The Influences of Films on Child Perceptions of Science and Scientists

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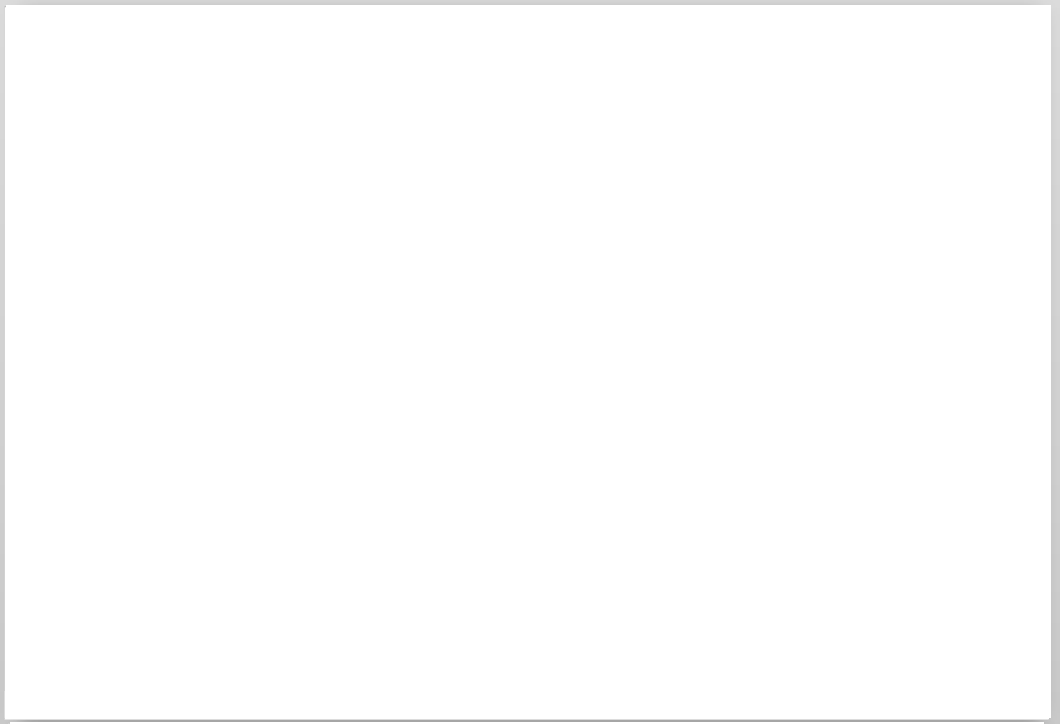
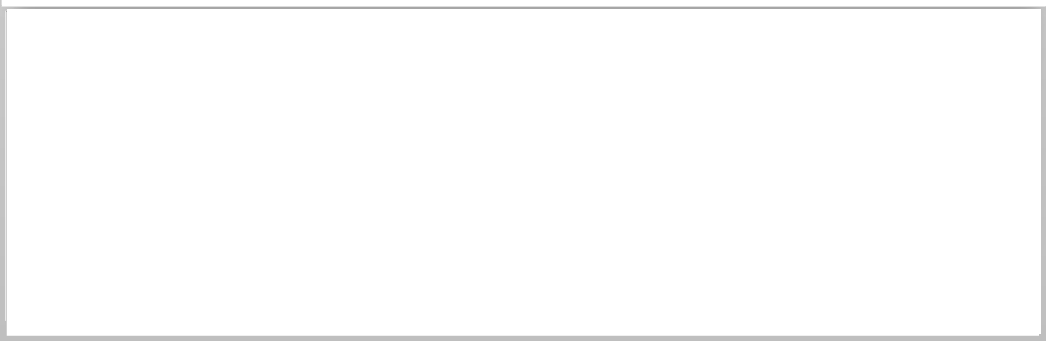
A thesis submitted to the University of Gloucestershire in accordance with the requirements of the degree of MSc. by Research in the Faculty of Applied Sciences
August 2015





Abstract

Many films contain science and scientists and therefore have the potential to influence audience perceptions of science and scientists. However, there is a lack of research on the influence that such films might have, particularly in children. This study examined whether children's perceptions of scientific principles, ethics and scientists was changed in response to film clips with scientific content with particular reference to age and gender.

Data were obtained from 181 students at the National Student Travel Foundation (NSTF) Science Expo in Malta. Younger (5-10 years) and older (11-16 years) classes of students watched four clips from films containing science or scientists then answered a series of open and closed questions on each clip that were designed to check their perceptions and whether the clips had influenced them.

The findings showed that students were influenced by both scientific content and the portrayal of scientists in film clips. Scientist characters in particular were able to shape student's opinions about science to be more positive or negative although attitudes towards both science and scientists were mostly positive overall. Males saw more possibilities in the future of science and prioritised excitement and results whereas females were more discerning about film content and focused on scientific testing and safety. Younger students displayed more stereotypes towards scientist appearance although both younger and older students succumbed to behavioural stereotypes.

Suggestions for future research and the wider applications of this study are made, particularly regarding the increase of film clips used as an educational tool and the discussion of scientists in lessons.

I declare that the work in this thesis was carried out in accordance with the regulations of the University of Gloucestershire and is original except where indicated by specific reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas.

Any views expressed in the thesis are those of the author and in no way represent those of the University.

Signed: Date: 26th August 2015

Acknowledgements

With thanks to the organisational help of the NSTF, particularly Becky Abela, for allowing me once again to be part of the Maltese Science Festival, and choose a topic which would enable me to conduct my research there. I appreciate the help with funding this trip provided by the NSTF and the University of Gloucestershire. Thanks also to MCAST for the use of their facilities in Malta, and to Adam Hart and Richard Rolfe for their assistance with every step of creating this thesis.

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CHAPTER 1: Introduction

1.1 Children and Science

Children's (5-18 years) interest in the sciences has declined in recent years according to many studies (e.g. Bolstad and Hipkins, 2008; Osborne and Dillon, 2008, Tytler et al., 2008). Research has highlighted that children tend to adopt stereotypical views of scientists during early years of schooling and have negative views of both scientists and science which are often strengthened as children get older (e.g Türkmen, 2003; Demirba, 2009; Samaras et al., 2012). However, with the right methods of engagement, including interaction with scientists, their interest levels can be increased (Anderson and Gullberg, 2014; Hall et al., 2014; Roberts, 2014). The attitudes and perceptions of children with regards to science and scientists are a product of their views on science and scientists, combined with their personal, professional and social experiences, with home and school environments having a large impact on this (Samaras et al., 2012). Regarding science, some of the more common child perceptions are that science was boring, that it was irrelevant to everyday life and their futures, and that science is simply a "body of facts" (Danaia et al., 2013; Gardner et al., 2009; Wolter et al., 2013). These ideas are likely to have a big impact on the way children interact with science, their investment in it as a subject and their acceptance of the information they are given.

The views of children on scientists and science have been widely studied (Türkmen, 2008) over the past fifty years (Dudek and Bernard, 2015), and 70% (Buldu, 2006) of studies involved the draw a scientist test (DAST) (E.g. Farland-Smith 2012; Hillman, 2014; Özel and Dogan, 2013). Developed by Chambers (1983), DAST involves children drawing what they think a scientist looks like. The resulting pictures are analysed with code indicators that give either 1 or 10 points depending on the presence or absence of the feature under examination and determine whether the features of the drawing are "stereotypical" or "alternative" (Farland-Smith et al., 2014; Özsoy and Ahi, 2014). Some tests have also combined DAST with interviews to obtain more in-depth knowledge of children's perceptions of scientists, but this approach is uncommon (Samaras et al., 2012).

Studies based on DAST suggest that children think of scientists as male, 50+, Caucasian, and working indoors with chemistry (Türkmen, 2008). They also tend to associate scientists with lab coats but there are mixed results with regards to perceptions of scientists wearing glasses and having 'crazy hair' (Özsoy and Ahi, 2014; Türkmen, 2008).

Several different factors have been investigated during tests of perception, including gender, age and country of origin. Studies have found significant gender differences in drawings of scientists (Samaras et al., 2012) with males generally drawing only male scientists and being more likely to include stereotypes while females sometimes draw female scientists (Buldu, 2006; Steinke et al., 2007). Differences have also been discovered in children of different ages, but although many tests found older children included more stereotypes than younger children (e.g. Özel,

2012; Ozgelen, 2012; Ünver, 2010) there are studies that have either not found this (Hillman et al., 2014) or have found the reverse to be true (e.g. Buldu, 2006; Özel and Dogan, 2013). International differences in perception have also been found. A study by Narayan et al. (2013) used the DAST in China, India, South Korea, Turkey and the US and results indicated that children from India and Turkey were more interested in becoming a scientist. In addition the perception of science as an active rather than passive practice was important in encouraging children to choose science as a career in the US and Korea but not the other countries.

With most studies involving the DAST, there is a lack of verbal or written exploration of children's perceptions in greater depth. Ambusaidi et al. (2015) made use of a 37-item questionnaire to determine perceptions and found that children struggle more to understand a scientist's relationship with society than a scientists' work, information that would have been difficult to ascertain from drawings alone. Another study took a more interactive approach. Farland-Smith (2009a) exposed female middle school children to scientists in laboratory and field exercises over a few days. She found that child perceptions of science and scientists were improved, encouraging them to debunk myths and pursue a science career. This suggests that perceptions can be changed when active engagement approaches are used.

Cultivating positive perceptions and views will influence children's attitudes towards science and scientists (Ozgelen, 2012) and possibly career choice (Farland-Smith, 2012). Understanding these perceptions, what shapes them and how they can be positively influenced is particularly important considering that the National Science Foundation (NSF) have found a severe drop in the interest in and

understanding of science (NSF, 2002). More specifically the number of children pursuing science careers has dropped in recent times (Farland-Smith, 2009b), with reductions in class sizes of natural sciences causing declining enrolments and even for courses to be closed in Polish secondary schools (Dudek and Bernard, 2015; Ramsay et al., 2005). One of the problems is the tendency for children to regard scientific engagement as a masculine pursuit, with girls considering it as impersonal, competitive and lacking imagination (She, 1998).

1.2 Films and Science

Filmed fiction is an important aspect of many people's lives. For example, the average American between 10-22 spends three hours watching films every week (Roberts et al., 1999). In the increasingly popular genre of science fiction, viewers are not limited for content, with 8630 sci-fi feature films listed on the Internet Movie Database (www.IMDB.com) between 1911 and Sep 2015. Science and technology are now the themes most sought after by producers with sci-fi featuring in 22 out of the top 60 all-time grossing films up to 2009 (Frank, 2003; Perkowitz, 2010). Films are produced predominantly to make money by entertaining a paying audience, however the inclusion of scientific material in their plots and characters also have the capacity to inform, whether intentionally or not (Frank, 2003). Indeed, it has been asserted that films are an important way for scientific ideas to be passed on to the general public (e.g. by Everitt and Patterson, 1999). The communication of scientific information via films can occur through dialogue, narration and the action of characters individual or in combination (Rose, 2003).

Little is known about the specific impacts of film science on audiences (Barriga et al., 2010). However, the presence of science in a medium designed as mass-consumption entertainment has the obvious potential to provoke questions of credibility, especially from those interested or involved in the field. Opinion is divided as to the possible negative and positive implications of science in fictional media. A strong advocate of the power of film science is publicist Warren Betts (who recruits science consultants for films), who has said that the popularity of science and technology mean making a film scientifically credible actually creates an audience for it (mentioned in Frank, 2003). Enhancing scientific credibility can avoid negative fan response from viewers who Hollywood believes care about science (Frank, 2003). With millions of people watching the content, and the potential for films to reach audiences over long periods of time (e.g. through TV showings, in-flight entertainment and DVD releases) it clearly has a potentially large capacity for influence, impacting the consultants and filmmakers involved and forming a powerful tool for the awareness of science concepts (Kirby, 2003a). In fact, it has been shown that films can lead to changed perceptions and understanding of science concepts and can change child interest levels. For example, half the children at the University of Central Florida chose the physics in films course over the standard physics course after initial trials that gave the film course as an additional option (Efthimiou and Llewellyn, 2004).

The National Science Board have raised concerns that films miscommunicate science to the public and that this has negative effects on attitudes towards science and scientific literacy (Barriga et al., 2010). Certainly there are large variations in the accuracy of scientific content by film, from those which use a small kernel of

truth to launch into an engaging story inconsistent with any number of scientific laws (such as *The Core* and *Armageddon*), to films that attempt to entertain their viewers while respecting the scientific concepts they have included (Perkowitz, 2010) (for example *Moon* and *Interstellar*). Prince (1996) divides this variation into two standards of reality used in visual fiction; referentially real images depicting events that actually occur and perceptually real images that contain elements of fantasy corresponding to a viewer's understanding of various phenomena. By presenting a single vision of nature in a perceptually real way (Kirby, 2003a), films can become what Kirby calls 'virtual witnessing technologies' that display the world beyond the capabilities of traditional media (Black, 2002). Belief in scientific accuracies can vary by gender, with men believing more inaccuracies when science was peripheral to the plot and women believing more inaccuracies when science was central to the plot (Barriga et al., 2010). There are several reasons films may contain scientific inaccuracies, including: making characters more appealing; restrictions introduced by the plot; lack of scientific input; limitations in money; and disagreement between scientists regarding the correct explanation of a scientific phenomena (Frank, 2003; Kirby, 2013; Perkowitz, 2010; Worsham and Diepenbrok, 2013).

Science has often been the source of danger in films and television, but the scientists themselves do not escape being stigmatized, frequently being portrayed as evil (like Dr. Josef Heiter in *The Human Centipede*) or having good intentions that backfire, such as John Hammond in *Jurassic Park* (Laprise and Winrich, 2010). Abandoning considerations of positive representations of science, Huxford (2000) goes so far as to say that science fiction is informed by phobias and regressive

impulses, essentially being about the fear of science itself. Biotechnology in particular, has often been made to look unnatural, perpetuating myths in the media (Miller, 2006). For example *The Guardian* compared the successful cloning of Dolly the sheep with the film '*The Boys from Brazil'* where clones of Hitler were made by Josef Mengele (McKie, 1997). However, scientists at the "hero" end of the spectrum are also represented, such as Clayton Forrester who combats invading Martians in *The War of the Worlds* or meteorologist Terry Rapson who perishes at his post to send data about the impending ice age in *The Day After Tomorrow*.

1.3 Children and Science in Films

The school curriculum is not a child's only source of knowledge about science and scientists. Children also obtain information from the TV, films, the Internet and books (Ambusaidi et al., 2015). Films are an important way in which scientific ideas are passed on to the general public (Everitt and Patterson, 2006), and the power of science in films to influence an audience is possibly no greater than when that audience comprises children (Barnett et al., 2006). That influence varies as children develop and become more intellectually mature. Younger children are far less critical of information presented to them than older children and adults, with one study saying that until the age of five children were unable to understand that what happens to a character does not also happen to the actor in real life (Goldstein and Bloom, 2015).

Children have been found to be active participants in choosing and utilizing media that meets their cognitive, personal integrative and social integrative needs with

regards to science, with accessibility, content and presentation being the key factors influencing their use of these resources (Gelmez Burakgazi and Yildirim, 2014). The popularity of films to children makes their use of science particularly influential, and as children may not have the chance to experience first hand representations of science, scientists and scientific environments in the media may offer the main exposure upon which their opinions are based (Steinke, 1999; Louv, 2008).

The exact content, context and presentation of films determines the way children then go on to perceive science and scientists and whether these views are positive or negative. Despite Türkmen (2008) stating that the influence of media like films has not been a significant source of information for children, studies in classes have highlighted the ability of films to mislead or negatively impact a child's understanding of science or perception of scientists (Barnett et al., 2006). Reis and Galvão (2007) found children's science fiction stories displayed the influence of stereotypes and catastrophes depicted in films, television programs and books revealing the power of the media as a source of scientific information. The ability of films to mislead is particularly the case when films start with a grain of truth before leaping into fiction (Laprise and Winrich, 2010). For example, a study looking at child responses to *The Core* found that the film's initially accurate description of the earth's interior structure by a respectable-looking "geophysicist" caused them to accept the inaccuracies that followed and even prioritize using them when explaining concepts over facts they had learnt in class (Barnett et al., 2006; Perkowitz, 2010).

In addition to factual inaccuracies, scientists in filmed fiction have been found to possess several stereotypical traits that may negatively influence children's perceptions, including eccentricity, social isolation, obsessiveness and recklessness (Perkowitz, 2010a; Van Gorp et al., 2014). It has been suggested that negative or unflattering portrayals of scientists as evil or socially inept in films and TV can reduce child interest in science or negatively change perceptions in areas such as gender roles (Perkins, 2004; Steinke, 2005). Women are often depicted supporting male scientists or as emotional, passive individuals who are outsiders to mainstream culture. This causes young females watching visual fiction to develop a masculine image of science, with one study finding that in 74 films the teams of scientists frequently included more than one male but never included more than one female (Kelly and Small, 1986; Signorelli, 1997; Steinke, 1999; Steinke, 2005). These gender-biased representations could be particularly damaging in light of a study by Bryant et al., (2012) which showed that females have more anxiety connected with learning about science than males. Women currently make up only 19.4% of the Science, Engineering and Technology (SET) workforce, and it has been noted that improving cultural ideas of female scientists in media may enhance efforts to promote female representation in SET areas (National Science Foundation, 2000; Steinke, 2004).

It is important to present science to children in a manner that generates curiosity and interest (Wolter et al., 2013). According to Venville et al., (2013), the key factors attracting people to science and making them want to become scientists are having an interest in science and being good at it. Both factors are influenced by multimedia learning (Ercan, 2014), which combines pictures and videos with text to

make the material more interesting and, by using both hemispheres of the brain, learning easier (Mayer, 2003; Paivio, 1991). With these studies in mind it is not surprising that teachers have tried to find new ways of engaging children and encouraging their interest, and that they have looked to filmed science fiction to do it. Many teachers have now started bringing sci-fi film content into the science curricula, capitalizing on the appeal of this genre to motivate and inspire children to become more interested in science and enhance their understanding (Laprise and Winrich, 2010). One of the key benefits of using films to teach science is their ability to develop critical thinking competence in children and dispel scientific misconceptions (Barnett and Kafka, 2007; Czerneda, 2006; González-González et al., 2014). For example, a study by Surmeli (2012), asked children to critique sci-fi films and write about how their use of science and technology affected society. This activity improved child attitudes and developed positive thoughts about using films in a science course. In a study by Bixler

(2007), children were tasked with teasing out flaws in the evolutionary scenarios of a science fiction story and this was found to be an engaging way of exploring difficult abstract concepts. There are other benefits of engaging in this way with scientific material, Lin (2014) found that the use of science fiction films had a positive impact on Junior high school children's creative processes. However, not all strategies have worked without modification. In a study by Hamdan et al., (2011), children struggled with a course that looked at the connection between science fiction and real life issues due to a lack of understanding of the fundamental concepts involved. This connection was understood better in a study by Stutler (2011), which found that gifted children used sci-fi content like 'The Twilight

Zone' as a natural springboard to learn about important events as well as developing research skills and studying real-world figures.

