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The Influence Of Television And Film On Interest In Space And Science

Katrina Marie Jackson

THE INFLUENCE OF TELEVISION AND FILM ON INTEREST IN SPACE AND SCIENCE

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Katrina Marie Jackson
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This thesis, submitted by Katrina Jackson in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done, and is hereby approved.

Chairperson – Dr. David Whalen

Committee Member – Dr. Michael Gaffey

Committee Member – Dr. Lana Rakow

This thesis is being submitted by the appointed advisory committee as having met all of the requirements of the School of Graduate Studies at the University of North Dakota and is hereby approved.

Wayne Swisher
Dean of the School of Graduate Studies

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Katrina M. Jackson
July 10, 2013

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ABSTRACT

Entertainment media has the great potential to inspire interest in the topics it presents. The purpose of this study is to better understand how entertainment media contributes to people's interests in space and science. There is a huge variety of science communication topics in previous literature, some of which deals with television and film, but very little that specifically study how television and film can inspire interest. A historical review of pioneers in the space industry shows that many were inspired by entertainment media, which at the time consisted of science fiction novels and magazines. In order to explore the possible relationships among influences for scientists and non-scientists and to determine specific questions for future research, I created and distributed an anonymous, online survey. The survey is suggestive, exploratory research using a convenience sampling method and is not meant to provide scientifically accurate statistics. 251 participants completed the survey; 196 were scientists and 55 were non-scientists. The survey showed that the participants did identify entertainment media as a major influencing factor, on a comparable level as factors such as classes or family members. Participants in space-related fields were influenced by entertainment media more than the participants in other fields were. I identified several questions for future research, such as: Are people in space-related fields inspired by entertainment media more than other scientists are? Are non-space-related scientists often inspired by space-related media? Do people who regularly watch science fiction tend to be more scientifically literate than average?

CHAPTER I

INTRODUCTION

Television and film have been so prevalent in popular culture over the past several decades that it is easy to see how they might inspire people's dreams or inform their concepts of people, places, and things. Movies and TV shows are often attributed to making certain activities or careers popular. For example, a 2009 article in the *Pittsburgh Post-Gazette* talks about televised dance shows inspiring new interest in ballroom and salsa (Bauknecht), and a 2010 CNN story discusses the so-called 'Glee' effect increasing the popularity of high school show choirs (Chen). On a recent episode of *60 Minutes*, Justice Sonia Sotomayor said she attributes her current position on the Supreme Court to reading Nancy Drew novels and watching *Perry Mason* on TV as a child (Justice Sotomayor, 2013, par. 21-27).

Though performing arts and legal dramas are easy topics to popularize and showcase on television, they are not the only ones. A 2009 article in *The Telegraph* attributes a rise in students seeking forensic science degrees to television dramas like *CSI* (Paton); a 2011 article in *The Observer* suggests that increased interest in British physics A-levels and university courses is partially caused by the sitcom *The Big Bang Theory* (Townsend); and a 2012 article says that Amazon reported a 500% increase in telescope sales following the broadcast of the British personality Brian Cox on BBC2's *Stargazing Live* (Thomas). It seems television can help popularize science topics as well.

Even within fictional television is the notion that TV can inspire people's interest in science and encourage people to pursue it as a career. On a recent episode of *The Big Bang Theory*, the physicist characters Sheldon and Leonard are excited to meet their favorite TV science personality from their childhoods, Professor Proton (Season 6, Episode 22, 2013). The fictional Professor Proton used to have a children's science show similar to the real-life *Watch Mr. Wizard*, but now rents himself out for children's birthday parties. Professor Proton feels shunned from the scientific community and that his life has been a waste, but Sheldon and Leonard convince him that he has contributed significantly to science advancements by inspiring thousands of kids to become scientists. Sheldon claims that without Professor Proton coming into his living room every afternoon at 4:00, he would have ended up a hobo or a surgeon instead of a world-renowned theoretical physicist.

