V. S., Abrosimova, Z. B., Adamchuk, D. V., & Baranova, E. V. (2005). Manifestations of deviation in the adolescent subculture. *Russian Education and Society, 47*(7), 49-71.

Taraban, R., Box, C., Myers, R., Pollard, R., & Bowen, C.W. (2007). Effects of active-learning experiences on achievement, attitudes, and behaviours in high school biology. Journal of Research in Science Teaching, 44(7), 960-979.

Trierweiler, H. (2006, March). Crime scene science. *Instructor, 115*(6), 63-65.

TV guide names top 50 shows (2009, February 11). Retrieved from http://www.cbsnews.com/2100-207_162-507388.html

Turteltaub, J., Bruckheimer, J. (Producers), & Turteltaub, J. (Director). (2007). *National Treasure II: Book of Secrets* [Motion picture]. USA: Walt Disney Pictures, Jerry Bruckheimer Films, Junction Entertainment, Saturn Films.

Van Roosmalen, E. H. & McDaniel, S. A. (1992). Adolescent smoking intentions: gender differences in peer context. *Adolescence, 27*(105), 87-105.

Vertue, S., Cameron, E. (Producers), & Haynes, T., Lyn, E., McGuigan, P.

(Director). (2010). *Sherlock: A Study in Pink* [Television series]. UK: Hartswood films, BBC Wales, WGBH.

Yorn, J., Scott, T., Rogers, M., McLeod, E. (Producers), & Scott, T. (Director). (2010). *Unstoppable* [Motion picture]. USA: Telecinco Cinema, Scott Free Productions, Prospect Park, Millbrook Farm Productions.

Zimmerman, C., Bisanz, G.L., Bisanz, J., Klein, J.S., & Klein, P. (2001). Science at the supermarket: a comparison of what appears in the popular press, experts' advice to readers, and what students want to know. *Public Understanding of Science, 10*. Retrieved from http://pus.sagepub.com/content/10/1/37 doi: 10.1088/0963- 6625/10/1/303

APPENDIX A

Questions asked about the content of the TV show and movie shown to the Focus Group Session 1

1. What disease do raccoons have?
2. What is fertilizer?
3. Can tumbleweed and thistle be digested by humans?
4. Does plutonium glow in the dark?
5. It is possible to genetically engineer plants?
6. What substance in cigarettes is addictive?
7. What is a duel?
8. Do tomatoes grow above ground or are they a root (grow below ground)?

APPENDIX B

Questions asked about the content of the TV show and movie shown to the Focus Group Session 2

1. What is archaeology the study of?
2. What is a compass?
3. Is gunpowder magnetic?
4. If you were to talk about history, who would the 'reds' be?
5. How do we get rid of nuclear radiation?
6. What kind of explosion forms a mushroom cloud?
7. What is quartz?
8. What is quicksand?
9. Are crystals fragile (easily broken)?

APPENDIX C

Themes for classroom discussion following the airing of the movie/TV show.

To be asked of all students present, inviting responses from everyone:

- Did you enjoy the movie/TV show?
- What concepts in the movie/TV show are related to the unit we just studied?
- Did the movie/TV show help your understanding of the unit we just studied? Why or why not?
- Are there any problems with using non-academic movies/TV shows in class to help with understanding of a (science) topic?
- Do you think content in non-academic television shows/movies is always correct?
- Do you think all the science presented in the movie/TV show was correct?
- How do you know whether science presented in movies/TV shows is correct or not?

APPENDIX D

Questions asked of sixth grade students for the second component of data collection

Unit 1: Scientific Method

1. The first step in the scientific method is ______________________.
2. Scientists do many _____________ of an experiment, to make sure that their data is correct.
3. _______________________ is an educated guess, with reasons, on what you think is going to happen in your experiment.