Considering a child's tendency to think of science as being all about 'facts', Gardner et al., (2009) feels that there is a responsibility for educators to deliver science content in such a way that it teaches children to appreciate the nature of scientific enterprise and its social ramifications. Jarman and McClune (2007) provide further support of this view, stating that curriculum designers should integrate the critical use of media sources as a way of promoting scientific literacy in the classroom. In this way, children will be able to go on to evaluate the merit and reliability of science content outside of the classroom (Laugksch, 2000). This is particularly important with regards to "framing", which is a way of focusing on certain aspects of an issue in popular media by selecting different words, images and presentation styles to help the receiver make sense of it (Nisbet and Scheufele, 2007). By arming children with the skills to identify and negotiate 'frames' their influences will be reduced and their scientific literacy will be increased (Gardner et al, 2009).

1.4 Study Rationale

Despite a few studies exploring children's responses to film clips and film's ability to misinform, there is a lack of research into the influences of both science and particularly the portrayal of scientists in films on child perception and attitudes (Barnett et al., 2006). This study will attempt to address those issues by answering two questions (as the children involved with data collection will do so in a student-teacher capacity they shall be referred to as students henceforth):

• What are the key perceptions students have about science, how does age and gender affect this and to what degree do films have the power to influence these perceptions in a negative or positive way?
• What are the key perceptions students have about what a scientist is, their appearance and behaviour, how do these perceptions vary by age and gender and are these perceptions influenced positively or negatively by scientists in films?

Addressing these aims will enhance our understanding of the ability of science within films to shape student's ideas and potentially create a more insightful plan of action for the use of filmed science fiction in teaching. To elucidate more specific patterns of behaviour and opinions these two primary aims will be broken down by age and gender. Information gained by this approach will enable us to give students a tailored and more positive impression of science and scientists and encourage them to pursue science as a career. It will also help to safeguard students from misinformation by teaching them to think critically about the content they see and to question rather than accept the scientific content of films.

CHAPTER 2: Methods

This study looked at the influence of science in visual fiction when used in the education of students (5-15 years). It explores the use of film clips with students of different genders, the breadth of science disciplines this strategy can effectively use and whether this method of teaching is more effective when used with certain ages.

Data collection was performed at the National Student Travel Foundation (NSTF) Science Expo in Malta between the 21st and 28th March 2015 (NSTF, 2015). This event is held at the Institute of Applied Science at MCAST, Paola and exhibits science projects from primary, secondary and post-secondary students. It was funded partly by the NSTF and partly through the University of Gloucestershire. During the Expo, visiting students between the ages of 5 and 16 also have the opportunity to attend interactive sessions held by various science communicators from different countries and institutions. Having previously attended the Science Expo in 2014 to give talks on prehistoric animals and the future of biology, it was clear that it offered a large captive audience of young scientists who could provide insight into the influence visual fiction has on students with regards to science and explore the concept of what it means to be a scientist. It is appreciated that the views of Maltese students may not be representative of students in other countries due to differences of culture and education but the scope of this study did not permit collecting data in multiple countries and many similar studies have been conducted in one country such as Greece (Samaras et al., 2012), Turkey (Türkmen et al., 2008; Özsoy and Ahi, 2014) and others (Ozel and Dogan, 2013; Hillman et al., 2014). Attending students came as part of school visits and so did not necessarily have a special interest in the sciences, but the focus of the event meant that participants in the sessions were likely to be open to its scientific content and engage more with the material.

2.1 Preparation of Questionnaires and Presentations

When structuring the sessions it was decided they should comprise several short clips that would cover broadly varying areas of science and allow both chapters to be investigated within a single presentation: Firstly, whether students were influenced or misled by the science they saw and secondly to understand their comprehension of what a scientist is and their attitudes based on the footage. Each clip was combined with a short questionnaire. This provided structure to the session and enabled statistical analysis. A follow up discussion was also included for each clip that was a more flexible way of obtaining information. These data gathering components were used to springboard into real life scientific comparisons that provided the necessary educational component of the sessions as required by the Science Expo, kept the students engaged and provided an opportunity to think of and test practical applications for the research.

As sessions at the Science Expo are divided between primary and secondary schools, two different presentations and two sets of questions were created to ensure content would be age appropriate and maximally engaging. This was important as some of the younger individuals were not fully fluent in English (Maltese is the first language of many Maltese people) and so concepts had to be particularly clear. Students from primary schools were between 5 and 10 years old and students from secondary schools were between 11 and 15 years old. Within any one session students were only a maximum of 1 year apart, with the exception of the first session, which was held on an open day and comprised participants aged between 8 and 51. Sessions were intended to last 45 minutes each and contained four clips of between 2 and 7 minutes. This allowed a breadth of science topics to be covered while providing enough time to obtain in-depth information on each one.

A website called FlickClip containing a database of film clips with scientific content and teaching ideas provided a good starting point and made it easy to efficiently check several hundred movie clips to find the right films and content for the presentations (Table 1) (MacKenzie, 2014). In order to allow comparison of responses between age groups two clips were chosen which were suitable for both audiences with an additional two clips for each which would allow more specific tailoring to older or younger students (Table 2). In order for the research to increase understanding in a wide range of areas, several criteria were involved in the selection process for clips:

• A broad range of science should be covered

• The science topics should offer potential benefits to humans as well as risks

• Scientists should be portrayed in both positive and negative lights

• Scientists should have a variety of different looks and display different behaviours (with some more stereotypical than others)

• Clips should be engaging, age appropriate and varied enough to maintain attention spans in students.

Table 1. Overview of films chosen for study (IMDB, 2015).

Film	Genre	Plot
Iron Man	Action, adventure, sci-fi	Tony Stark is an inventor and weapons contractor who creates a weaponised suit of armour to fight evil after being held captive in an Afghan cave
Jurassic Park	Adventure, sci-fi, thriller	Advancements in technology have led to the creation of cloned dinosaurs on a remote island due to be repurposed as a theme park. However, when the power goes off the dinosaurs escape and threaten the lives of the scientists sent to assess the park
Despicable Me 2	Animation, comedy, family	Gru, a super-villain trying to raise three daughters is recruited to help the Anti-Villain League find out who has stolen a laboratory in the Arctic
Cloudy With a Chance of	Animation, comedy, family	Inventor Flint Lockwood is stuck working in his father's sardine store until he finally has success

Meatballs		with one of his inventions and food starts to rain from the clouds. But when the machine responsible is overused the food becomes a menace to the human race
Ghostbusters	Comedy, fantasy	When three odd-ball scientists get fired from their positions at a university they decide to go into business as a ghost extermination company called 'Ghostbusters.' Initial skeptics soon find themselves needing the team to take out a powerful spirit
Armageddon	Action, adventure, sci-fi	NASA recruits a misfit team of deep core drillers to save the planet after discovering an asteroid the size of Texas is soon going to impact Earth

Table 2. Focus and justification of film clips used in data collection.

Film	Age Group	Clip Length	Clip Content	Area Covered	Rationale
Iron Man	Both	7:20	Tony Stark builds his Iron Man suit and takes it for his first flight. It takes many attempts to get it right and he ignores some health and safety warnings, almost causing him to fall back to earth when his suit freezes up	Scientific possibilities/ health and safety/what is a scientist	Exploring student perception of scientists, value of safety and comprehension of scientific possibilities
Jurassic Park	Both	3:10	Richard Hammond's video showing how scientists brought the dinosaurs back. The clip discusses dinosaur DNA found in mosquitoes and filling in the gaps with frog DNA	Genetic research	Displays student acceptance of science methods in films, and comparison with real life knowledge
Despicable Me 2	Younger	3:22	Dr. Nefario quits his job creating inventions for Gru as he wants to be more 'evil.' The clip starts with him creating a new jelly flavour but it is unpopular	Good/bad scientists and how they look	Explores student ideas about positive/ negative impacts of scientists and stereotypes in appearance
Cloudy with a Chance of Meatballs	Younger	2:05	Flint Lockwood successfully makes the clouds rain food for the first time. We see the enjoyment of those in his town eating the food that rains upon them	Scientific possibilities/ inventions	Looks at acceptance of extraordinary films inventions as possible
Ghostbusters	Older	3:00	Dr. Venkman investigates ESP in a male and female student with the use of electric shocks. He only shocks the male even though both get questions wrong	Ethics	Explores the power of films to negatively influence perception of scientists and attitudes towards ethics
Armageddon	Older	2:35	A group of individuals are put through NASA testing to become astronauts. Their behaviour is fairly rowdy throughout and does not conform to scientist stereotypes	How scientists look and behave	Understanding student definitions of scientists and acceptance of attributes in films vs. real life

2.2 Data Collection

One of the key aspects of this research was finding a suitable way to examine how students respond to and identify with science and scientists in films. Methods of data gathering had to bear in mind the short attention span of students (quoted in Carlson 2005, "Millennials and 'Me'") and obtain enough depth without losing their interest before they got to later clips. Four questions were created for each clip, designed to demonstrate whether the clip shown had changed or influenced a participant's perspective on a particular concept, to ascertain whether they believed inaccuracies contained in the clip and to explore how closely they felt the scientific creations shown were possible with our current level of scientific knowledge and technological advancement (Table 3). Where appropriate, the questions also aimed to find out how participants felt about the actions of the scientists in the clips and whether this affected how they viewed scientists in real life (See Appendix). A few questions (for example *Iron Man* question 3 and *Cloudy With a Chance of Meatballs* question 4) tested comprehension levels or focused more on engagement as student entertainment and inspiration was an important aspect of the presentations at the Science Expo. Questions involved a mix of tick box answers offering quantifiable data that could be subjected to statistical analysis and qualitative open-ended questions whose answers could express more depth and sensitivity to context. Many contained both approaches, with a yes/no question and a follow up asking participants to explain the reasoning behind their answer, so that important themes could be analyzed from every angle.

Table 3. Rationale for questions used in research.

Film	Question	Rationale
Iron Man	1. I think that Tony Stark is a scientist (Yes/No) Why?	Explores what students think a scientist is in relation to Tony Stark and leads into further questioning.
	2. Does Tony Stark make you want to be involved with science and creating technology more or less? (More/Less)	Tests whether the portrayal of the scientist in this film has a positive or negative affect on students watching.
	3. In your opinion, why does Tony ignore his computer and fly his suit before it is properly tested?	Checks comprehension of clip and appreciation for health and safety aspects of science.
	4. Could scientists build a suit like this? (Yes/No) Why? Why not?	Looks at whether students accept or question the advanced technological ideas the film clip has shown them.
Jurassic Park	1. Do you think scientists could bring back the dinosaurs using the method in this clip? (Yes/No) Why? Why not?	Tests whether students accept scientific methods they see in films as facts even in extreme scenarios like the reversal of extinction explained here.
	2. Were you aware of other methods to try and bring back the dinosaurs before watching this clip? (Yes/No) If yes, where did you find out about these ideas?	Checking student's current level of knowledge, interest in the area and sources of information.
	3. Do you think scientists are trying to bring back the dinosaurs in real life? (Yes/No)	Shows whether students believe things shown in films are possible in real life.
	4. Do you think it's a good idea to try and bring back the dinosaurs? (Yes/No) Why? Why not?	Explores student alignment with scientist's actions through comparison to answers in previous question.
Ghost-busters	1. Is Dr. Venkman being honest to his participants? (Yes/No) Why? Why not?	Checks comprehension of clip content and character motivations.
	2. Would you say yes to being involved with one of his experiments? (Yes/No) Why? Why not?	Looks at whether students relate themselves to the students in the clip.
	3. Does seeing this experiment make you want to be a scientist more or less? (More/Less/Neither)	Shows whether student's interest in scientific pursuits is influenced by the content they have seen.
	4. After seeing this clip do you think most scientists behave ethically? (Yes/No) Why? Why not?	Tests whether students can have their opinion of scientist behaviour changed by a film clip.

Table 3 (continued). Rationale for questions used in research.

Film	Question	Rationale
Armageddon	1. Does the behaviour of the people in this clip change the way you think scientists would behave? (Yes/No) Why? Why not?	Looks at behaviours which don't align with stereotypical scientist actions and whether students find this surprising.
	2. Have you learnt more about scientists from films or school? (Films/School/Neither) Why?	Shows whether films are a powerful source of information about scientists for students.
	3. What does it mean to be a scientist?	Explores student definitions of a scientist.
	4. Do scientists look like the people in this clip? (Yes/No/Maybe) If no, how do they look different?	Looks at whether physical stereotypes of scientists are believed by students.
Despicable Me 2	1. Why do you think Dr Nefario quit his job?	Tests comprehension of clip and level of understanding.
	2. In the clip Dr Nefario talks about going somewhere 'more evil.' Do you think there are evil scientists in real life? (Yes/No) What would make a scientist evil?	Explores whether students extend a story-based black and white attribute such as 'being evil' to the real world and whether their suggestions come from film ideas of 'evil scientists.'
	3. Do you think real scientists would look different or similar to Dr Nefario? (Different/Similar) How?	Explores physical stereotypes of scientists and whether films help to uphold these.
	4. How do you think Dr Nefario's lab is different to a real lab?	Shows whether students recognize the exaggerations used in films.
Cloudy With a Chance of Meatballs	1. Flint has made an invention capable of raining food. Would it be possible to make it rain food? (Yes/No) Why?	Checks student understanding of scientific concepts and acceptance of ideas presented in films.
	2. Would it be a good or bad thing if it rained food? (Good/Bad) Why?	Shows whether students give reasons based on responses to the situations in the clip or think about it in relation to the real world.
	3. Do you think inventions in films are mostly real or mostly made up? (Mostly real/Mostly made up)	Looks at whether students believe what they see in films.
	4. Which inventions from films would you most like to see made real?	Engages students with film content and allows exploration of other films during session.

The sessions themselves were organized by the NSTF, with class size varying between 13 and 29 and both same gender and mixed classes taking part. In total, 13 sessions were given across a six-day period and 181 students filled in the questionnaires (Table 4). There were several logistical challenges which could not be mitigated as the NSTF were responsible for organising the sessions themselves. These included schools arriving late so that there wasn't time to give the entire session, schools not turning up at all reducing the total number of participants, some primary schools comprising students of 5 and 6 years who were unable to fill in the questionnaires, and a larger number of primary schools being available meaning fewer older students participating. Other issues were managed through the week and included the wording of questions given during the discussion becoming more finely tuned to age as the week went on, with those for primary school students becoming more basic and those for secondary school students more complex. Obviously this remained flexible based on the comprehension and engagement of individual groups and care was taken to avoid changing the meaning of what was being asked.

In addition to the questionnaires, sessions were recorded so that greater context could be given to answers through discussion of clips. This also provided additional flexibility, so that questions could be adapted based on the interactivity of the students in a particular session, enabling the data to be more tailored and explore certain themes in greater depth if an interesting comment was made.

Table 4. Details of sessions carried out during data collection.

Session and age group	Gender	Age	Number of students	Length of session (minutes)	Clips shown	Questions given?
1-younger	Mixed	Mixed 8-51	20	53	All	Yes
2-older	Female	13-14	21	49	All	Yes
3-older	Female	14-15	22	49	All	Yes
4-younger	Mixed	7-8	25	40	Iron Man, Despicable Me 2, Cloudy With a Chance of Meatballs	Yes
5-younger	Mixed	8-9	24	15	Iron Man	Yes
6-younger	Female	5-6	16	40	Iron Man, Despicable Me 2, Cloudy With a Chance of Meatballs	No
7-younger	Female	5-6	20	36	Iron Man, Despicable Me 2,	No
8-younger	Mixed	9-10	24	21	Iron Man	Yes
9-younger	Mixed	5-6	18	49	All	No
10-younger	Mixed	5-6	19	38	Iron Man, Despicable Me 2, Cloudy With a Chance of Meatballs	No
11-younger	Mixed	5-6	22	37	Iron Man, Despicable Me 2, Cloudy With a Chance of Meatballs	No
12-older	Male	11-12	29	44	Iron Man, Jurassic Park, Ghostbusters	Yes
13-younger	Male	7-8	24	41	Iron Man, Jurassic Park	Yes

2.3 Data Input and Analysis

Quantitative

Data from questionnaires that had the permission box ticked (see 2.4 Ethical Considerations) were entered into Excel. Percentages used in graphs were always based on answers to individual questions rather than variables of interest (e.g. the percentage of males who responded 'yes' versus those who said 'no' to a given question). Statistical tests assumed an expected ratio of 1:1 for answers to yes/no questions (in other words the expectation was that students were equally likely to respond 'yes' or 'no'). Chi-square tests were performed on the responses to test for statistical differences in the answers to each question and Fisher's exact tests were performed to compare differences in answers between males and females and younger (7-10) vs. older (11-15) participants. Tests were undertaken using online GraphPad calculators (http://www.graphpad.com/quickcalcs/).

Qualitative

The questions for each clip were categorised by thesis chapter depending on whether they focused on the perceptions of science (Chapter 3) or scientists (Chapter 4). When analysing data it is important to use a more categorical level of coding so that reliance on broad descriptions is minimised (Gibbs, 2007). This enables grey areas to be reduced and like concepts to be assigned to the same categories. With this in mind a list of concepts and themes covered by each question was written out with responses categorized by gender and age so that themes and biases could be easily seen. Word frequencies were analyzed using Nvivo software and were also divided by gender and age, so that the most common themes could be easily found using words that represented them (NVivo, 2014). Similar words were

grouped together (for example, “lied”, “lie”, “lying”, “lies”), a maximum of five words per question were recorded, and at least five responses had to have used them for a word to be included. Recordings of sessions were analyzed with additional and prominent themes noted from the discussions of the questions for each clip, including responses to the slide asking students to say which film scientist character looked most and least like a real scientist from a range of images which connected with question 3 of the *Despicable Me 2* clip. Summaries of data were then written out paying attention to differences in age for the *Iron Man* and *Jurassic Park* clips (that were viewed by both age ranges) and differences in gender where present. Quotes were also included where they expressed an opinion particularly clearly or deviated from the general consensus. Some students gave answers to questions that indicated they were not taking the questionnaire seriously (e.g. bananas as an answer) and quotes were only used from these students where the answers made sense.