The idea plainly exists that television can increase people's interest in science and other subjects and can even influence their career choices, but to what degree does this actually happen? What sort of relationship really exists between the consumption of television and other entertainment media and a person's primary interests? What is this relationship specifically for space and science? Once these relationships are determined, what role do they serve in science communication?

There are many aspects to science communication and differing ideas on what exactly science communication should be. There is the point of view of science organizations who simply want to effectively communicate to the public what they are doing. There are those who want to explore the communication of science through art. There is the perspective that overall scientific literacy is abysmally low, and working to

increase the public's scientific literacy is in the best interest of society. Then there is the standpoint that it is a flawed model to assume your job is to educate an illiterate public, and the focus should really be on engaging the public in conversation on relevant science topics. There seems to be a lack of consensus on what exactly is the purpose of communicating science – educating the illiterate, increasing the number of scientists, increasing the funding for science, engaging the public and bringing back the "citizen scientist", or some combination of the above.

In a post regarding the science celebrity Brian Cox written on the Imperial College London's Science Communication Group's blog by Steve Fuller, a social epistemology professor, Fuller (2013) says:

> First, Cox deserves full credit for being a mass populariser of science... The problem rather lies in what exactly he is selling about science. Does he really want everyone to join in the grand scientific quests? Would that even be in science's best interests? Doesn't science really need more resources – both technical equipment and public indulgence – to carry on with its work? While undoubtedly a growth in the ranks of the scientifically competent is desirable, simply multiplying minds may only serve to expand the number of hypotheses worth testing without providing the means to do so. (par. 2)

Something Fuller seems to be missing is that in addition to possibly increasing the number of people who want to pursue science as a career, popularizing science can also increase resources, public interest, and funding for science. Whether or not we should focus on science literacy, science engagement, or expanding the STEM workforce, one thing I think we can all agree on is that increasing public interest and funding for science

is a good thing. I hypothesize that entertainment media could be an effective means to accomplish this. When discussing the role of science consultants in movies, science communication lecturer David Kirby explains, "Whether the surface of Mars matches the 'real' Mars or not does not matter if the film is able to inspire people about the possibility of Mars exploration" (2003b, p. 275).

This thesis will focus on how television and other entertainment media influence people's interests and career choices in space and science. In Chapter II I will provide a review of the existing literature regarding science communication, particularly in regard to television and entertainment media. I find that though there are many interesting topics published in science communication research – such as models of communication; the variety of informal science education methods; and the portrayals of science and scientists in entertainment media – there is very little literature addressing how entertainment media can influence people's interests and career choices in science.

In Chapter III I will provide an overview of how entertainment media has influenced some of the pioneers of the space industry. This provides a historic perspective to the central thesis issue. Chapter IV will detail the methods of my research and how I created a survey to begin an exploratory study of what possible relationships exist between television and scientists. The survey is meant to be a starting point for further research and to uncover more detailed questions for future studies. Chapter V will show the results of the survey and several possible ways of looking at the data. Finally, in Chapter VI I will discuss what possible relationships the data presents, and impart questions for further research.

CHAPTER II

LITERATURE REVIEW

Science communication is a wide field of academic study with many different approaches and topics. Having no previous coursework in the subject, I reviewed a broad swath of literature pertaining to science communication as a whole, informal science education, and any sub-topics focusing on television or film. This chapter will include summaries of literature on overall science communication; science journalism and agency press; different methods of outreach and communication; stereotypes, perceptions, and portrayals from TV and film; portrayals of female scientists; effects on science literacy; effects on public participation in science; studies of specific TV shows; other topics related to TV and film; and other interesting articles.