Circle the correct answer:

4. The independent variable is:
    a. What you change during an experiment
    b. What you measure during an experiment
    c. What is kept the same during an experiment
    d. What is not measured during the experiment
5. Quantitative data is
    a. Data that you measure in numbers
    b. Data that you observe
    c. Data that you do not collect

d. Data that supports your prediction

Unit 2: Rocks and Weathering

1. What is the Earth made of?

2. If you were to dig towards the centre of the Earth, what would you find on the way there? You may use diagrams to aid your answer.

3. What is the core of the Earth made of?

Fill in the blanks.

4. The Earth's ________________ is made up of rocks.

5. A rock is formed from a mixture of _________________.

6. Minerals are usually chemical _______________.

7. The main rock types are ________________ and ____________________.

8. _________________ is the breakdown of rocks into smaller fragments.

9. Why do you find larger rock fragments deposited higher up a river, and smaller ones deposited lower down?

10. What are fossils?

11. List these in order of size, smallest first: Rock fragment, atom, molecule, grain

Unit 3: Earth and Beyond

1. What is at the centre of our solar system?
2. What two planets are closest to the Earth?

3. Is the Moon a planet? (Yes or no)
4. What did people a long time ago think was at the centre of the solar system?
5. What causes the seasons? (summer, winter, spring, autumn)
6. What is the sun? (a planet? A star? A satellite?)
7. Briefly describe the movement of the Earth.
8. Why does the moon change during the course of a month? (e.g. sometimes you see a full moon, and sometimes you don't).
9. Where does the Earth get light from?
10. Does sound travel through space?
11. Does heat travel through space?

APPENDIX E

Questions asked of seventh grade students for the second component of data collection

Unit 1: Scientific Method

1. The first step in the scientific method is ______________________.
2. It is important to do many ____________ of an experiment to make sure the data is correct.
3. ______________________ is an educated guess, with reasons, on what you think is going to happen in your experiment.

   Circle the correct answer:

4. The independent variable is:
   1. What you change during an experiment
   2. What you measure during an experiment
   3. What is kept the same during an experiment
   4. What is not measured during the experiment
5. Quantitative data is
   1. Data that you measure in numbers
   2. Data that you observe
   3. Data that you do not collect
   4. Data that supports your prediction

Unit 2: Rocks

1. The Earth's ________________ is made up of rocks.
2. A rock is formed from a mixture of ________________.
3. Minerals are usually chemical ________________.
4. The main rock types are ________________ and ____________________.
5. ________________ is the breakdown of rocks into smaller fragments.
6. Why do you find larger rock fragments deposited higher up a river, and smaller ones deposited lower down?
7. What are fossils?
8. List these in order of size, smallest first: Rock fragment, atom, molecule, grain
9. What is the Earth made of?
10. If you were to dig towards the centre of the Earth, what would you find? You may use diagrams to aid your answer.
11. What is at the very centre of the Earth?

Unit 3: Environmental Science

1. What is adaptation to the environment?
2. Give an example of an animal that has adapted to its environment, saying how it has done so.
3. What is the difference between predator and prey?
4. Give an example of a predator and its prey
5. What is the process by which animals adapt to their environment called?

6. Where does all the energy to Earth ultimately come from?

7. What is a producer? Give an example.

8. What is a consumer? Give an example.

9. What/who can use the sun's energy to make food?

APPENDIX F

Questions asked of eighth grade students for the second component of data collection

Unit 1: Scientific Method

1. The first step in the scientific method is ______________________.
2. Ways to improve an experiment are listed in the __________________ section of a lab report detailing an experiment.
3. ______________________ is an educated guess, with reasons, on what you think is going to happen in your experiment.

Circle the correct answer:

4. The independent variable is:
    a. What you change during an experiment
    b. What you measure during an experiment
    c. What is kept the same during an experiment
    d. What is not measured during the experiment
5. Quantitative data is
    a. Data that you measure in numbers
    b. Data that you observe
    c. Data that you do not collect

d. Data that supports your prediction

Unit 2: Energy Flow and Food Chains

1. Producers are able to make their own ________________________.
2. __________________ feed upon dead and decaying materials.
3. __________________ enters ecosystems as sunlight.
4. There are ________________ of energy between different trophic levels.
5. The energy in all ecosystems originally came from the ________________.
6. What does the term 'biomass' mean?
7. State the difference between a herbivore and a carnivore.
8. Define the term 'foodweb'.
9. State the type of food all primary consumers eat.