2.4 Ethical Considerations

In accordance with the ethical regulations of the University of Gloucestershire, the use of children triggered the need for a full ethical consideration of the study. Consequently, an application was made to the Faculty Research Ethics Panel and approved prior to the trip. This stated that students would remain anonymous and age appropriate content used. An explanation of the research was made at the start, with students given the chance to withdraw, and a permission statement on questionnaires had to be ticked in order for their answers to be used in the research gathered. Questionnaires and audio recordings of sessions were destroyed after the data had been coded and entered into Excel.

Chapter 3- How Do Students Perceive Science in Films?

3.1 Introduction

Film can influence a student's attitude to science (Kirby, 2003a) as discussed in Chapter 1. Research in this area is limited, tending to focus on misinformation rather than influence (Barriga et al., 2010). Furthermore, studies suggest that students may use film depictions over what they learn in the classroom to inform them about concepts (Barnett et al., 2006). Studying influence may offer a clearer insight into the power of films to turn students away from or towards the sciences and may help to improve the recent decline in student interest in science (Bolstad and Hipkins, 2008). With this in mind, this chapter explores how students can be influenced by the science they see in films. It will look not only at student's current perceptions about science but also changes in attitude following film clips and evidence that film content is being used to understand science concepts or increase knowledge of them.

Based on current research, several outcomes are possible:

• Some but not all students may be influenced by science content, and believe inaccuracies shown to them, particularly when scenes have a basis in science and then introduce fictional ideas (Barnett et al., 2006).

• Students may find science to be uninteresting or not relevant to their lives (Danaia et al., 2013).

• Younger students will be more accepting of science concepts in films than older students (Özel, 2012).

• Female students will show less confidence with relation to pursuing the sciences (Bryant et al., 2012).

Evidence for the influence of film content can be used to justify to educators the inclusion of this content to aid clarification in teaching, increase critical evaluation of it and enhance engagement and interest levels in the sciences. Analysis will explore the whole data set first and follow up with a look at the differences between males and females and two different age groups.

3.2 Methods

As detailed in Chapter 2, a total of 181 children were surveyed, answering questions on film clips covering different science themes. Two sets of clips were devised, one for younger (5-10 years) and one for older (11-15 years) students. Data were analysed both quantitatively and qualitatively. The questionnaire was given as a single sampling effort comprising science and scientist questions and responses specific for the chapter in question were divided up afterwards. For quantitative and qualitative analysis the following questions are relevant with regards to student responses for questions on science:

Table 5. Quantitative questions exploring student perceptions of science.

Film	Questions
Iron Man	2. Does Tony Stark make you want to be involved with science and creating technology more or less? (More/Less) 4. Could scientists build a suit like this? (Yes/No)
Jurassic Park	1. Do you think scientists could bring back the dinosaurs using the method in this clip? (Yes/No) 2. Were you aware of other methods to try and bring back the dinosaurs before watching this clip? (Yes/No) 3. Do you think scientists are trying to bring back the dinosaurs in real life? (Yes/No) 4. Do you think it's a good idea to try and bring back the dinosaurs? (Yes/No)
Cloudy With a Chance of Meatballs	1. Flint has made an invention capable of raining food. Would it be possible to make it rain food? (Yes/No) 2. Would it be a good or bad thing if it rained food? (Good/Bad) 3. Do you think inventions in films are mostly real or mostly made up? (Mostly real/Mostly made up)

Table 6. Qualitative questions exploring student perceptions of science.

Film	Questions
Iron Man	3. In your opinion, why does Tony ignore his computer and fly his suit before it is properly tested? 4. Could scientists build a suit like this? (Yes/No) Why? Why not?
Jurassic Park	1. Do you think scientists could bring back the dinosaurs using the method in this clip? (Yes/No) Why? Why not? 2. Were you aware of other methods to try and bring back the dinosaurs before watching this clip? (Yes/No) If yes, where did you find out about these ideas? 4. Do you think it's a good idea to try and bring back the dinosaurs? (Yes/No) Why? Why not?
Cloudy With a Chance of Meatballs	1. Flint has made an invention capable of raining food. Would it be possible to make it rain food? (Yes/No) Why? 2. Would it be a good or bad thing if it rained food? (Good/Bad) Why? 4. Which inventions from films would you most like to see made real?

3.3 Results

3.3.1 Quantitative Analysis

General Comparisons

The biggest differences in answers from a 1:1 ratio occurred for *Iron Man* question 2 and *Cloudy With a Chance of Meatballs* question 3, with 92% of students stating that Tony Stark made them want to be involved with science more and 90% of students believing that most inventions in films are made up (Figure 1).

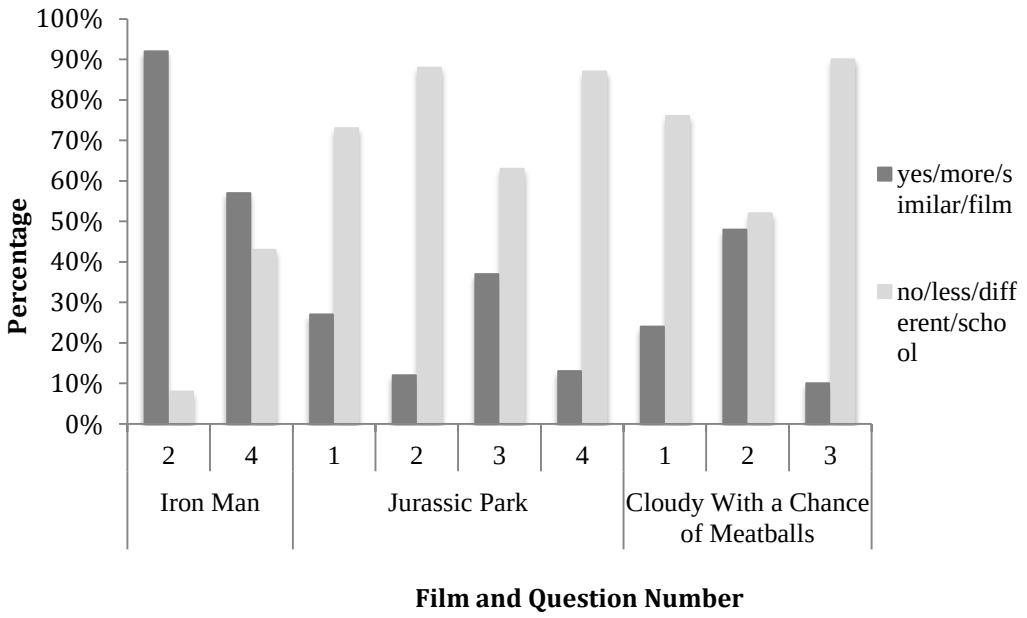


Figure 1. Percentage differences for answers to questions on science based on three different film clips shown to students (5-15 years). Questions and specific options for answers to each can be found in Chapter 2 (Methods).

Chi-square tests (Table 7) revealed statistical significance from the expected 1:1 ratio for answers to the following questions (most popular answer in bold):

Iron Man:

2. Does Tony Stark make you want to be involved with science and creating technology more or less? (**More**/Less)

Jurassic Park:

1. Do you think scientists could bring back the dinosaurs using the method in this clip? (Yes/**No**)

2. Were you aware of other methods to try and bring back the dinosaurs before watching this clip? (Yes/**No**)

3. Do you think scientists are trying to bring back the dinosaurs in real life? (Yes/**No**)

4. Do you think it's a good idea to try and bring back the dinosaurs? (Yes/**No**)

Cloudy With a Chance of Meatballs:

1. Flint has made an invention capable of raining food. Would it be possible to make it rain food? (Yes/**No**)

3. Do you think inventions in films are mostly real or mostly made up? (Mostly real/**Mostly made up**)

Table 7. Testing the differences in answers by students (5-15 years) from an expected 1:1 ratio to science-based questions from three film clips using Chi-square tests.

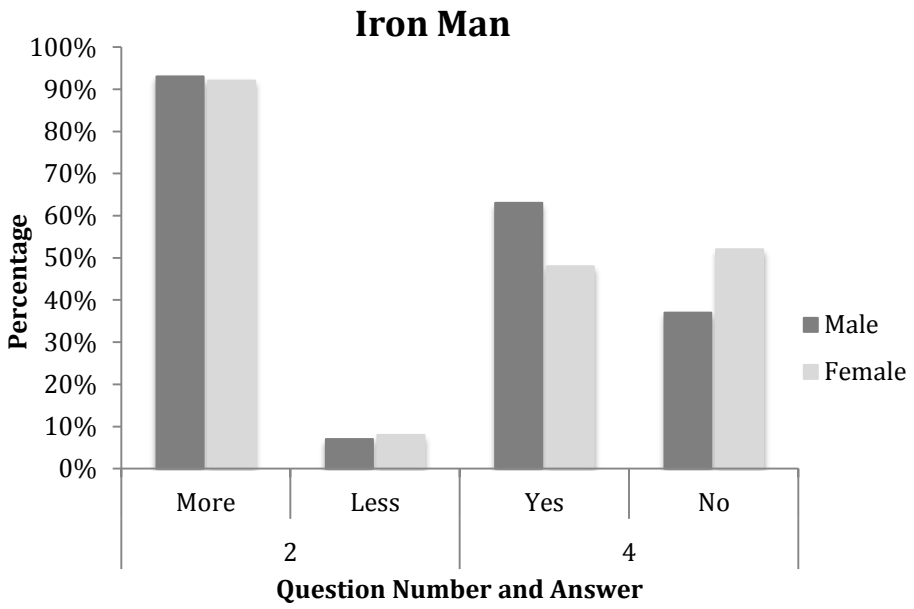
Film	Question	χ^2	Degrees of Freedom	P Value
Iron Man	2	114.62	1	<0.0001
	4	2.88	1	0.09
Jurassic Park	1	17.19	1	<0.0001
	2	48.76	1	<0.0001
	3	5.76	1	0.0164
	4	46.69	1	<0.0001
Cloudy With a	1	2.76	1	0.016
Chance of	2	0.04	1	0.84
Meatballs	3	12.8	1	0.0003

Students felt that Tony Stark made them want to be involved with science and technology more, but there was no significant differences in whether they thought his suit could actually be built. All *Jurassic Park* questions showed significant differences between their answers from a 1:1 ratio. Most students did not believe that the method explained in the *Jurassic Park* clip rang true, believing that dinosaurs could not be brought back in this way, although a relatively high percentage (27%) thought this was possible and believed what they had seen in the clip. In general students were not aware of other methods to bring back the dinosaurs, with most thinking that scientists were not attempting to do this and that it would be a bad idea. Lastly, most students felt it was not possible to make the clouds rain food and that most inventions in films are made up, although 10% thought that inventions in films were mostly real.

Comparisons of Gender

The clearest differences in answers between males and females were for the clip from *Jurassic Park* (Figures 2-4). To explore differences in the proportion of males and females giving different answers to questions, Fisher's exact tests were used (Table 8).

2.



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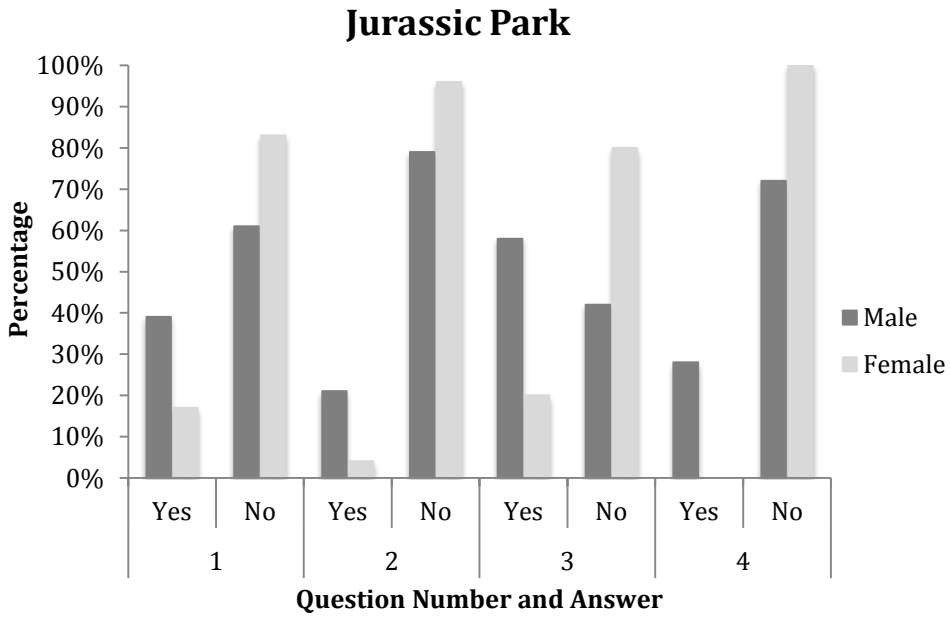

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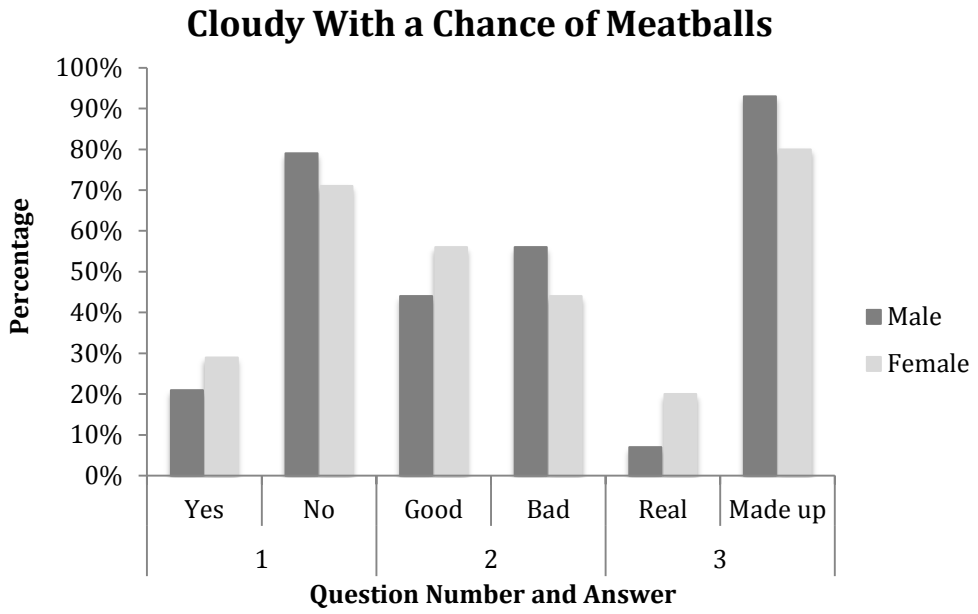


Figures 2-4. Percentage differences in answers to questions on science for three film clips between male and female students (5-15 years). Questions and specific options for answers to each can be found in Chapter 2 (Methods).

Table 8. Fisher's exact tests comparing the proportion of males and females giving different answers to questions on science.

Film	Question	P Value
Iron Man	2	1
	4	0.097
Jurassic Park	1	0.029
	2	0.038
	3	0.0005
	4	<0.0001
Cloudy With a Chance of Meatballs	1	1
	2	0.69
	3	0.45

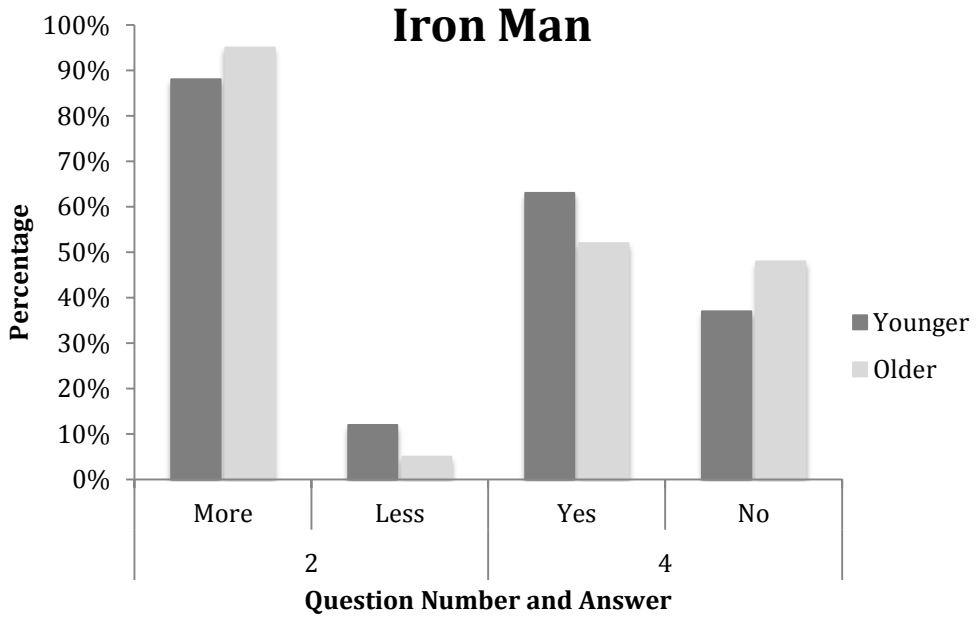
Jurassic Park showed statistical significance in the proportion of males and females giving different answers to every question, particularly question 4 (Males Yes-28%, Females Yes- 0%, Males No-72%, Females No-100%), but there was no significance in the proportion of answers for any other film's questions. The

majority of male students still answered negatively to these questions, but there were more individuals prepared to believe that dinosaurs could be brought back using the *Jurassic Park* method, that scientists were trying this and that it might actually be a good idea.

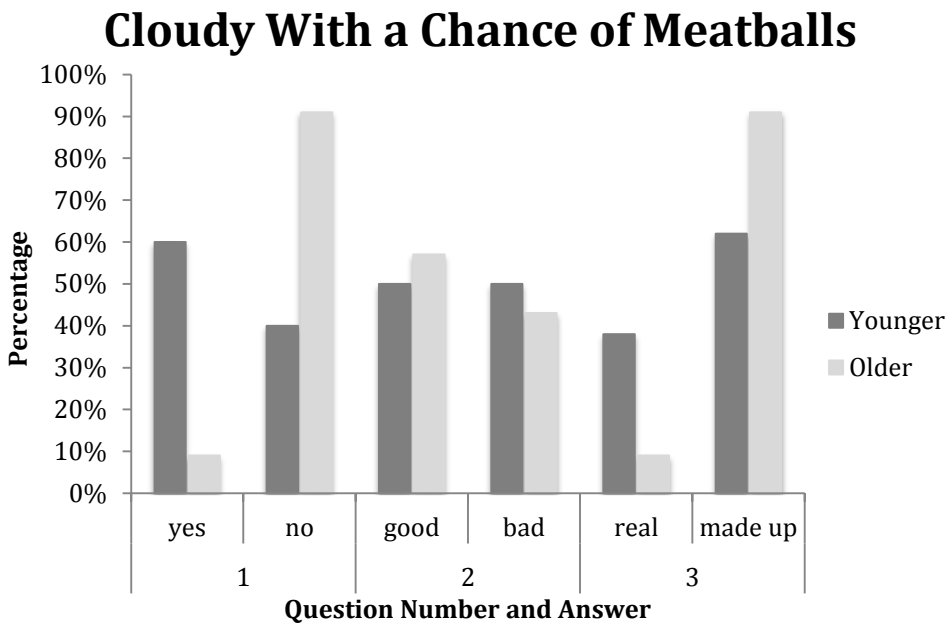
Comparisons of Age

The biggest differences between older and younger students in their answers to questions were for *Cloudy With a Chance of Meatballs* (Figures 5-6). *Jurassic Park* was omitted from this analysis as there were only five responses across the four questions. Statistical analysis was performed using Fisher's exact tests (Table 9).