Overall Science Communication

Science has historically been a popular topic in the media, but it is now considered more of a niche area (Weigold, 2001). In the traditional science communication business, there are journalists who report on science news stories, science information professionals who act as a liaison between the scientists and the reporters, the scientists, and the audiences. In 2001, there were 600 to 800 science and medical reporters out of an estimated 122,000 reporters (Weigold, 2001). Because of time restraints, they mostly rely on press conferences and journal embargoes[1] for sources of

science news stories. The science information professionals are not usually trained in science, and often are seen by both scientists and reporters as representatives of organizational administration. There is the general impression that scientists don't communicate very well on their own, and the general perception among scientists that going public or talking with the media compromises a scientist's integrity. The audience of science communication, the general public, is often scientifically illiterate, though they are also often ignorant about history, geography, math, or almost any specialty area.

There are several tensions among the participating parties of science communication. The way journalists work is fundamentally different than the way scientists work. This could also be said of television and film producers, or any person in the role of creating media for the public. The media creators are all trying to tell an engaging story within the bounds of their type of media, while scientists are primarily focused on being accurate in their research and in the reporting of their research. Science information professionals, such as public affairs officers, play parts on both sides, but are also invested in trying to control the attention paid to and the reputation of their organizations. Journalists usually have confidence in scientists, but may think that scientists tell only a small part of the whole story (Weigold, 2001). They also sometimes get frustrated by science news embargoes. Scientists don't like it when journalists ignore the balance of scientific evidence, and try to give equal weight to theories and points of view that aren't equal. All the players need to work through these areas of tension to successfully communicate science.

[1] Journal embargoes are the case when journal publishers offer a copy to science journalists about a week early with an agreement that the journalists will use that time to gather sources on interesting stories, then publish their articles once the journal is publicly released.

Weigold gives some suggestions for how science reporting could be improved (2001). There could be specific training for science journalists. However, reporters don't necessarily need science training to report well, and it would be impractical to train in all fields of science. Perhaps there could be training that addresses cognitive shortcuts that lead to inaccuracies. Science communicators could focus more on audience needs by connecting the stories to everyday life, telling the reader why it's important, and anticipating likely confusion. Reporters could work more closely with sources. However, the trouble with this is that scientists usually want to add more things and are concerned about the omission of details, while the journalists need their stories to be short and concise, especially if they're on TV.

Weigold describes three models of science communication (2001). The deficit model assumes a lack of knowledge in the audience which the scientists and science communicators must try to fix; it aims to increase overall literacy through effective communication. The rational choice model aims to teach people what they need to know about science to be good citizens. The context model aims to communicate the relevant science that people want to know in their own circumstances. Several papers I read either assumed the deficit model or argued against the deficit model. It is easy to assume that science communication should be the experts educating the laypeople, but once you learn that this is just one of many models, it is interesting to consider whether the deficiency model is the right choice. Hank Campbell describes the deficiency model as a pitfall to avoid in science communication (2008). He advises science communicators to avoid believing their duty is to correct the scientific illiteracy of the uneducated public, because all data is subject to interpretation, including by laypeople. Science gradually became

something the public was not qualified to understand, and the concept of the citizen scientist went away (Campbell, 2001). However, with new web technologies and a shift in scholarly science communication focus, the second age of the citizen scientist has arrived.

Science Journalism and Agency Press

As previously mentioned, science is not a prevalent topic in the news. A 2010 study of western European TV news programs showed that only 1% of the stories were about science and technology (Verhoeven). Barrosa and Pullen conducted an informal survey in 2008 of the relatively few journalists who are devoted to science stories. The science journalists said their most frequent sources are press releases from scientific institutions and direct contact with researchers (Barrosa & Pullen, 2008). The aspects that they take into consideration most when choosing and writing a story are the subject and its credibility. They consider astronomy and space science the most popular science subject. The survey shows there are still many difficulties in science/journalist interactions.

Nielsen et al. did another survey regarding the credibility issues that science journalists consider. The journalists say that they want to be as accurate and honest in their reporting as they can, but some overstatement is inevitable to try to make the piece seem interesting and provocative (Nielsen, Jorgensen, Jantzen, & Christensen, 2007). They say credibility problems often stem from trying to make a story bigger than it really is or from letting unscientific factors dictate the timing of the publication of a press release. Institutional press releases, where journalists get a lot of their stories from, are

often saturated with superlatives, making it difficult for journalists to separate the big stories from the smaller ones. Ivan Oransky complains about the hype in NASA press releases. Overhyping an embargoed press release can lead to wild, inaccurate speculation, and then disappointment once the real story is smaller than the speculation (Oransky, 2011). This was the case when NASA embargoed a press release on the arsenic-based bacteria study and announced that "NASA will hold a news conference… to discuss an astrobiology finding that will impact the search for evidence of extraterrestrial life."