Unit 3: Nutrient Cycles and Population Size

1. What is a greenhouse gas?
2. Burning fossil fuel increases the concentration of which gas in the atmosphere?

2b. What effect do increased levels of this gas have on the environment?

3. Define 'Population'
4. Give two factors that affect the rate of population growth of an organism.
5. What is the most abundant gas in the Earth's atmosphere?

6. How does water vapour return to the Earth's surface? (In what form does it return?)
7. Why is carbon dioxide (CO_2) being blamed for the Earth's rising temperature?

7b. What is the process described in the question above called?

8. Can plants use atmospheric nitrogen gas?

APPENDIX G

Questions asked of ninth grade students for the second component of data collection

Unit 1: Motion

1. Define velocity. What are its standard units?
2. Define acceleration. What are its standard units?
3. Describe the slope (shape) of a speed vs. time graph for an object
   a. at rest
   b. moving with constant speed
   c. Moving with changing speed
4. If I know the increase of an object's velocity over a period of time, can I find the acceleration? If so, how?

Unit 2: Forces

1a. In physics, what is meant by a force?

1b. What are its standard units?

2. A rocket with mass=200kg is launched vertically into the air with a force of 3000 N. What is its acceleration? (ignore air resistance, g= 10 m/s^2)

3. In the picture below, calculate the upward forces exerted on the plank. The force due to the man is 500 N. (Ignore weight of plank, g= 10 m/s^2)

4. What is centre of mass?

5. When is a system in equilibrium?

6. Give an example of a system in equilibrium

Unit 3: Work, Energy, Power

1. Define work.
2. Define energy.
3. What are the SI units for energy?
4. Define Power.
5. What are the SI units for power?
6. Draw an example of an energy transfer diagram for a flashlight.
7. List two forms of potential energy and give an example of each.
8. Provide an example of a device that makes use of converting energy from:

a. chemical energy into light

b. electrical energy into mechanical (kinetic) energy

APPENDIX H

Questions asked of tenth grade students for the second component of data collection

Unit 1: Scientific Method

1. The first step in the scientific method is ______________________.
2. Ways to improve an experiment are listed in the __________________ section of a lab report detailing an experiment.
3. ______________________ is an educated guess, with reasons, on what you think is going to happen in your experiment.

Circle the correct answer:

4. The independent variable is:

a. What you change during an experiment

   b. What you measure during an experiment

   c. What is kept the same during an experiment

   d. What is not measured during the experiment

5. Quantitative data is

   a. Data that you measure in numbers

   b. Data that you observe

   c. Data that you do not collect

   d. Data that supports your prediction

Unit 2: Air and Water

1. What is acid rain?
2. How does acidity of ground water increase?
3. What damage can acidity in the water cycle do?
4. What are the major contributors to air pollutants?
5. What damage does pollution in air cause?
6. What process contributes most to the increasing levels of carbon dioxide being present in the Earth's atmosphere?
7. What is rusting?
8. What can be done to protect materials from corrosion or rusting?
9. Why is it especially harmful if the acidity of lakes and ponds increases?
10. We have hydrochloric acid in our stomach. This is a strong acid. Why does it not damage us?

Unit 3: Sulphur

1. How acidic is acid rain? (You may either give an approximate pH value or explain qualitatively).
2. List two properties of an acid.
3. Where do acidic gases in the atmosphere come from?
4. Are there any natural phenomenon that produce acid gases? If so, give the gas (es) and its source.
5. How can acids be neutralized?
6. What is the difference between a strong acid and a concentrated acid?

7. What unit is acid strength measured in?
8. What unit is acid concentration measured in?
9. Can strong and concentrated acids dissolve organic material like bones? If so, does this process occur rapidly?
10. Can strong and concentrated acids dissolve inorganic material like rubber? If so, does this process occur rapidly?