5.



6.



Figures 5-6. Percentage differences from a 1:1 ratio in answers to questions on science in film clips between younger and older students (5-10 years and 11-15 years).

Table 9. Fisher's exact tests comparing the proportion of younger and older students giving different answers to questions on science.

Film	Question	P Value
Iron Man	2	0.15
	4	0.19
Jurassic Park	1	0.56
	3	1
	4	0.13
Cloudy With a Chance of Meatballs	1	0.014
	2	0.73
	3	0.17

With regards to gender the biggest difference in response occurred for the *Jurassic Park* questions, but this could not be accurately assessed here as so few younger students answered the questions. The only statistically significant difference in response with respect to age was the *Cloudy with a Chance of Meatballs* question asking whether students thought it would be possible to make it rain food, with 9%

of younger students believing this to be a possibility and 91% of older students believing this wasn't a possibility.

3.3.2 Qualitative Analysis

Where there were at least twenty written responses to a question from students, frequencies of related words for gender and age were recorded using NVivo (2015) (Tables 10 and 11).

Table 10. Word frequencies by gender for most popular themes to relevant questions on science.

Film	Gender	Question	Top Related Themes	Frequency	Weighted Percentage
Iron Man	Female	3	Try	13	5.5
			Work	10	4.2
			Test	10	4.2
			Fly	8	3.4
		4	Technology	14	5.1
			Advancing	9	3.3
	Male	3	Excited	11	12.6
			Test	8	9.2
		4	Hard	6	3.7
Jurassic Park	Male	1	DNA	12	9
	Female	4	Dangerous	14	7.6
			Destroy	7	3.8
			Kill	6	3.3

Table 11. Word frequencies by age group for most popular themes to relevant questions on science.

Film	Age Group	Question	Top Related Themes	Frequency	Weighted Percentage
Iron Man	Younger	3	Fly	12	8.5
			Excited	12	8.5
			Try	6	4.2
			Experiment	5	3.5
		4	Hard	6	4.6
	Older	3	Test	16	6.5
			Excited	11	4.4
			Work	11	4.4
			Try	10	4
			Fly	6	2.4
		4	Technology	23	7.2
			Advancing	12	3.7
			Impossible	6	1.9
			Future	5	1.6
Jurassic Park	Older	1	DNA	11	11
		4	Dangerous	20	5.2
			Destroy	9	2.3
			Kill	8	2.1

Iron Man

Question 3

This question checks comprehension levels among students and demonstrates whether students consider health and safety issues when it comes to science. Many of the younger students did not look beyond the fact that Tony wanted to test his suit, failing to provide any insight as to the reasons behind this, although some did note that he was excited to try it out. Older students had more a varied list of emotional responses to explain Tony's enthusiasm including impatience, confidence, his adventurous nature and excitement. Excitement and impatience were reasons cited mostly by males, whereas only females mentioned that Tony had no concern for health and safety.

Question 4

Advancing technology was the number one reason given for Tony Stark's suit being a possibility among older students, with one individual saying they already have suits like it in Tokyo, though several conceded that it would only be possible in the future. Several individuals showed their belief in the potential of science, with comments like *'Everything is possible in science'* and *'Technology nowadays is progressing day by day so basically everything is possible.'* The younger students were more scientist focused, saying that it was the capability of scientists themselves rather than the technology which exists which would make creating the suit possible and underestimating the difficulties, saying it would be simple or that it would take five days or 30 days to make, although one older student did say *'With advanced technology humanity invented building a suit like this would be a piece of cake!'* One older and three younger students also said it would be possible because Tony could do it.

Of the younger students who felt that it was not possible to make an Iron Man suit, many gave a basic response saying it would be too "hard" or "complicated" but without elaboration. There were more explanations given among older students, such as saying the suit defies the forces of gravity, there is no space for fuel, not enough money or not having the right materials. However four students from both younger and older groups (six females, two males) said that it was just a film, appreciating that anything is possible in a story, and saying *'It is a science fiction film so some things aren't true.'*

Jurassic Park

Only older students gave written explanations to these questions.

Question 1

Of those who thought that the method used in *Jurassic Park* might be able to bring the dinosaurs back (which involved cloning dinosaur DNA found in mosquitoes), most cited the fact that DNA was being used as the reason it would be possible. A couple of students highlighted that it would be possible but not yet, for example, *'It's quite a good idea but I think with our advanced technology in the near future we can do it.'* Part of the explanation in *Jurassic Park* involves the use of frog DNA to fill in the gaps of broken down dinosaur DNA, and one student who agreed that the *Jurassic Park* method could be used understood the problems this would cause, although he presumed that complete DNA from dinosaurs existed; *'Scientists can use DNA found entirely intact to be able to produce a clone of the dinosaur and start a population. However, frog DNA would completely change the composition of the original DNA.'* This student clearly understands pieces of the puzzle but does not comprehend the difficulties involved with some of the other steps. A couple of individuals who agreed the method was possible clearly connected the film with real life as though it were a documentary, with one female stating*, 'He (character John Hammond) has an idea how to bring dinosaurs back'* and another actually believing that resurrecting dinosaurs had already happened*, 'If they find a fly like they did before they can do it* ***again*** *[author's emphasis].'*

The majority of individuals felt that the method would not work, with the most popular reasons being that you can't bring back extinct animals or simply that it is impossible or too difficult. A few individuals went on to give more complicated explanations of the flaws in the process, talking about the problems of DNA breakdown, difficulties with finding mosquitoes in amber, the issues of DNA mixing or using an egg to hatch a dinosaur. One female took a more theological approach, saying *'Nobody can restore life except God,'* another student didn't even believe that mosquitoes in amber existed, saying*, 'It's impossible to find a mosquito from millions of years ago',* and another focused on the fact that she was watching a film, simply stating *'It is not reality.'* Answers to this question did not vary greatly by gender, with a fairly even spread across gender for different answers.

Question 2

Only 10 of 84 students responded positively about being aware of other methods to bring dinosaurs back aside from those explained in *Jurassic Park*. The sources of these ideas were; talks and TV, documentaries, internet, newspaper clips, school, science books and by thinking about it. One student mentioned that sheep had been cloned using a similar technique to *Jurassic Park* and another said *'If a male and female dino from the same species are found the species could grow and grow*.'

Question 4

The vast majority of students thought that dinosaurs should not be brought back if it were possible. Of those who were open to the idea, all of them were male, and reasons ranged from keeping them in zoos or learning about them to using

dinosaurs as food if animals become extinct, keeping one as a pet and *even 'If you tame them they can carry huge loads.'* One 14-year-old considered several different aspects in his response: *'There are both advantages and disadvantages. A lot of research can be made on the living dinosaurs than on fossils. We could even obtain new chemicals from them that can help in the medicine. However, these things were in fact the responsible animals that have kept us from evolving for millions of years until they were extinct and we could evolve so great care needs to be taken.'*

Of the individuals who thought it would be a bad idea to bring back the dinosaurs, the overwhelming theme was the danger that they would present to us. Students had a variety of drama-based responses to questions, starting with the dinosaurs being too dangerous and moving up to them eating people and even wiping out humanity altogether. Each of these ideas had similar numbers of responses, with comments including *'They will kill everything,' 'They would make us humans extinct'* and *'Dinosaurs are quite dangerous and if humans had to bring them back the dinosaurs would feast on our bones!'*

Cloudy With a Chance of Meatballs

Only a few students of each age answered the following questions.

Question 1

One younger and older student thought that it would be possible to make it rain food, with the younger student conceding that it would be difficult and the older student saying you could drop food in different locations. Neither explained how it could be done. A younger student's comment *'Because it's only in films'* was the

only one to give a reason that focused on the fictional premise of the scenario. There were no discernable differences in the responses of males and females.

Question 2

Students were divided in their opinion on whether raining food would be a good or bad thing, with one 14 year old male saying: *'We could feed entire poor countries, won't waste time cooking and spend any money on food. However, a lot of waste would appear, scavengers would appear and many diseases would spread'*. In a similar vein, older students generally gave reasons from a global standpoint, citing decreases in starvation and saving money as good reasons and increases in obesity, risk of disease and poverty from loss of jobs in the food industry as negative reasons. Younger students focused on the immediate effects, saying food might '*fall on you'*, would be '*unclean on the floor*' or '*poisonous*'.

Question 4

Many of the older students' and all of the younger students' suggestions for film inventions they would like to see made real were connected with the clips they had seen, such as Iron Man, dinosaurs and a food machine. One student took a different perspective, saying *'None of them since the more we create the more life becomes dangerous (most films show bad science)'* and giving an explicit comment about the inaccuracy of films.

3.4 Discussion

Most of the film clip questions on science showed a statistically significant difference from a 1:1 ratio for possible answers (yes/no more/less good/bad similar/different) to the questions. In fact, the only questions that divided opinion to any extent were question 4 from *Iron Man* that asked whether we could build a suit like this is real life and question 2 from *Cloudy With a Chance of Meatballs* that asked whether it would be a good or bad thing if it rained food.

When looking at the proportion of male and female students who gave different answers, only *Jurassic Park* showed a statistically significant difference, but this applied to every question. Here, more male than female students thought that dinosaurs could be brought back, that scientists were trying to do this and that it would be a good idea, however, the majority of their answers to these questions (58% overall) were still negative.

When looking at the proportion of older and younger students who gave different answers to questions, Only the questions asking whether students thought it would be possible to make it rain food was statistically significant, with more younger students thinking it would be possible.

3.4.1 General Perceptions of Science in Response to Clips

Regarding the possibilities of scientific ideas in films becoming real, students were quite clear in the capabilities of science to resurrect extinct species. Generally, students felt sure that extinction was forever, and the *Jurassic Park* clip was unable to change their minds. Perhaps if the film had come out more recently they would have been less sure that the method used in the film was not possible, or the

permanence of extinction may have been heavily entrenched by teachers at school already. However, students were more ambivalent about the capabilities of technology, with opinion split between whether a suit like Iron Man's could be created. This may be because students are less likely to have received lessons that confirm an answer to this question in either direction and so may be more prone to believing what they see in films without definitive guidance from school.

Iron Man also highlighted the scientific foci of students, with their answers relating to ideas of testing and experimenting, enthusiasm for the realisation of scientific projects, and also health and safety concerns. There was a generally positive perception regarding the future, with a confidence that the advancement of technology would take care of things that aren't currently possible. However, regardless of the answer, the fact that students were considering what was possible in terms of the technology present in the real world suggested that the majority of students did not blindly accept that an *Iron Man* suit was possible because it existed in a movie. In line with the perceptions found in Malta research by Koren and Bar (2009) also found that most students were positive about science and its uses in society.

The *Jurassic Park* clip revealed that students were aware of DNA and its importance in biology but they frequently misunderstood the nuances of its mechanisms, leading to oversimplifications in their reasoning when saying it could be used to bring back dinosaurs. As for those individuals who disagreed many discarded even this basic knowledge of DNA and questions surfaced about blood not being enough to complete the task of 'making' a dinosaur. Again many students

fell back to the concept that the future would take care of the impossibilities of today, with the vague notion that time itself would overcome the issues standing in the way. Indeed, those who subscribed to this view acted as though there were no permanent barriers in science, a notion that may itself have been inspired by science fiction films that are well known to explore concepts as far reaching as time travel and superpowers. Aside from films, a range of other media sources of scientific information on resurrecting the dinosaurs was given, with only one individual saying they had heard about ideas at school. Other students said TV, the internet and newspapers, all of which are known for their unreliability as sources of accurate scientific information (e.g. Goldacre, 2008; Rezbach et al., 2013; Plencner, 2014). This exposure only increases the number of sources that may provide misinformation to students, and makes a critical appraisal of content even more important.

3.4.2 Influences

Students shared the same opinion for most questions, but in some cases having any students disagree with the majority shows that films are able to influence individuals. For example, most students did not believe that dinosaurs could be brought back using the method in *Jurassic Park*, but more than a quarter (27%) of students thought that the method would work. An even greater proportion (37%) believed that scientists are trying to bring back dinosaurs in real life. Similarly, 24% of students thought that it would be possible to make the clouds rain food and 10% thought that inventions in films were mostly real. The proportion of these responses is even more surprising given how far removed from reality many of these concepts

are. Similar results have been found in connection with watching TV leading to a stronger belief in what science can achieve (Nisbet et al., 2002). Clearly, the capability of films to influence student perceptions of science exists, even if it does not affect everyone equally. Despite this, students were not particularly concerned by the level of accuracy in films, although only 11% showed an appreciation that they were for entertainment with no desire to change that.

Some of their comments suggested that influences from one film clip might have changed how they perceived the next. Students seemed to be taking on board Tony's repetition of steps when perfecting his suit, asserting that Flint Lockwood should also repeat his steps to improve his experiments. This link is by no means certain though and if the influence came from *Iron Man*, it is not clear how long its effect will last and no research has been done that highlights length of influence for this type of content. They may have been using earlier aspects of the presentation to inform their answers to later parts with no guarantee that these impacts will be taken with them once they leave. An even stronger argument against influence involved students directly voicing disagreement with the ideas presented simply because they were from a film, and therefore fictional. However, despite being scattered throughout the film clips, this direct dismissal of science in films was uncommon. It is likely that certain individuals are a lot less prone to being influenced by films and that different personality traits such as being highly rational or imaginative may result in a predisposition for believing or rejecting what they see in films and other fictional media. In fact, research has shown that different personality traits can affect how trusting individuals are, with extroversion and openness to experience increasing the disposition to trust and neuroticism and

conscientiousness leading to a lower disposition to trust (Sutherland and Tan, 2004). Differing level of these traits may impact how trusting students are of the scientific content they see in films and this would be an interesting area for research.

Another important aspect was the context of the science. When students choose how they feel about science, the way it is presented is just as important as the science itself, with *Iron Man* doing this positively and *Jurassic Park* being negative. This was particularly clear when a single student changed their perception of science from one clip to the next. For example, 'Technology nowadays is progressing day by day so basically everything is possible' was their statement after seeing the *Iron Man* clip. However, they went on to say, 'It's not a very good idea to bring back the dinosaurs,' after seeing the *Jurassic Park* clip.

Furthermore, their attitude towards the idea of seeing an *Iron Man* suit or dinosaurs in real life rarely considers scenarios in a real world context that cause alternative results to those shown in the film. For instance, it is quite possible that a suit similar to those in *Iron Man* could actually be used in negative ways in the wrong hands, just as the presence of dinosaurs could be used to further our knowledge of biology. Only a few students (13%) were able to present a scenario where a concept in a film could end with a different impact in real life, such as one student who said 'a lot of research could be made on living dinosaurs.' The vast majority (87%) saw dinosaurs in real life leading to a catastrophic and dramatic end for society that was reminiscent of disaster movies. This response disregards that precautions that would be taken in real life to keep dinosaurs and humans separate, with students becoming

blind to the possibility of safe enclosures that keep millions of animals behind bars in zoos without difficulty. It is worth noting that this negative attitude toward dinosaur resurrection must come as a result of seeing the *Jurassic Park* movie in its entirety, as the clip shown only explained the methods to bring them back and mentioned no negative repercussions, but when asked most students had seen the whole film at some point before the presentation. Student responses about dinosaurs bringing about the destruction of the world is possibly one of the clearest indicators that students are influenced by the way films present a scenario, and expect the same result to happen in real life.

3.4.3 Gender Differences

The differences in male and female answers did not suggest a significant disparity in their ability to be influenced by films, though responses claiming that what they were watching was only a film were heavily gender-biased, with 16 females and only 2 males saying this at some point during their answers. This could indicate that females are better able to keep an external perspective when they are watching films and males are more likely to become absorbed in the story and therefore be more influenced by it. A study of secondary school students by Preece and Baxter (2000) found the opposite, with females generally less skeptical than males, although this did depend on the topic in question, as males were less skeptical when the scenario was of interest to them. There were also distinctions to be made in the way that males and females perceived the science they were seeing, with females overall being more concerned with safety and testing. Males were more focused on reward and excitement, and showed a willingness to accept perceived risks as evidenced by

their more positive response to bringing the dinosaurs back. However, this only applied when combined with reward (such as the excitement of seeing dinosaurs), and when there was only personal risk (Dr. Venkman's electric shock experiment in *Ghostbusters*) males were just as unwilling as females to take part.

3.4.4 Age Differences

Although both age groups gave indications that films have the power to influence their perceptions of science this impact was definitely heightened in younger students, with more fanciful ideas being more readily accepted. Older students required some degree of scientific premise to be fooled, like that shown in both the *Iron Man* and *Jurassic Park* clips, where the presence of a scientific process reduced their confidence in the ability to distinguish the real from the fictional (Barnett et al., 2006). However, whether the reasoning of students who dismissed what they had seen simply stemmed from their personal experience (they have never seen a living dinosaur or working Iron Man suit) or what they have been taught was beyond the reaches of this research and merits further investigation. The more explanatory comments (needing fuel for Iron Man's suit or DNA breaking down) did suggest that they were using knowledge from related concepts and it would be useful to explore the source of this information with similar studies in future.

Areas of confusion also differed between age groups, with younger students taking things more literally, such as Iron Man's suit being made of iron, and older students being more likely to treat questions as a personal request, such as students thinking

they were being asked if they could build an Iron Man suit. This indicates that younger students are more likely to accept what they witness in film without question, but that older students may be more likely to misinterpret the more subtle signals which pass younger students by altogether.

In addition, younger students were far more focused on the present and near future, giving responses that considered things in the short term and answering questions based on what they understood as being possible right now, whereas older students considered how the answers to questions might change as we progress into the future. This was particularly evident when thinking about the consequences of making it rain food. Also, younger students were far more likely to only consider how hypothetical situations would affect them, regardless of whether the situation would apply to everyone (such as bringing the dinosaurs back). Elkind (1967) found that egocentrism diminishes by the age of 15 or 16, and older students in this study also took a less egocentric view, being able to think about the global consequences and often giving answers which ignored their personal stake altogether.