Oransky also complains about embargoes on information that is already public, such as an embargo on a new Hubble image that backed up an older interpretation which was already published, or organizations that post abstracts online before a conference but won't let reporters write about them. Vincent Keman, in studying the case of the Mars meteorite ALH84001, argues that embargoes are not as necessary as those who participate in the system may think (2000). The point of embargoes is to ensure accuracy in major science stories by making sure the science paper is all ready to go, and by making sure science journalists don't have to rush to prepare the story, because they all get the information at the same time and have several days before the information can be made public. However, a journalist who wasn't participating in the embargo system broke the story of the Mars meteorite before the planned date, and the press over the next couple days was for the most part accurate. Keman suggests that a premature release had little effect on how accurately the public understood the findings, and argues that embargoes should serve the public interest and not simply the interests of its participants.

Ray Villard also discusses the release of scientific discoveries. He says that the process of science publication is at odds with news reporting, and discusses two discovery stories that have been criticized for releasing information too early – the Mars meteorite and the Terebey Planet (Villard, 2008). He says that it is not as big a deal as some make it out to be when information is released early, and that it is okay to have big science stories that are uncertain or that are later modified or refuted. This can be a catalyst for more scientific investigation and public interest. Villard argues that it is impossible to keep a major finding under wraps until it has been completely analyzed by everyone, and that research can be publicized before publication on a case-by-case basis.

Besides the timing of discovery announcements, it is also important that people and information are quickly accessible for journalists. Keman says that the one negative aspect of having the Mars meteorite story released early was that most members of the science team were not immediately available (2000). Journalists had to talk with other scientists who were not as familiar with the discovery, and the scientists who made the discovery were not able to personally share their work. Organizations must also be able to provide quick and easily accessible information. Diane Scherzler says that in her personal experience as a German public broadcaster, she finds NASA much more accessible than ESA (2008). The NASA website is easier to navigate, and has material readily available to use. The ESA website has a media center and a multimedia gallery, but it doesn't list any terms of use, and they took two weeks to respond to an emailed inquiry. This can be frustrating for someone in Europe, and damaging in the long run to have only a handful of media-savvy scientists controlling all the news stories.

Different Methods of Outreach and Communication

There are many non-traditional ways of learning about science. Sean Cavanagh writes about using informal experiences in teaching science (2009). He talks with a high school physics teacher from northern Virginia who uses movies, TV, and web-based games as ways to inspire students. He also talks with an AP biology teacher at the same school who uses an online interactive game called Immune Attack. Games present much more problem-solving challenges than other media that simply present information. Another non-traditional format is theatre. Well-known theatre pieces involving science are Michael Frayn's Copenhagen and Tom Stoppard's Arcadia (Dowell & Weitkamp, 2011). There is a movement toward collaboration between scientists and theatre practitioners, especially in England because of promotion and financial support from the Wellcome Trust's Sci-Art program. Theatre practitioners who want to create a science-related production are often inspired by something interesting they read or by the financial support available. They seek out scientists to fact-check their work or to collaboratively participate in the creative process. Scientists mostly agree to participate because they see it as their duty to provide information to others and to make sure they portray accurate information. Scientists often assume the deficit model until they get more involved with the creative process, at which point they start to understand what makes a good story and shift from public understanding to public engagement.

Astronomy and space sciences in particular have explored a large variety of outreach and communications methods. Organizations like the Spitzer telescope team and the Hubble telescope team have created popular video podcasts because they are relatively easy to produce and astronomy has great visuals (Christensen & Hurt, 2008).