3.4.5 Applications

Some institutions have attempted to control the potential for science content in films to misinform by using film clips in an educational setting, where teachers can address the responses to inaccuracies. This can turn faults and inaccuracies in films into a positive influence on students' ability to think critically about what they see, a highly important skill that improves comprehension and effective expression of ideas (Lau, 2003; K¡ir¡kkaya and Bozkurt, 2011). Lesson plans and even courses

have been created which focus on increasing student scientific literacy through critical analysis of concepts portrayed in both film and television (Table 12) (Shaw, 2000; Barnett et al., 2007). In fact, the value of science fiction films in teaching basic principles has been used for two decades, and has been particularly useful regarding physics and chemistry concepts (Freedman and Little, 1980; Liberko, 2004). In response to this Motz (2013) developed a Cognitive Science Movie Index (CSMI) with the aim of aggregating movies that possess science that may be used for outreach and education purposes (such as *Ex Machina* and *The Imitation Game*). Using films to teach science has the power of being visually engaging and interesting to students, taking advantage of a medium they seek for entertainment to build interest in science and safeguard against them being misled by pseudoscience, all while exposing them to socially relevant issues frequently used in films (Dubeck et al., 1995; Dubeck et al., 2004; Barnett et al., 2007). In this way, even the 'bad science' in films becomes a useful lesson, whereby comparisons can be made between what happened in the film and what would happen in real life (Perkins, 2004), leading to students who can make grounded and unbiased decisions (Miller, 2006). Research into the effectiveness of these courses has shown positive results (Surmeli, 2012; Lin, 2014), with interest stimulated in students from both required and elective science courses, although this result was more pronounced in students who had chosen to focus on the sciences (Laprise and Winrich, 2010).

Table 12. Science in films and TV for HE courses.

Course	University	Overview	Course Website
Science and the Cinema	UNSW Australia	Involves viewing films with scientific content and discussing how faithfully the movies portray the science incorporating social and ethical issues.	http://www.handbook.unsw.edu.au/undergraduate/courses/2015/SCIF1004.html
From Frankenstein to The Matrix: science fiction and film	University of Manchester	Looks at how ordinary people have reacted to developments in science through differences in science from the nineteenth century through today.	http://www.chstm.manchester.ac.uk/undergraduate/courses/hstm20302/
Science on screen	Imperial College London	Uses critical analysis and the representation of science and scientists in film and television, relating to science fact and science fiction.	http://www3.imperial.ac.uk/horizons/courseoptions/scs/scienceonscreen
Science in Film: The Good, the Bad and the Ugly	Southern Illinois University	Discusses how science and scientists are portrayed in earth-science based movies with critical analysis.	http://www.science.siu.edu/academics/dept/syllabi/S14/geo/351np.pdf
Physics in Film – Star Wars and Beyond – Junior SPARK	Brown University Rhode Island	For ages 12 plus, explores physics and astronomy inspired by science fiction and how often this incorporates science fact.	http://www.brown.edu/academics/pre-college/catalog/course.php?course_code=CEPI0603
Physics in Films: An assessment	University of Central Florida	Using Hollywood films to generate interest in science and engage students who have been resistant to science courses by showing clips and using them to explain scientific concepts.	http://arxiv.org/abs/physics/0609154
Lights, Camera, ACTION: The Chemistry of Movies and TV	University of New Orleans	Looks at how chemistry is portrayed in films and TV.	http://www.uno.edu/cos/chemistry/Undergraduate/courses.aspx

Based on evidence that shows the value of films in lessons and the findings of this study there should be an increase in science courses that use film and TV clips to teach critical thinking of media and explore and teach different science concepts. Clips can be used as a springboard in sessions in a similar format to that used during presentations at the Maltese Science Festival. This approach worked well, grounding the concept, engaging them with it, and making the comparisons with real life more exciting because it was being connected with something in a movie. The best example of this is the *Iron Man* clip, which used the steps of Tony Stark's creation to explain the scientific method in slides during the presentation (Figure 7), and also used the invention of the Iron Man suit to initiate discussion about real life suits and their uses and benefits to society. Seeing science fiction brought to life can be inspirational, resonating with young people and helping them to envision a career in STEM (Subramaniam et al., 2012). This use of visual fiction is the perfect way to introduce a more critical appraisal of science in students. It is not only engaging but also an easy to understand method of exploring science which may not be accurate, and this can be used to discuss more complex and subtle inaccuracies hidden in media and even journal articles.

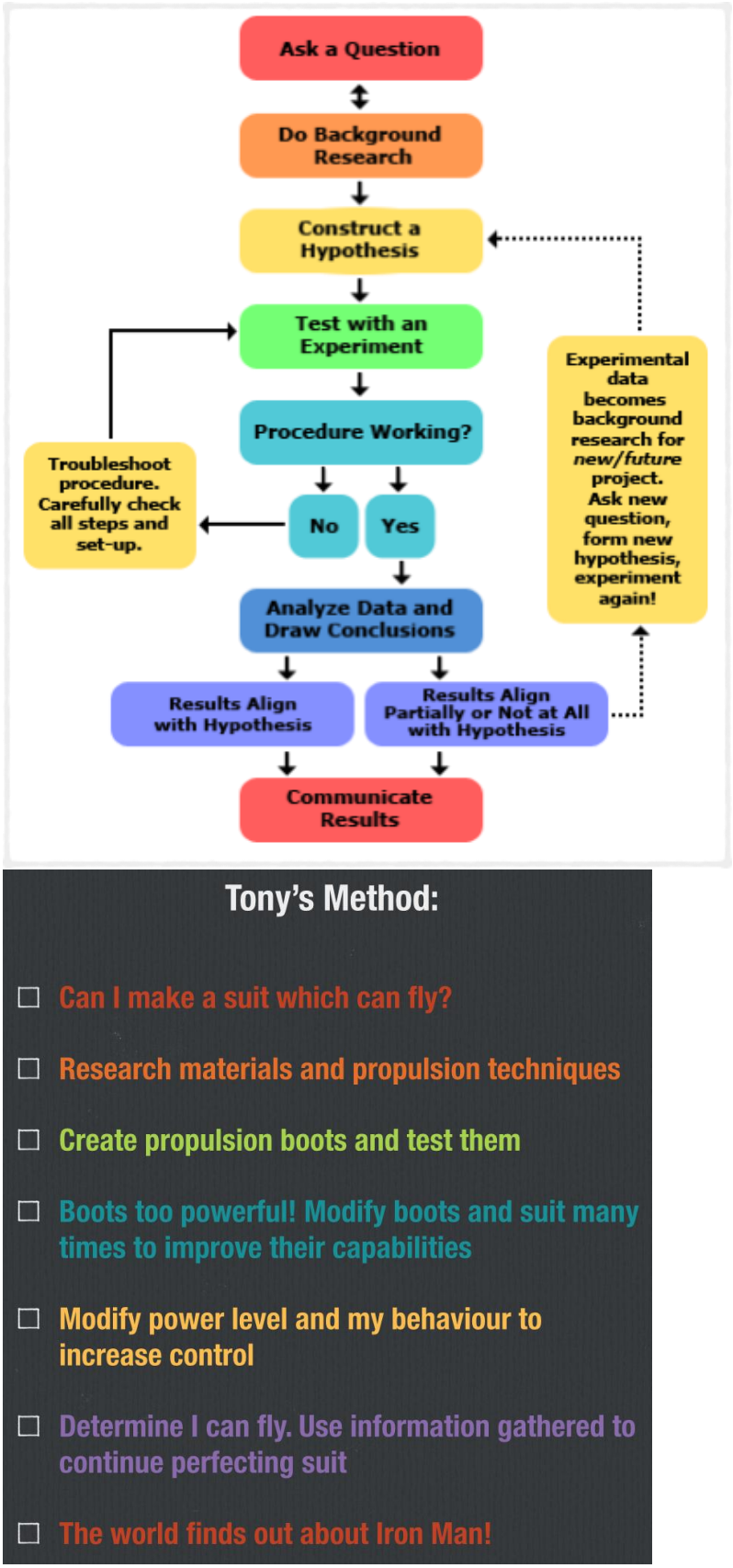


Figure 7. The scientific method and Tony Stark's method in Iron Man colour coded to match.

Currently many students are graduating from secondary school in western countries without the ability to think critically (Carlgren, 2013). Exposing students to critical thinking earlier on will provide an important skill required at university level and by employers, enabling students to better compete for available positions (Conley and Mcgaughy, 2012). In addition, encouraging a critical eye at a younger age ensures that all students are given this skill before they choose a subject in higher education, so that even if they decide not to pursue a scientific discipline, they will have the experience and knowledge to not blindly accept the articles they see in the media and in visual fiction such as films and TV. Using clips in this way can safeguard against the uncritical acceptance of film content witnessed by students. It can encourage students to question what they see and appreciate that even science which is often viewed as a fact-based discipline beyond reproach (Gardner et al., 2009) sometimes has agendas or angles using content that supports the claims of those behind it.

Chapter 4-How Do Students Perceive Scientists in Films?

4.1 Introduction

As discussed in Chapter 1, the ability of films to influence the perceptions of students towards scientists has focused on the negative effects of scientist stereotypes on student interest in science (Perkins, 2004; Van Gorp et al., 2014). It was found that many students have little or no exposure to scientists so their only visual representations of them tend to come from media or films (Ambusaidi et al., 2015). Also, many studies on student perceptions of scientists concentrate on the draw a scientist test (DAST) and miss out on the deeper awareness that comes from discussion and written answers to questions (Farland-Smith et al., 2014). These can explore abstract concepts about scientist behaviour or motivation that are difficult for adults let alone children to represent visually. With this in mind this chapter looks at how scientists in films are perceived by students and also considers their perception of scientists in general. It includes explorations into what a scientist is, how they look and how they behave as well as the moral implications of scientists and whether students generally have positive or negative attitudes towards them. Chapter 4's research questionnaire will include open questions with the hope of offering a greater understanding into not only existing student perceptions of scientists but also how these might be changed by witnessing film content.

Previous research has indicated the following possible responses to this research:

• Students will have stereotypical ideas about the appearance of scientists. For example, wearing lab coats, elderly and with glasses (Özsoy and Ahi, 2014)

• Student's ideas about scientists will come from films more than their education (Steinke, 1999)

• There may not be a clear difference regarding prevalence of stereotypes between older (Ünver, 2010) and younger (Buldu, 2006) students

• Females will be more likely to think about female scientists in their answers, but there will still be a male bias (Steinke, 2007)

The support or otherwise of these hypotheses can be used to encourage a more positive perception of scientists by students where necessary and increase the likelihood of them being inspired to choose a career in science. Analysis will explore the whole data set and follow up with a look at the differences between males and females and two different age groups.

4.2 Methods

As detailed in Chapter 2, a total of 181 students were surveyed, answering questions on film clips that discerned students perceptions of scientists. Two sets of clips were devised, one for younger (5-10 years) and one for older (11-15 years) students. Data were analysed both quantitatively and qualitatively. The questionnaire was given as a single sampling effort comprising science and scientist questions and responses specific for the chapter in question were divided up afterwards. For quantitative and qualitative analysis the following questions are relevant with regards to student responses for questions on scientists:

Table 13. Quantitative questions exploring student perceptions of scientists.

Film	Questions
Iron Man	1. I think that Tony Stark is a scientist (Yes/No) 2. Does Tony Stark make you want to be involved with science and creating technology more or less? (More/Less)
Ghostbusters	1. Is Dr. Venkman being honest to his participants? (Yes/No) 2. Would you say yes to being involved with one of his experiments? (Yes/No) 3. Does seeing this experiment make you want to be a scientist more or less? (More/Less/Neither) 4. After seeing this clip do you think most scientists behave ethically? (Yes/No)
Armageddon	1. Does the behaviour of the people in this clip change the way you think scientists would behave? (Yes/No) 2. Have you learnt more about scientists from films or school? (Films/School/Neither) 4. Do scientists look like the people in this clip? (Yes/No/Maybe)
Despicable Me 2	2. In the clip Dr. Nefario talks about going somewhere 'more evil.' Do you think there are evil scientists in real life? (Yes/No) 3. Do you think real scientists would look different or similar to Dr. Nefario? (Different/Similar)

Table 14. Qualitative questions exploring student perceptions of scientists.

Film	Questions
Iron Man	1. I think that Tony Stark is a scientist (Yes/No) Why? Why not? 4. Could scientists build a suit like this? (Yes/No)
Ghostbusters	1. Is Dr. Venkman being honest to his participants? (Yes/No) Why? Why not? 2. Would you say yes to being involved with one of his experiments? (Yes/No) Why? Why not? 3. Do you think scientists are trying to bring back the dinosaurs in real life? (Yes/No) 4. After seeing this clip do you think most scientists behave ethically? (Yes/No) Why? Why not?
Armageddon	1. Does the behaviour of the people in this clip change the way you think scientists would behave? (Yes/No) Why? Why not? 2. Have you learnt more about scientists from films or school? (Films/School/Neither) Why? 3. What does it mean to be a scientist? 4. Do scientists look like the people in this clip? (Yes/No/Maybe) If no, how do they look different?
Despicable Me 2	1. Why do you think Dr. Nefario quit his job? 2. In the clip Dr. Nefario talks about going somewhere 'more evil.' Do you think there are evil scientists in real life? (Yes/No) What would make a scientist evil? 3. Do you think real scientists would look different or similar to Dr. Nefario? (Different/Similar) How? 4. How do you think Dr. Nefario's lab is different to a real lab?

4.3 Results

4.3.1 Quantitative Analysis

General Comparisons

The biggest differences in answers from a 1:1 ratio were for the *Iron Man* questions and first two *Ghostbuster* questions (Figure 8). For *Iron Man* 93% of students said that Tony Stark made them want to be involved with science more and 92% said they thought Tony was a scientist, for *Ghostbusters* 99% of students said that they didn't think Dr. Venkman was being honest to his participants and 99% said that they wouldn't want to be involved with one of his experiments. Most students (49%) stated that the experiment did not impact whether they wanted to be a scientist or not but a much higher number said the experiment made them want to be a scientist less (46%) than more (5%).

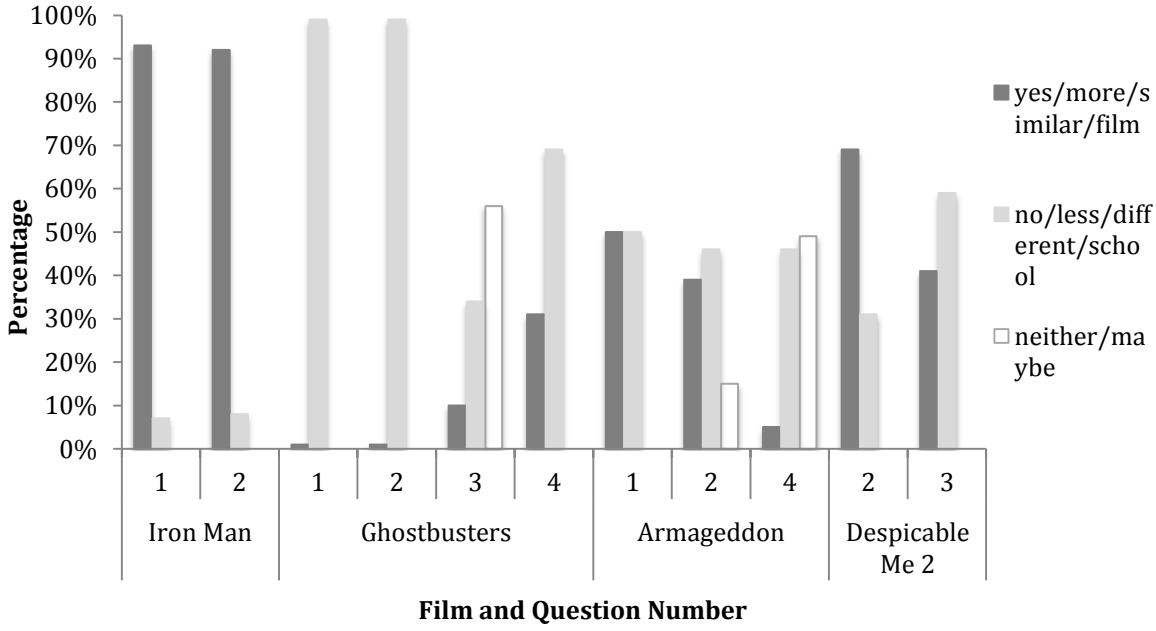


Figure 8. Percentage differences in possible answers to questions on scientists based on four different film clips shown to students (5-15 years). Questions and specific options for answers to each can be found in Chapter 2 (Methods).

Statistical significance (Table 15) was found in the differences in answers given from a 1:1 ratio for the following questions (more popular answer in bold):

Iron Man:

1. I think that Tony Stark is a scientist (**Yes**/No)

2. Does Tony Stark make you want to be involved with science and creating technology more or less? (**More**/Less)

Ghostbusters:

1. Is Dr. Venkman being honest to his participants? (Yes/**No**)

2. Would you say yes to being involved with one of his experiments? (Yes/**No**)

Armageddon:

2. Have you learnt more about scientists from films or school? (Films/**School**/Neither)

4. Do scientists look like the people in this clip? (Yes/No/**Maybe**)

Despicable Me 2:

2. In the clip Dr. Nefario talks about going somewhere 'more evil.' Do you think there are evil scientists in real life? (Yes/**No**)

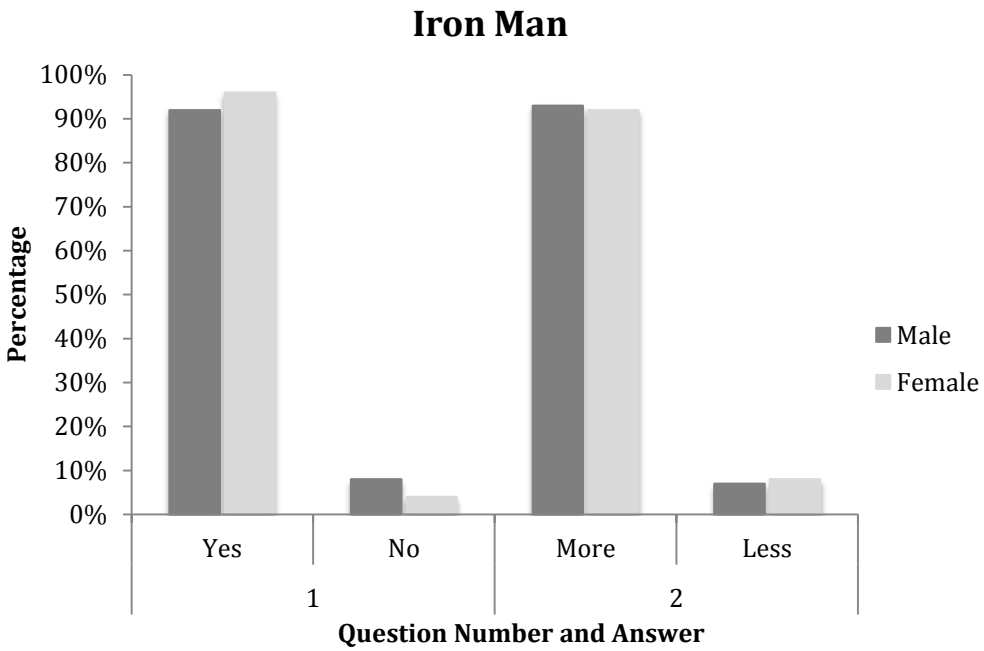
Table 15. Chi-square tests on differences in answers to scientist based questions.

Film	Question	χ^2	Degrees of Freedom	P Value
Iron Man	1	125.9	1	<0.0001
	2	114.62	1	<0.0001
Ghostbusters	1	67.06	1	<0.0001
	2	67.06	1	<0.0001
	3	23.04	2	<0.0001
	4	9.66	1	0.0019
Armageddon	1	0	1	1
	2	7.09	2	0.029
	4	14.01	2	0.0009
Despicable Me 2	2	6.42	1	0.011
	3	1.5	1	0.23

Comparisons of Gender

The largest differences in answers between males and females were for the *Ghostbusters* clip question 3 asking whether the clip made students want to be a scientist more or less and the *Despicable Me 2* clip question 2 asking whether students thought there were evil scientists in real life (Figures 9-12). A higher proportion of male than female students said they would want to be a scientist more (17% vs. 5%) and a higher proportion of male students thought that there were evil scientists in real life (74% vs. 43%). To test these proportions for statistical significance Fisher's exact tests were used (Table 16).

9.



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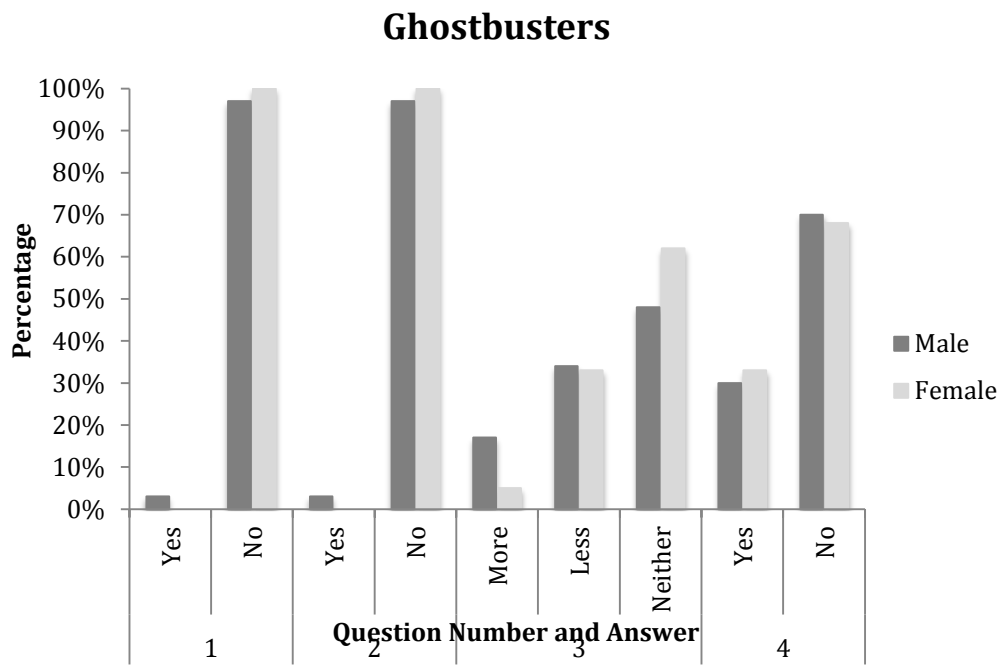
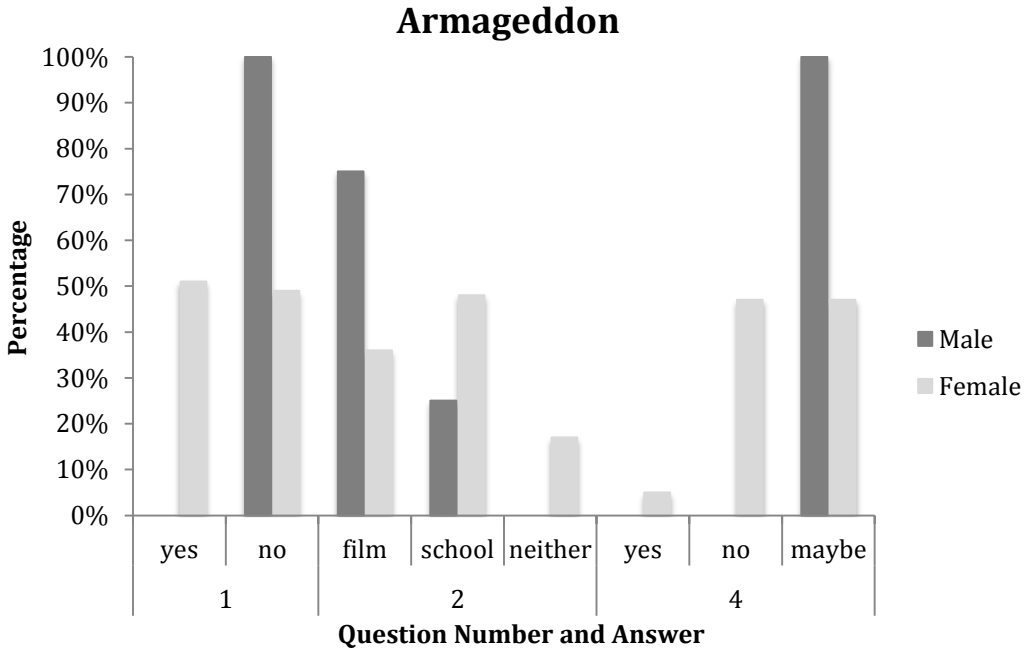
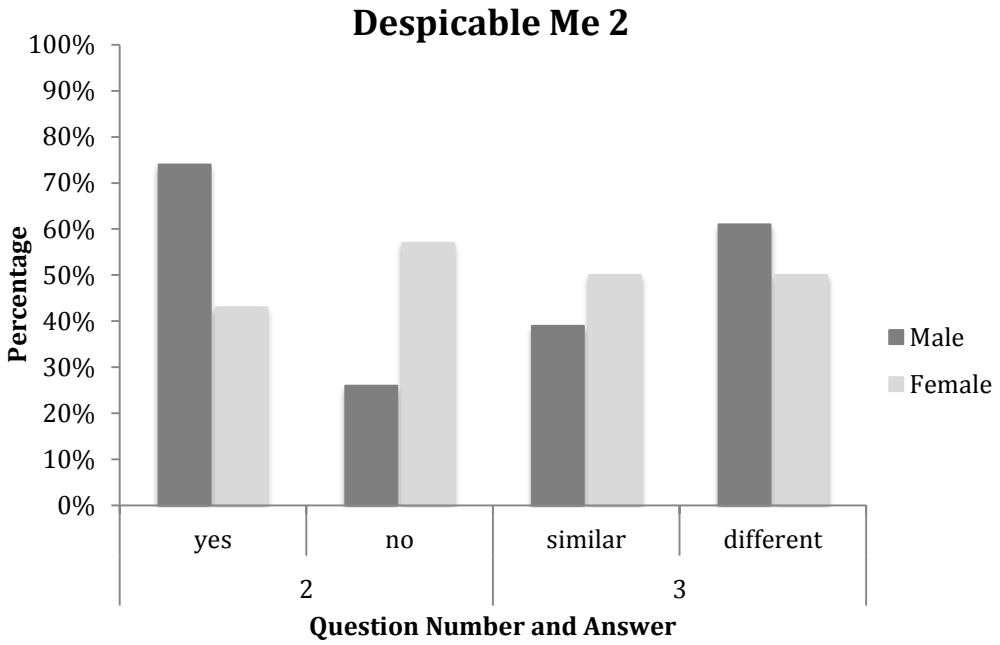

Ghostbusters
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
Yes
No
Yes
No
More
Less
Neither
Yes
No
1
2
3
4
Question Number and Answer
Male
Female

11.


Armageddon
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
yes
no
film
school
neither
yes
no
maybe
1
2
4
Question Number and Answer
Male
Female

12.



Figures 9-12: Percentage differences in answers to questions on scientists between male and female students for four film clips.

Table 16. Fisher's exact two-way classification tests comparing the proportion of males and females giving different answers to questions on scientists.

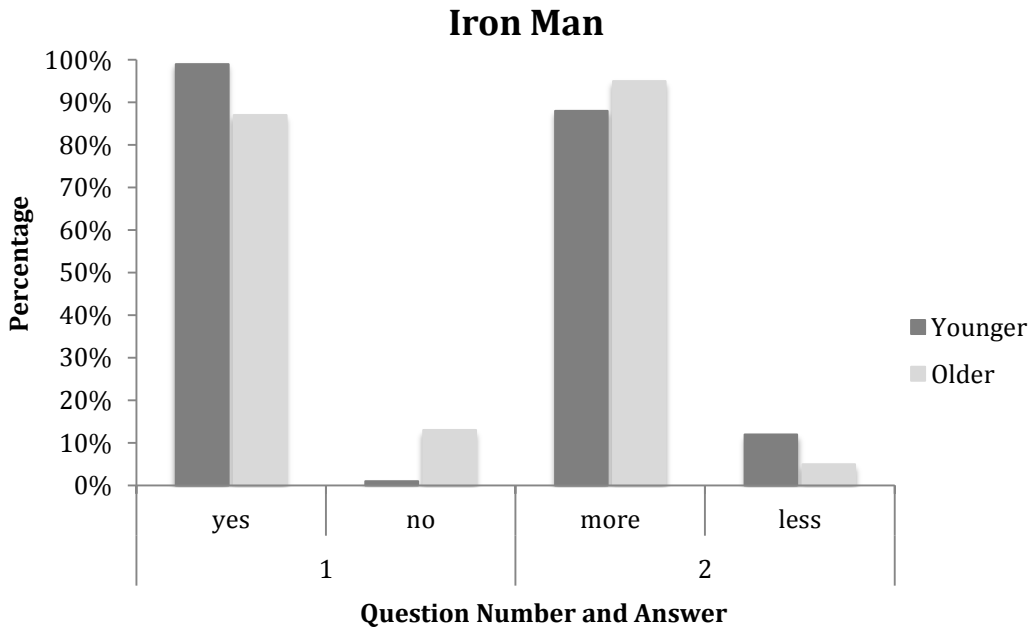
Film	Question	P Value
Iron Man	1	0.32
	2	1
Ghostbusters	1	0.42
	2	0.42
	3	0.18
	4	1
Armageddon	1	1
	2	0.36
	4	1
Despicable Me 2	2	0.18
	3	0.68

There were no statistically significant differences in the responses of males and females to any of the questions given on scientists.

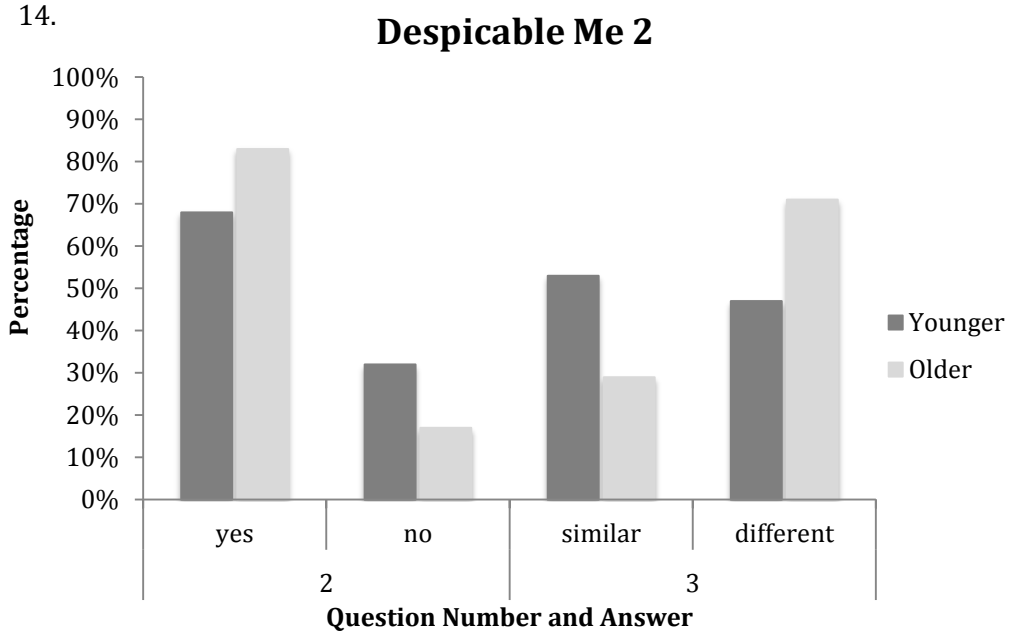
Comparisons of Age

The biggest differences between older and younger students in their answers to questions were for the *Iron Man* questions, which asked whether they thought Tony Stark was a scientist and whether he made them want to be a scientist more or less (Figures 13-14). Ninety nine percent of younger students said he was a scientist but only 87% of older students agreed. The reverse majority occurred with question 2, where 88% of younger students said Tony made them want to be a scientist more and 95% of older students felt this way. To test whether these differences were statistically significant Fisher's exact tests were used (Table 17).

13.



14.



Figures 13-14: Percentage differences in answers to questions on scientists between male and female students for two film clips.

Table 17. Fisher's exact tests comparing the proportion of younger and older students giving different answers to questions on scientists.

Film	Question	P Value
Iron Man	1	0.0022
	2	0.15
Despicable Me 2	2	0.47
	3	0.33

The only statistically significant difference in the responses of younger and older students to questions on scientists was whether they thought that Tony Stark was a scientist or not, with a higher percentage of the older students thinking that Tony was not a scientist.

4.3.2 Qualitative Analysis

Descriptions of prevalent attitudes and themes covered by students follow, with considerations of difference in gender and age. Where there were at least twenty written responses to a question from students, frequencies of related words by gender and age were recorded using NVivo (2015) (Tables 18 and 19).

Table 18. Word frequencies by gender for most popular themes to relevant questions on scientists.

Film	Gender	Question	Top related themes	Frequency	Weighted percentage
Iron Man	Female	1	Suit	35	8.8
			Build	22	5.5
			Invents	11	3.4
			Knows	10	3.1
			Tries	9	2.8
		4	Technology	14	5.1
			Advancing	9	3.3
	Male	1	Suit	21	8.9
			Made	21	8.9
			Invent	9	3.8
			Created	6	2.5
		4	Hard	6	3.7
Despicable Me 2	Male	1	Jelly	8	7.5
			Job	7	6.5
			Bad	6	5.6
Ghostbusters	Female	1	Shock	15	8.2
			Right	8	4.4
			Wrong	8	4.4
			Fair	7	3.8
			Lying	7	3.8
		2	Shock	14	10
			Fair	6	4.3
			Wrong	5	3.6
	Male	1	Lying	15	8.6
			Girl	13	7.4
			Right	10	5.7
			Wrong	9	5.1
			Shocking	8	4.6
		2	Shock	11	16.9
		4	Lying	6	12
			Fair	5	10
Armageddon	Female	3	New	17	9.6
			Invent	11	6.2
			Discover	9	5.1
			Study	6	3.4
			Experiments	5	2.8

Table 19. Word frequencies by age group for most popular themes to relevant questions on scientists.

Film	Age group	Question	Top related themes	Frequency	Weighted percentage
Iron Man	Younger	1	Suit	29	8.4
			Make	29	8.4
			Invents	12	3.5
			Build	10	2.9
			Creating	8	2.3
		4	Hard	6	4.6
	Older	1	Suit	38	10.1
			Build	23	6.1
			Invent	12	3.2
			Robot	10	2.7
		4	Technology	23	7.2
			Advancing	12	3.7
			Impossible	6	1.9
			Future	5	1.6
Despicable Me 2	Younger	1	Jelly	11	11.2
			Evil	9	9.2
			Bad	7	7.1
Ghostbusters	Older	1	Shock	23	7.5
			Girl	19	6.2
			Right	18	5.9
			Wrong	17	5.5
			Lying	16	5.2
		2	Shocked	25	12.3
			Dangerous	7	3.5
			Wrong	6	3
			Lying	6	3
		4	Lying	13	8.2
Armageddon	Older	1	Acting	5	4.6
		3	New	17	9.5
			Invent	12	6.7
			Discover	9	5
			Study	6	2.8
			Experiments	5	2.8

Iron Man

This clip was shown to both older and younger students, with 89 responses by males and 67 responses by females.

Question 1

The majority of older and younger students felt that Tony Stark was a scientist, with the number one reason being because he made a suit or machine. Attitudes towards scientists were also evident and generally positive, with three students claiming he was a scientist because he was trying to save the world or talking about his knowledge and competency, for example: *'Because he is inventing something that was never seen before on earth and you need to have knowledge to be a scientist and he clearly had knowledge'*. One student also highlighted persistency as a key quality of a scientist with their comment, *'He performs all the steps used in an experiment. Also he keeps trying over and over again and doesn't give up immediately.'*

Differences between males and females were negligible, although only males mentioned the fact that he made weapons (2%) and only females gave *'using science'* as a reason Tony was a scientist (11%).

Younger students focused more on the things around Tony than Tony himself, citing his equipment and lab, his robots and explosions as reasons he was a scientist. One student failed to discern Tony Stark as a character in a film; simply stating *'He is a very famous scientist.'*

Several older students pointed out that they thought he was more of an engineer or mechanic, comprehending roles in different STEM areas. Others ignored the

complexities of what Tony Stark was trying to achieve and instead focused on the fact things had gone wrong a few times (‘*Not all experiments worked’*), stating that his lack of intelligence or competency meant that he wasn’t a scientist, and missing the fact that science frequently involves correcting mistakes. One even said ‘*He’s not intelligent and his machine has to tell him things*,’ unaware that the machine itself had been invented by Tony Stark.