There are many astronomy-related videos on YouTube, like telescope tutorials, time-lapse videos, and public outreach from organizations like NASA (Shida & Gater, 2007). Because there are so many visuals that astronomy can use, an Aesthetics and Astronomy Group (A&A) formed in 2008 to study the best way to present astronomy images (Smith et al., 2011). After a large survey and a focus group, A&A came up with several recommendations, such as using illustrative scales, including extra information for how experts view the images, and having the text be in a conversational format. They were able to quickly implement these recommendations onto Chandra's outreach website, and have been receiving positive feedback in the comments and ratings sections (Arcand, Smith, Watzke, & Smith, 2010).

Besides having images online where people have to seek them out, astronomy communicators have also tried to bring the images to the people by placing them in public spaces. With the "From Earth to the Universe Project", they placed astronomy images with short descriptions at Atlanta and Chicago airports, an Alaska tourist center, a Tennessee library, a New York college campus, and a Washington DC park (Arcand & Watzke, 2011). Anyone interested could also take the material and display it, and by 2011, there were about a thousand exhibit sites in 70 countries, translated into 40 languages. The project concluded that this sort of exposure could reach millions of people inexpensively, and could "lead to inspiration, personal, and small learning gains" (Arcand & Watzke, 2011). Yet another format, which does not even include visuals, is radio. Italy broadcast an astronomy radio show from July 2007 to January 2009 (Nobili & Masiero, 2010). Each program would feature a young astronomer and a celebrity, and would be pre-recorded so it could be broadcast on many channels and web stations. They

had about 30,000 listeners a week, and concluded that "radio is a great medium to spread astronomy to a wider audience in new and non-traditional venues".

Astronomy communication has also benefitted from using different connections and partnerships. Kristine Larsen writes about the connection between astronomy and Harry Potter, which could be used as an avenue for astronomy outreach and a way to promote the International Year of Astronomy (IAY09) (Larsen, 2008). Harry and his classmates took astronomy class, had to write a paper about the Galilean moons, and had an observational astronomy portion on their OWL exam. Not all of Rowling's astronomy is correct, but the books make several references to planetary conjunctions. The Venus-Jupiter conjunction on November 30 and December 1, 2008, would be a good opportunity to engage Harry Potter fans of all ages, because it would be visible from 4:30-7:30pm, and it would be bright enough to see from anywhere. They could give out OWL certificates, Harry Potter star-wheels, and information about the upcoming IYA09. Oana Sandu and Lars Lindberg Christensen also encourage collaborating with entertaining partners for unconventional outreach. They list examples like Milky J rapping about the Hubble telescope on the Jimmy Fallon Show, an electric sports car that did a promotional drive across the full length of the Pan-American Highway and stopped at the European Southern Observatory's site in Chile, and CERN taking advantage of its pop culture connection in Angels and Demons (Sandu & Christensen, 2011).

They also discuss creating large social experiences of astronomy, like the 2009 Twitter event "Meteorwatch" (Sandu & Christensen, 2011). This Twitter event encouraged participants to share their experiences of the Perseids meteor shower, and received a lot of press. The Newbury Astronomical Society, which created the event,

received 300,000 hits on its blog in the time during and immediately after the event. Twitter has also changed the way people view and connect with NASA spacecraft. Since 2008, NASA spacecraft have had "personal" Twitter accounts, where they frequently post updates of their daily lives and findings, respond directly to their followers, and occasionally direct posts at other spacecraft (Vertesi, 2010). This anthropomorphizing of the spacecraft allows followers to feel intimately connected, even resulting in heartfelt condolences and tributes once a spacecraft's life has ended. This also changes the way information is shared and released; releases used to be reserved for scientific publications and major press conferences, where everything was sifted through and appropriately credited. Some scientists would still rather wait for validation before they release their data, while others are okay with a more transparent and interactive process of frequently and quickly releasing data and images through spacecraft's Twitter accounts.

Cinema Science

David Kirby notes that there were few studies before 2000 on science communication in fictional cinema (2008, p. 41). He attributes this to the prevalence of the deficit model, and that movies are not a great way of increasing science knowledge under this model. The studies on this topic since 2000 have come from a variety of disciplines and focus on four questions:

> How is science representation constructed in the production of cinematic texts? (production); how much science, and what kind of science, appears in popular films? (content analysis); what are the cultural interpretations of science and technology in popular films? (cultural meanings); what effect, if any, does the

fictional portrayal of science have on science literacy and public attitudes towards science? (media effects). (Kirby, 2008, p. 41-42)

Kirby believes that the question that currently needs the most attention is the role of science in the production process, and that understanding this role would contribute greatly to an understanding of cinema as a mode of science communication (2008, p. 31).

Stereotypes, Perceptions, and Portrayals from TV and Film

There have been several studies looking at how TV and film portray scientists. Scientists are most likely to be shown as white, male, and are not shown with a family (Werngart, 2003; Long et al., 2010; Long, Boiarsky, & Thayler, 2001). In reality, a significantly greater percentage of scientists are male rather than female and white rather than a minority. Science communication scholars have wondered whether it is better to portray the current reality or to portray the reality we would like to see in the future by showing more equal representation of females and minorities. In any case, the portion of females and minorities portrayed as scientists has increased over the years; more will be discussed about the portrayal of females in the next section.

Communication scholars have been pleased to find that most TV programs or films over the past couple decades do not support stereotypes such as the mad scientist or scientists being geeky and antisocial. A study of films over the past eight decades shows that many portrayed scientists are easily manipulated or corrupted, particularly if they were in medical fields, physics, chemistry, or psychology (Werngart, 2003). Mad scientists, which composed a fifth of their sample, had usually isolated themselves from

official science and felt misunderstood, and often had a secret basement lab. David Kirby summarizes the stereotypes of scientists in films by decade in Figure 1.

Time period	*Scientist stereotypes*	*Scientific fields*	*Representative films*
1900–10	Helpless scientists	Electricity	*X-Rays* (1897)
		X-rays	*Reversing Darwin's Theory* (1908)
		Evolution	
1911–20	Helpless scientists	Eugenics	*Damaged Goods* (1914)
			The Regeneration of Margaret (1916)
1921–30	Mad scientists	Glands	*A Blind Bargain* (1920)
		Engineering	*Metropolis* (1926)
1931–40	Mad scientists	Medicine	*Frankenstein* (1931)
	Biopics		*The Story of Louis Pasteur* (1936)
1941–50	Biopics	Medicine	*Shining Victory* (1941)
		Psychology	*Madame Curie* (1944)
1951–60	Amoral scientists	Space science	*Destination Moon* (1950)
		Nuclear science	*Them* (1954)
1961–70	Absent-minded professors	Space science	*The Nutty Professor* (1961)
			2001: A Space Odyssey (1969)
1971–80	Amoral scientists	Ecology	*Silent Running* (1971)
			Soylent Green (1973)
1981–90	Helpless scientists	Computer science	*War Games* (1983)
			Robocop (1987)
1991–present	Heroic scientists	Genetic engineering	*Jurassic Park* (1993)
		Astronomy	*Deep Impact* (1998)

Figure 1. Stereotypes of Scientists in Films (Kirby, 2008, p. 46)

Studies of more recent portrayals show that scientists are rarely depicted as evil (Long & Steinke, 1996; Dudo et al., 2010; Steinke, 2005). Scientists are only occasionally depicted as nerdy and antisocial (Steinke, 2005; Long & Steinke, 1996). Scientists and science are often portrayed in a positive light, especially on children's programs, where science is shown as fun, part of everyday life, and something that everyone can do (Long & Steinke, 1996). The study of children's programs only complains that the shows do not show the reality of being a scientist, because they only show the successes. If they had included The Magic School Bus in their study, they would have seen a counterexample of this, since Ms. Frizzle's science motto is to "take chances, make mistakes, and get messy!" It is quite common for TV shows and films to portray science as one truth instead of a continuous process of making mistakes and

learning, either by depicting definitive facts and successful experiments, or by showing one physical reality.