Question 4

As well as using this question on building a suit in real life to discuss the limitations or capabilities of science itself, several students gave insights into their perceptions of scientists with their answers. Those who mentioned scientists stated that it was their capabilities that made building a suit like Tony Stark’s possible. Comments included; ‘*scientists are capable*,’ ‘*scientists are smart*,’ ‘*if you are a real scientist you are intelligent you will succeed*,’ ‘*scientists can make anything*,’ and ‘*yes because scientists are always inventing new things and some day they will be capable of building a suit like this*.’ None of the students mentioned any limitations of scientists in their reasons that the suit could not be built.

Ghostbusters

This clip was shown only to older students.

Question 1

The key behaviour of scientist Dr. Venkman in this clip is his unfair treatment of the students. He is clearly biased towards the girl giving her no shocks despite her

wrong answers. The boy he shocks whether he gets an answer right or not. Almost everyone thought he was not being honest, with responses divided between individuals who said he was lying, cheating or being unfair. Another response indicated that Venkman's behaviour differentiated from their expectations of scientists, *'What kind of scientist would lie to his test subjects?'*

Question 2

Only one individual with no written response said they would say yes to being involved with one of Dr. Venkman's experiments. The majority of those who said no were split between the fact that he had lied or was unfair and their fear or desire to avoid being shocked. None of the female students took the fact they might be less likely to be shocked into their considerations, but two male students recognized that it would be bad to take part because they were male and Venkman only shocked the male.

Question 4

Unlike the previous two questions, this one divided opinion. The most common response from individuals who thought most scientists behaved ethically was that the content in the clip was just a movie. In some cases this gave students an opportunity to show how they feel about scientists, for example, *'after all this is a film and a lot of scientists are great and well-behaved and very neatly with their studies.'* Others recognized that not all scientists would behave like Dr. Venkman, and a couple took a more callous perspective of scientists, saying things like, *'they do what is needed to have success in their experiments.'*

Of the students who felt after the clip that scientists do not behave ethically many gave reasons such as being unfair or dishonest, and many said things like *'they use you,'* and *'they have no respect for the volunteers'* clearly extending their feelings from Dr. Venkman to scientists at large. Some took more specific behaviours in the clip and applied it to other scientists, for example, *'when they like someone they behave differently than with someone whom they hate.'* Whereas others went a step further with their negative perceptions, for example, *'most scientists only want the results/answers and they don't care that they're hurting a living organism'* and *'some scientist behave ethically but others are closed minded and very cruel.'* The concept that scientists would stop at nothing to get the results they desire was particularly prevalent among female students with 20% of females writing about this and 9% of males.

Armageddon

The answers to these questions were predominantly made by females, with only a couple of males giving written responses, so male/female trends will not be explored. The clip was shown only to older students.

Question 1

The individuals posing as scientists in this clip do not behave in ways stereotypes of scientists would suggest. They dance on tables, are loud, rowdy and argumentative. Students were divided as to whether this clip changed their beliefs about the behaviour of scientists, but their answers gave a good deal of insight into how they

think scientists behave in real life, with the following words being used to describe them: serious, professional, polite, quiet, have care, organized, responsible, respectful, mature, educated. Many individuals whose opinion had changed did not like the people in the clip, calling them "arrogant" "clumsy" and "rude" and one female even said *'This is a film and if scientists act this way, they should get fired.'*

Students whose opinion didn't change generally gave the fact the clip came from a film as their main reason, saying that it exaggerates behaviours seen in real life or that scientists would behave differently, for example, *'It is just a film and I know that scientists are more responsible and professional.'* Behaving responsibly was the most common theme, with students being surprised at behaviour that didn't conform to this expectation, saying that they wouldn't expect scientists to behave the way they did in the clip.

Question 2

Lost of interesting comments were made in response to this question investigating where their knowledge of scientists came from, elucidating students' thoughts about whether films can be learning devices and highlighting aspects of science not covered by certain schools in Malta. Several of the students who said they had learnt more about scientists from films explained that they had watched sci-fi films and that this had taught them, with others explicitly stating films are more informative regarding scientists and the way they look than schools, for example, *'we don't focus on science like films give you information'* and *'films learn you more and to work in teams by dressing lab coat lab glasses.'* Some students actually

stated that they don't study scientists at school, *'in school we learn science but we don't learn about the people who studies [sic] science'* and *'because we don't talk/speak about them'* while some simply felt that films were the more engaging way of learning, saying *'they have more creative ways.'*

Of those saying they learnt more about scientists from school the main reasons were basic explanations that school teaches you and statements about science not being accurate in films, such as *'I learn from films but they are not always true, but from school I learn a lot of interesting things about scientists and science.'* The main focus of comments about the films themselves pointed out that they are just a story or their use of exaggeration, *'Films are not accurate and in films they exaggerate a lot.'*

Question 3

The overwhelming theme regarding what it means to be a scientist included some reference to discovering or inventing something new, echoing the kind of dramatic creation often seen in films containing scientists. Responses also frequently made references to the practice of investigation and research, and a few mentioned the use of experiments. Some answers provided clues as to the way students perceived science, such as *'love chemicals and difficult stuff'* implying that the sciences are challenging, and there were a couple of responses which showed overwhelmingly positive perceptions, *'to experiment and try to make a better world for us to live in'* and even *'to be a scientist is to the save the world.'*

Question 4

Answers to the final question covered a broad range of themes about how scientists would look or behave differently to those in the clip. Students thought that real scientists would be more careful, organized or polite, and despite the collaborative nature of many scientific careers one student felt scientists *'(they) usually work alone and they like to be accurate.'* Some students concentrated on clothing, *'scientists wear protective clothing and they take self-precautions'* and some showed a maturity in appreciating that there is no one 'look' for a scientist, *'They look more like normal people' and 'scientists could have a body building body and a good health,'* with only one student giving a stereotypical physical feature as a response, *'In a lab coat and maybe with frizzy hair.'*

Despicable Me 2

Both younger and older students answered these questions, although there were too few older student comments to make clear distinctions in the responses between ages.

Question 1

Younger students generally said Dr. Nefario left his job he was bad at making jelly. Dr. Nefario's job dissatisfaction was a more common answer among older students, who considered the wider context of the situation, mentioning long term issues such as his unappealing research prospects and not receiving enough money rather than the immediate problems he faced within the clip itself.

Question 2

When considering what might make a scientist 'evil' after seeing Dr. Nefario, older students had far more realistic knowledge of dangers associated with science which might threaten lives. They mentioned using inventions to make something harmful, including *'They would put their inventions to bad use such as using nuclear power for bombs rather than power stations,'* and *'some scientists use science for evil things like weapons that can destroy entire populations such as the atomic bombs or drugs that can kill people.'* Younger students gave responses far more connected to films than real life, with several stating that "potions" or *'Poison of evil'* would make a scientist evil. There were other ideas likely to have been inspired by films, with several references to an evil scientist being someone who wants to destroy or take over the world and one student who stated that *'an evil machine and an evil laugh'* would be the signs to look out for.

Question 3

Few older students said Dr. Nefario would look similar to scientists in real life, and those who did focused solely on his attire, giving Dr. Nefario's lab coat, goggles and gloves as similarities. The most popular reason that he might look different was his age, with several students saying that real scientists might be younger, and a couple noting that they might also be in better physical shape. Some students gave intellectual differences such as higher intelligence in real scientists and refused the stereotypical scientist concept by suggesting things like *'Not all scientist look crazy and can't be old. A scientist works to improve society.'* One 14 year old male went even further to show his acknowledgement and dismissal of stereotypes, *'Not all scientists wear a white lab coat and are old like the stereotypical depiction of a mad*

scientist. Many scientists look like normal people, going from a place to another doing research.'

Younger students who thought scientists might look similar to Dr. Nefario were more likely to extend these stereotypes to physical attributes, saying things like *'There are lots of scientists that look like each other.'* One also noted that *'sometimes scientists can be creepy.'* Only younger students used the graphical representation used in the film as the basis for the differences, saying *'This is Pixar'* and *'he is in cartoon.'* A few mentioned that real scientists would not be evil or that the goggles and lab coat were actually things that real scientists wouldn't necessarily wear.

Question 4

The final question focuses on the labs used by scientists, and how a real one might look different to Dr. Nefario's. Only older students mentioned that Nefario's lab looked fictional, and said a real lab would be smaller, would not be hidden, would have more apparatus and no sci-fi equipment. Only younger students mentioned that a real lab would not contain minions, with four individuals giving this answer. They also said a real lab would be bigger and contain more. Only one student said they thought it would actually look similar and another said it would be different because *'real labs usually have robots.'*

Knowledge of Real Life Scientists

When asked to name real life scientists, older students said Stephen Hawking, Marie Curie, Nikolai Tesla, Einstein and Bill Gates. Younger students said Stephen

Hawking and Dr. Who. In addition during the discussion of the *Despicable Me 2* clip a slide was shown including nine scientist characters from films (Figure 15). Students were asked to say which image they thought looked most like a real scientist and which least resembled a real scientist. Eight sessions were involved in this question, with only the first session containing older students (Table 20). Based on this table, students thought Dr. Emmett Brown (from *Back to the Future*) (3) looked most like a scientist and Dr. Evil looked least like a scientist. The only individual wearing a lab coat with votes for least like a scientist was the CGI character; Dr. Nefario. The female with the most votes for looking least like a scientist was Jane Foster (from *Thor*) (6), the only individual with no equipment in the picture and no lab coat.

Figure 15. Image from slide 15 in presentation showing the following film scientist characters: **1.** Bruce Banner and Tony Stark (Mark Ruffalo and Robert Downey Junior in *The Avengers*), **2.** Ellie Arroway (Jodie Foster in *Contact*), **3.** Dr. Emmett Brown (Christopher Lloyd in *Back to the Future*), **4.** Dr. Nefario (voiced by Russell Brand in *Despicable Me*), **5.** Dr. Evil (Mike Myers in *Austin Powers the Spy who Shagged Me*), **6.** Jane Foster (Natalie Portman in *Thor*), **7.** Dr. Grace Augustine (Signourney Weaver in *Avatar*), **8.** Alan Turing (Benedict Cumberbatch in *The Imitation Game*), **9.** Ryan Stone (Sandra Bullock in *Gravity*).

Table 20. Most and least realistic science characters in films based on images and voted for by students.

Session	Images containing the most realistic looking scientists	Images containing the least realistic looking scientists
1	Dr. Grace Augustine, Alan Turing,	Dr. Emmett Brown, Dr. Evil
4	Bruce Banner	Dr. Evil, Jane Foster, Ryan Stone
6	Bruce Banner, Ellie Arroway, Dr. Evil, Ryan Stone	Dr. Emmett Brown,
7	Tony Stark, Dr. Emmett Brown,	Jane Foster
9	Dr. Emmett Brown, Ryan Stone	Dr. Nefario
10	Bruce Banner, Ellie Arroway	Dr. Nefario, Dr. Evil
11	Dr. Emmett Brown, Ryan Stone	Dr. Evil
13	Dr. Emmett Brown, Dr. Evil, Dr. Grace Augustine	Jane Foster, Alan Turing

4.4 Discussion

The majority of the questions relating to film clips on the portrayal of scientists showed a statistically significant difference from a 1:1 ratio for possible answers to the questions. Only the first *Armageddon* question asking whether the behaviours of the people in the clip changed how students thought about scientists and the third *Despicable Me 2* question asking whether real scientists would look different or similar to Dr. Nefario caused a lack of bias, with answers being split more evenly between the two options.

Exploring the proportion of male and female students that gave different answers found no statistically significant difference between males and females for any question, contrary to other research showing significant differences in attitudes (Jones et al., 2000)

Examining the proportion of older and younger students who gave different answers to questions revealed a statistically significant difference for only one question which came from the *Iron Man* clip and asked whether students thought Tony Stark

was a scientist or not. In this case a higher number of older than younger students thought that Tony was not a scientist (13% versus 1%), instead placing him in some other role within STEM such as engineer.

4.4.1 General Perceptions of Scientists in Response to Clips

Most students had confidence in the capabilities of scientists. Their perceptions of scientists suggest reserved, hard working individuals who value success and whose endeavors could have a big impact on others. They are often seen to be quiet people working alone, wearing lab coats and safety equipment. To students, the fundamental feature of being a scientist involves the creation of something, with an idea that this will be challenging, involve research and experiments and may well improve the world or even save it.

The idea that being a scientist means inventing something has been found in other research too (Buldu, 2006), in fact many of these stereotypical views have presented before in other studies, such as their opinions on scientist appearance (Özsoy and Ahi, 2014) and students finding sciences difficult (Cleaves, 2005) but this does not tell the full story. As well as being prone to stereotyping, certain individuals were keen to abandon these viewpoints, with a number of students directly attacking the preconceptions that scientists all look and behave in the same way.

Having said this, all the students seemed to be surprised by the behaviours of the men in the *Armageddon* clip whether it had changed their perception or not. No one justified the behaviour in any way, or used the arguments they presented in other questions about scientists all being different from each other. There were several

behaviours displayed in the clip including; people dancing on tables, being disrespectful, shouting, behaving in an unruly manner, not taking things seriously, and students did not associate any of these things with scientists. This may be due to their attitudes towards the professionalism and responsible nature of scientists that was too strong to be altered by a short amount of footage. It is appreciated that this also may not be the case if the study were repeated in other countries; Malta is a relatively conservative country.

Students were also asked to think about specific scientists in films and real life. When asked to list real life scientists only one female name was given, Marie Curie, as opposed to six males. Also, students still subscribed to the notion of a mad scientist when asked to pick the individual from the pictures which looked most like a scientist, choosing Dr. Emmett Brown from *Back to the Future* (a caricature of a mad scientist whose portrayal incorporates all the major stereotypes) from this list more than any other individual. This is perhaps not all that surprising given that Einstein was the real scientist known by the most individuals, someone whose look was not too dissimilar from this stereotypical image of Dr. Emmett Brown. A study by Demirbas (2009) similarly found that students mentioned Einstein, Newton and Edison when asked to consider real scientists, once again showing a heavy focus on the "inventing" or "discovery" aspects of science.

4.4.2 Influences

Questions from different film clips elicited different perceptions of scientists, with *Iron Man* causing them to discuss capabilities, potential and repeated methods, *Ghostbusters* causing them to bring up more ruthless and success-driven aspects,

Armageddon driving them to talk about responsibility and professional behaviours and *Despicable Me 2* leading to comments about stereotypical scientist attire, fitness and a scientist's age. Apart from *Armageddon*, where actually students used the rowdy behaviour of individuals in the clip to present their more stereotypical ideas, the student's perceptions were based upon the character traits held by the scientists in question.

It is concerning that films seem capable of influencing student's perceptions unless the content goes against stereotypes students already hold about scientists. Behavioural stereotypes seemed more resilient than those based on appearance, as several students watching the *Despicable Me 2* clip did concede that a lab coat and goggles was not necessarily representative of scientists as a whole. This is different from other studies where students have consistently depicted scientists in lab coats (Dudek and Bernard, 2015). Student's opinions disagreed with findings from other studies too, which stated that students saw scientists as being older or possessing 'crazy' hair (Özsoy and Ahi, 2014; Türkmen, 2008).

Perhaps the clearest indications of influence came when students compared what scientists were able to do in the films with possibilities in real life, especially when they used the characters to explain why scientists could or couldn't do something. The most common example of this was when students said a suit could be built because Tony had done it, but one student also said that dinosaurs could be brought back because John Hammond had done it. This demonstrates a surprising level of acceptance in the film content students see, especially when connected to characters that don't exist. It is one thing to see a method used in a film and suppose that this could be copied but to use film characters as a basis for reasoning shows they are

treating them as real people, as if the film is a documentary more than entertainment. Without further research it is not clear whether respect for the scientists in films is driving these thought processes or if they would also treat characters from other professions (such as a lawyer or a doctor) as though they were real.

Of course there is also the possibility that the students have accepted an unspoken hypothetical premise between teacher and student during the presentation, wherein they act as if the characters are real when answering the questions but that they would abandon this mental construct once the presentation is over and be able to distinguish the real from the unreal outside of the scenarios presented. In support of this premise, Alward (2006) found that simulated mental states of empathy with fictional characters do not share the behavioural consequences of unsimulated states. Parasocial interaction can involve identification with fictional characters and is not uncommon even among adults, where part of the escapism of enjoying film and TV involves talking about the motivations and desires of their favourite characters as though they knew them or they were real people (Alward, 2006; Shedlosky-Shoemaker, 2014). Students may be immersing themselves in the worlds presented to them during the presentation to better understand the behaviours they see without actually confusing them with real life. In support of this the negative opinions many students had on scientists in general after the *Ghostbusters* clip were not consistent with their responses to being asked what a scientist was, as many students described scientists in a neutral or positive light, and there were no negative comments. Despite their awareness of the costs of the scientists that brought back the dinosaurs in *Jurassic Park*, or of Dr. Venkman's unethical

research, students were thankfully not turned against scientists when asked to consider them outside the confines of a movie concept. The possibility of students accepting a premise only in the context of the questions should be considered in future research to avoid influence being apportioned incorrectly.

Conversely, the way student perceptions of scientists flowed and changed from one clip to the next suggests that they are being influenced by the clips, at least at the time of watching. In addition, as with the chapter on science, the context of the film seems important in determining the way students perceive scientists. *Iron Man* presents a scientist in a positive likeable way, and the students responded by having overwhelmingly positive views of not just him, but the capabilities of scientists themselves when the questions extended to real world situations. However, the negative ethical presentation of Dr. Venkman in *Ghostbusters* led students to see scientists in a negative light in real life too. For example, one student said '*there are great scientists*' after seeing *Iron Man* and went on to say '*not everyone is fair and some pick favourites when testing on humans*' in response to *Ghostbusters*. Potential exposure to negative influences persists in entertainment, with new releases still placing a dark spin on the actions of scientists. For example, the *Jurassic World* film released in June 2015 has a scientist who doesn't know when to stop as the main villain. This "determination at all costs" attitude was one of the key negative perceptions of students during this research. In order to further examine the level of belief students have in the content witnessed it would be useful if future studies gave follow up interviews to individuals who referenced film characters in their answers. One factor which supports a longer term influence was the responses of some students to the title pages of *Iron Man* and *Jurassic Park*

before the clips were played, as students who had seen the films before in their entirety were positive about *Iron Man* but talked about the danger of dinosaurs.

There were several examples of older students giving confused, incongruent or contradictory responses to different clips. For example, one student said that scientists are 'not nice' after seeing Dr. Venkman but then went on to say that real scientists would be different from the individuals in the *Armageddon* clip because they would show 'more nice behaviour.' Another was aware that films might not offer a true representation but was still influenced by the content they saw, saying scientists 'use people' based on the content of the *Ghostbusters* clip but then going on to say that films exaggerate the truth after seeing the *Armageddon* clip. This suggests that students are trying to make sense of what they see, are still deciding what their overall impressions are and most importantly that their ideas can be influenced by the content they watch. This was especially clear where questions asked directly whether student's thoughts had changed after seeing something. Qualitative analysis of the *Ghostbusters* clip question 4 was possibly the best indication of this, with 37% of students stating something negative about the behaviour of scientists in real life based on the behaviour of Dr. Venkman. Often the behaviour of Venkman was simply donated to scientists in general, with one student saying '*most of them are cheaters*,' and another stating scientists '*don't care if they are hurting a living organism*.' This readiness to overlay the behaviour of one individual to all others in the same role shows just how important it is to ensure that students are shown that the content they see may not be representative of situations and people in real life.

Even if students are aware that films are inaccurate, many are not exposed to scientists in schools, even though this practice can encourage them to pursue science as a career (Farland-Smith, 2009a). This was particularly evident from their answers to whether they learn more about scientists from school or films. Students felt they learnt about the science itself but not the people behind them at school, and said that films give them an idea of what a scientist is. In fact a surprising 39% of students said they learnt more about scientists from films, with 46% saying school and 15% saying neither. This means that less than half of the students felt they learnt the most about scientists during their actual education. With such a high proportion saying they learn about scientists from films it is no wonder that stereotypes and dramatic perceptions of scientists saving the world or harming anyone who gets in their way were present. Even more concerning, the comments from some students saying they did not actually learn about scientists at school means there is little knowledge already present to compete with what they see in films and other more inaccurate sources. A study on Omani secondary school students found supporting evidence, with the main source of information about scientists for students being the media (29%), which was more popular than either the school curriculum (27%) or teacher's discussions (19%) (Ambusaidi et al., 2015).

Often students' attempts to define scientists centered on invention, which could demonstrate that they are influenced by the dramatic creative processes witnessed when scientists are present in films. There are many examples of this, including several from the films featured in the presentation such as *Iron Man*, *Jurassic Park*, *Despicable Me 2* and *Cloudy With a Chance of Meatballs* but also other productions like *Back to the Future* and *Honey I Shrunk the Kids*. However, this preoccupation

with one facet of a scientist's repertoire could be a result of both filmmakers and students focusing on the most interesting aspect of a scientist's research; the end products.

Three questions directly asked students to state whether they had been influenced by what they had seen, with two of these questions looking at whether it might affect their future interest in the sciences. In this study, students were more influenced by positive scientists than negative ones, although both were direct relationships, with 93% of students saying Tony made them want to be involved with science more and 34% of students saying that Dr. Venkman's ethically questionable experiment made them want to be a scientist less. This suggests that Tony has a positive impact on their feelings about science, and that Dr. Venkman has a negative effect, with this response extending beyond the film and causing a surprisingly large 69% of students to say they don't think scientists behave ethically after seeing the *Ghostbusters* clip. The third question found that students were divided between whether the people in the *Armageddon* clip changed the way they thought scientists behaved. These explicit responses suggest that not only do films have the power to affect student future interest in science, but that the students are also aware of this impact. This influence is only likely to be magnified with increased exposure to a variety of films containing scientists, carving their overall perception and effecting whether students want to emulate the paths of these individuals.

4.4.3 Gender Differences

There were not many gender differences in the responses of students to film scientists, and those that were found were related to answers to *Ghostbusters* and *Iron Man* questions. Female students were more concerned than males about scientists causing physical harm to others, with males finding honesty more important. Fairness seemed equally important to both genders, with females no less concerned about the bias despite the fact that the female was not being shocked in the tests, and both placing fairness above honesty in importance. However, males were more discerning about what comprises a scientist, with a number of individuals saying Tony Stark was actually an engineer, and they were more focused on the active processes scientists partake in, whereas females defined scientists more in terms of their attributes such as intellect and knowledge.

Although the gender differences were infrequent, gender biases are still overwhelmingly present in the films themselves. The focus of clip choice was based on covering a wide range of concepts and facilitating questions that would lead to a greater understanding of attitude, with no consideration of gender at all. Despite this, the clips were overwhelmingly biased with all the scientist characters being male-Tony Stark, Dr. Venkman, Dr. Nefario, Flint Lockwood, the male voice in the DNA video. The only woman in the clips was being treated as an object by Venkman, and he was biased to her not because of her ability but because he was attracted to her.

4.4.4 Age Differences

Unsurprisingly, there were several key differences in the way younger and older students thought about scientists. Studies have found contrary results regarding whether younger or older students are more prone to stereotypes (Ünver, 2010; Özel and Dogan, 2013, but this study found that younger students were more prone to stereotypical ideas about the appearance of scientists. However their perceptions were less based on the scientist's behaviour and more on what they had around them as evidence of scientific practice than were older students' perceptions. Generally older students took a more global view when describing the actions of scientists that would make them 'evil,' focusing on things that might destroy populations. This is not surprising considering secondary level education in Malta incorporates the environmental aspects of science which would enable students to consider more global and wider impacts (The National Curriculum Framework, 2011). Although older student responses described dramatic situations that wouldn't be out of place in a film, those of younger students often had no basis in the real world such as making an evil ray, showing their willingness to choose unreal film inventions in lieu of real world knowledge. Lastly older students had a better grasp of abstract concepts such as success but younger students were more likely to think about motivations behind being 'evil' such as revenge or glory.

One potential reason that younger students showed a greater reliance upon stereotypes than older students in this study could be a result of younger students being less able to express themselves. It has been found that stereotypes are learned during childhood (Lakoff, 1990), and stereotypes that are present are often discussed as part of a limited perspective present in students. But it could also be

argued that stereotypes are actually a symptom of adults attempting to simplify concepts to make them more digestible to students. Therefore, it isn't simply that students are stereotyping, but that we are creating stereotypes to make things recognizable and memorable and therefore help students interpret the world around them (Hinton, 2007). For instance, a lab coat is an easy way for adults to represent a scientist visually as a teaching aid that helps to distinguish them from other professions in the eyes of students but may lead to the presumption that this is how scientists always dress. Following this perspective students are then reliant on adults or sources of information later telling them that the ideas they had been shown were not exclusively correct, and that the real world is more complex.

4.4.5 Applications

As discussed in Chapter One, there have been many attempts to incorporate film clips into science classes covering different topics and ages, but there is little evidence to suggest that this has been used to further knowledge of the scientists themselves. And it is possible that the level of influence is greater for the use of scientists than science because this research suggests they are less exposed to scientists in school and more exposed to them in films. Lessons using film clips should therefore involve teaching about scientists as much as they teach about science. Furthermore, greater emphasis should be placed on learning about what scientists actually do day to day rather than just explaining a concept and saying who discovered it, especially considering the proportion of students who feel their information on scientists comes predominantly from films. Attaching a faceless name to an area of science does little to explain the processes behind the discovery,

whereas including enough information to make this name a person and explain their motivations is a far more intimate way to inspire students to try and have a similar impact (Chen and Cowie, 2014). Film characters are naturally larger than life and inspiring and should help students to engage with the idea of becoming a scientist themselves. These ideas should not involve rewriting lesson plans, but simply finding a way to incorporate the story of who discovered a concept with the explanation of it; using a film clip either as a starting point or discussion aid once the concept has been explained.

One way of taking a more personal approach could involve introducing concepts through the story of those behind them, and bring in the idea that our knowledge of these concepts evolves over time by discussing the people working on them now. This is important as it represents a more progressive way of learning which could also help to eliminate the male biased view students may have if focus is solely based on male dominated scientific discoveries of the past (Cooper et al., 2010). More complicated scientific processes are often explored in this way at Higher Education level (for example Purves et al.'s textbook: Life: the science of Biology (2004) takes this approach at the start of many of its chapters) but why not approach the more simple concepts using this format too? After all, Entwisle and Greenberger (1972) suggested that students have already formed their perceptions of scientists by the time they are 11, so it would be preferable to implement these ideas early on. Several studies and initiatives have involved encouraging interaction of students with scientists by either bringing scientists into schools or taking students on day trips to meet scientists and learn about recent discoveries (Scherz and Oren 2006: Morrison and Estes, 2007: Rennie 2012: Falloon and Trewern 2013). Where this is

not possible using fictional scientists offers an alternative method of engaging students in the practices of real world scientists.

When used in education it would be preferable to show a broad selection of film clips as this study shows it enables students to think about scientists from a wider array of perspectives. This makes it more likely that the full range of both behavioural and appearance based stereotypes held by students will be revealed. In turn these ideas can be mitigated by showing real life examples of scientists that are contrary to those shown in clips and may go on to act as role models for students, encouraging them to pursue a science career and enrich their learning of science (Chen and Cowie, 2014).

CHAPTER 5: Concluding Remarks

5.1 Science, Scientists and the Future

With both scientist and science perceptions, the key difference was gender. Males were more likely to go against the majority with their responses to questions, with 17% of students actually saying Dr. Venkman's blatantly unethical experiment made them want to be a scientist more and 28% saying they would like the dinosaurs to be brought back. This could show a more fearless nature, or perhaps simply a more contrary one. There is also the chance that some of the more extreme answers could be a result of students not taking the questions seriously and there is no way of confirming the honesty of their answers except where students have clearly put a lot of thought into them. These responses would be expected to be honest, whereas some students gave answers such as 'bananas' or 'LOL' to

questions, indicating that their answers overall may hold less weight. To combat this, quotes from students who gave nonsensical answers were only used when their answers made sense and indicated that they had taken the question seriously. It is more difficult to measure whether students are taking tick boxes seriously or comprehend the question, but comparison with their other answers was able to help with this problem.

There is a great deal of scope for future research in this understudied area. With this study in its design aiming to explore the breadth of influences that are possible across different ages and genders, covering scientists and several areas of science as well as different types of film, there is a great deal of depth to mine in each of these areas that were far beyond the scope of the research. Future studies compare the effect of film clip sets with a purely positive or negative impression of science or scientists, increase the depth of information obtained further by using small focus groups instead of class questionnaires or explore differences in engagement level for lessons on specific concepts or scientists with and without the aid of film clips as an aid to discussion. Finally they could investigate the source of information for student responses to questions to ascertain in more detail how much of their information can be ascribed to school or films.

There are also many possibilities for studies on the influence of science or scientists in films that were not explored in this study. For example, the influences of cultural and educational background are likely to be substantial. Studies performed in different countries could allow for these differences to present themselves and to see how this affects the way students perceive the same images of science and

scientists in films. Studies have already found that students from different countries can develop different misconceptions of scientists (Farland-Smith, 2009) and it would be interesting to see whether these differences also affect the way they process the content seen in films. Another option that would be interesting, if challenging to test, would involve exploring how long the influences of films last as there is currently little research investigating impacts from a temporal perspective. Performing secondary questionnaires at a later date could offer insight that would help determine whether impacts are truly meaningful in the sense that they continue to alter behaviours or effect decisions long after witnessing the content.

As mentioned more general research has been done on personality effecting level of trust (Sutherland and Tan, 2004). However no previous research could be found involving studies comparing student personality with a willingness to accept scientific misinformation. A study in this area would demonstrate which individuals are more likely to be taken in by inaccurate information given in films and could be expanded from studies of students to the general public.

5.2 Final Thoughts

This research has highlighted the perceptions of students to science and scientists and the influence films can have on these perceptions in several areas and covering both age and gender. Student opinion was mostly in agreement for answers to questions on science and scientists. They considered the content of each clip on its own merits, so that belief in the science shown and attitudes to the actions of the scientists varied by film. Similarly to other research (Koren and Bar, 2009) students

were positive about both science and scientists where content was positive or neutral, with a strong belief in the ability of time to render the impossible possible with regards to technological advancements. However some students became negative when the clips showed negative outcomes and in these cases their responses often shared the same dramatic sense of catastrophe seen in the films themselves. In general they were more surprised by instances of negative behaviour in scientists than the negative repercussions of science.

There were changes in student perception of both science and scientists after watching the clips, though as expected some students were more easily influenced than others. This influence was also shown in the way some students gave conflicting statements with previous answers based upon the content of subsequent clips, and where students referenced a character's actions as proof the scientific premise in the clip could really occur. Students were worryingly underexposed to scientists during their education, with many individuals conceding that they either don't learn about scientists at school or get most of their information about them from movies.

Regarding gender, males were more positive about the possibilities of science and keener to see things become a reality regardless of the dangers, a fact that was particularly evident in their answers to the *Jurassic Park* questions. Females were more concerned about safety and harm in relation to scientists, with a greater focus on scientific processes than results. There was no discernible difference in the capacity of males or females to be influenced by science or scientists in the clips, however females were more likely to explain behaviours and scenarios in clips by

saying it was only a film. Several differences in age were also present. Younger students were more likely to be influenced by content than older students, more readily accepting less realistic ideas, giving more self-centered answers, and focusing on the present. They were also more prone to appearance-based stereotypes than older students, although both age groups subscribed to behavioural stereotypes. Contrary to some other studies (Ozgelen, 2012; Ünver, 2010), several older students were quite keen to explain that physical stereotypes were incorrect and did not subscribe to scientists having to look a certain way.

It may be true that films don't influence every young person who watches them, but this study indicates they are influencing enough individuals to make the inclusion of film clips in education a worthwhile endeavor. The capacity for influence and the success of previous studies suggest that incorporating film content into science lessons would be beneficial at all ages, and was found to be a highly engaging method of teaching. In addition, the higher rate of acceptance for inaccurate film content at younger ages suggests that this use of scientific film content should occur at a younger age than previous studies have explored. Particular focus should be given to education through the exploration of real and fictional scientists and the use of clips as an opportunity to teach critical thinking. Evidence suggests this area is currently under-explored in research and lessons and has great potential for the inspiration of students to see themselves as future scientists (Barnett et al., 2006). Furthermore, the benefits are likely to be just as profound for those who do not continue with their scientific studies by exposing them to critiques of scientists and scientific discoveries (Jarman and McClune, 2007), making it even more important to include an appraisal of science fiction film content at a young age in schools.

Future research should consider research in different countries to explore cultural differences in children's responses to science and scientists in films, and possibly the impact of predominantly English language films. There is also an opportunity to continue measuring influences as new films come out and the nature of science content and depiction of scientists within them changes over time, with recent films such as Ex Machina and The Martian providing new examples worth exploring.

6. Appendix: Student Questionnaires

1. Science and Scientists in Films (Younger Students)

I am happy for the answers given on this questionnaire and during the discussion in this presentation to be used in research on audience engagement with science in films.

Yes ☐ No ☐

Age: School: Male/Female:

Iron Man

1. I think that Tony Stark is a scientist

Yes ☐ No ☐

Why? Why not?.....

.....

.....

2. Does Tony Stark make you want to be involved with science and creating technology more or less?

More ☐ Less ☐

3. In your opinion, why does Tony ignore his computer and fly his suit before it is properly tested?.....

.....

4. Could scientists build a suit like this?

Yes ☐ No ☐

Why? Why not?.....

.....

Jurassic Park

1. Do you think scientists could bring back the dinosaurs using the method in this clip?

Yes ☐ No ☐

Why? Why not?.....

……

……

2. Were you aware of other methods to try and bring back the dinosaurs before watching this clip?

Yes ☐ No ☐

If yes, where did you find out about these ideas? .....

……

……

3. Do you think scientists are trying to bring back the dinosaurs in real life?

Yes ☐ No ☐

4. Do you think it's a good idea to try and bring back the dinosaurs?

Yes ☐ No ☐

Why? Why not?.....

……

……

Despicable Me 2

1. Why do you think Dr Nefario quit his job?

.....

.....

.....

2. In the clip Dr Nefario talks about going somewhere 'more evil.' Do you think there are evil scientists in real life?

Yes ☐ No ☐

What would make a scientist evil? .....

.....

.....

3. Do you think real scientists would look different or similar to Dr Nefario?

Different ☐ Similar ☐

How?.....

.....

.....

4. How do you think Dr Nefario's lab is different to a real lab?

.....

.....

.....

Cloudy with a Chance of Meatballs

1. Flint has made an invention capable of raining food. Would it be possible to make it rain food?

Yes ☐ No ☐

Why? .....

.....

.....

2. Would it be a good or bad thing if it rained food?

Good ☐ Bad ☐

Why? .....

.....

.....

3. Do you think inventions in films are mostly real or mostly made up?

Mostly real ☐ Mostly made up ☐

4. Which inventions from films would you most like to see made real?

.....

.....

.....

Thank you for your participation!

2. Science and Scientists in Films (Older Students)

I am happy for the answers given on this questionnaire and during the discussion in this presentation to be used in research on audience engagement with science in films.

Yes ☐ No ☐

Age: School: Male/Female:

Iron Man

1. Do you think that Tony Stark is a scientist?

Yes ☐ No ☐

Why? Why not?.....

……

……

2. Does Tony Stark make you want to be involved with science and creating technology more or less?

More ☐ Less ☐

3. In your opinion, why does Tony not perform recommended diagnostics before flying his suit?

.....

……

……

4. Could we build a suit like this?

Yes ☐ No ☐

Why? Why not?.....

……

Jurassic Park

1. Do you think scientists could bring back the dinosaurs using the method in this clip?

Yes ☐ No ☐

Why? Why not?.....

……

……

2. Were you aware of other methods to try and bring back the dinosaurs before watching this clip?

Yes ☐ No ☐

If yes, where did you find out about these ideas? .....

……

……

3. Do you think scientists are trying to bring back the dinosaurs in real life?

Yes ☐ No ☐

4. Do you think it's a good idea to try and bring back the dinosaurs?

Yes ☐ No ☐

Why? Why not?.....

……

……

Ghostbusters

1. Is Dr Venkman being honest to his participants?

Yes ☐ No ☐

Why? Why not?.....

……

……

2. Would you say yes to being involved with one of his experiments?

Yes ☐ No ☐

Why? Why not?.....

……

……

3. Does seeing this experiment make you want to be a scientist more or less?

More ☐ Less ☐ Neither ☐

4. After seeing this clip do you think most scientists behave ethically?

Yes ☐ No ☐

Why? Why not?.....

……

……

Armageddon

1. Does the behaviour of the people in this clip change the way you think scientists would behave?

Yes ☐ No ☐

Why? Why not?.....

……

……

2. Have you learnt more about scientists from films or school?

Films ☐ School ☐ Neither ☐

Why? .....

……

……

3. What does it mean to be a scientist?

.....

……

……

4. Do scientists look like the people in this clip?

Yes ☐ No ☐ Maybe ☐

If no, how do they look different?.....

……

……

Thank you for your participation!

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