Dudo et al. sought to update the Gerbner 1985 study that showed the negative impact of TV on people's attitudes toward science (2010). They find that contrary to the 1985 report, TV viewing is not associated with negative attitudes toward science. They do find that other aspects of the 1985 report are supported, like TV viewing is negatively associated with knowledge of science, TV viewing is negatively associated with using other media that may promote science knowledge, and that TV's negative effect on attitudes toward science is stronger among those who have taken college science classes. Since scientists are usually portrayed positively, the effects of science in popular media are not as dire of a circumstance as some would make it seem.

While portrayals of science on film and television seem to have been becoming more positive, people's perceptions and stereotypes of science have also been becoming more positive. Susan Losh performed a study comparing answers to NSF Surveys from 1983 and 2001 (2010). Overall, adults had more positive images of science in 2001 than in 1983. Sixty-seven percent of adults in 1983 were happy if their child became a scientist, which increased to 80 percent in 2001. 35 percent of labor force workers in 1983 had considered a science-related career, which increased to 45 percent in 2001. One third of adults in 1983 said that scientists were "odd and peculiar", which dropped to one quarter of adults in 2001. Some negative stereotypes still exist, though in lesser numbers. 28 percent of adults in 2001 agreed that scientists had few interests besides work, and 19 percent agreed that scientists get less fun out of life. Woman generally viewed science more positively than men, but considered science as a career less often.

Portrayals of Females in Science

As previously mentioned, female scientists are still portrayed less often than male scientists, though the percentage has been increasing. In the study of films from the past eight decades, 12% of scientists were female; in a study of films from 1991 to 2001, 34% of the films featuring scientists had female scientists as primary characters; a 2010 study of TV programs popular among middle-schoolers showed that 42% of the scientist characters were female (Dudo et al., 2010; Steinke, 2005; Long et al., 2010). Researchers are especially concerned about how female scientists are portrayed in films and TV shows that adolescent girls are likely to watch, because adolescence is both when girls start to develop their identities and when they start to lose interest in science. Gender schema theory and social cognitive theory describe how socializing agents like TV and film can help shape girls' identities and their visions of possible future selves. These may contribute to why relatively few girls choose to go into science; in 2005, 31% of scientists in academic settings were female, and 26% in non-academic settings were female (Long et al., 2010). It has been suggested that girls avoid science because they naturally want to help people, and they see scientists as "nerds who focus on mechanical tasks with little direct human relevance" (Long et al., 2010).

In the film study, female scientists were portrayed as mostly attractive, mostly professional and realistic (and not mad or maniacal, clumsy or absentminded, or nerdy and antisocial), and knowledgeable, confident, and passionate (Steinke, 2005). They were almost always a leader or an equal member of a team. They usually were respected by male colleagues, but sometimes had to defend themselves. Most were involved in a

romantic relationship, but few sacrificed their profession for romance. Few were shown as working mothers. The researcher was pleased that the female scientists were portrayed realistically and in positions of high status, and that romance could help girls identify with the characters. She saw the overwhelming focus on work rather than families as overt and subtle stereotyping, but notes that more research needs to be done to determine which attributes serve as vicarious role models for girls and which portrayals are effective in changing girls' attitudes toward science careers.

In the TV study, females were shown in high-status positions as frequently as males (Long et al., 2010). Both males and females were unlikely to be shown as married or to have kids. The males were more likely to be independent than the females, though both were as likely to be athletic or dominant. Both males and females were as likely to be shown as caring, dependent, and romantic. The males were more likely to be violent than the females, an attribute that boys generally like to see. NSF-funded programs had more equal gender distribution than other programs. Though there was no gender difference in the lack of a family, this stereotype of scientists prioritizing a professional life over a personal life may push away girls. The researchers find it encouraging that the scientists are not portrayed as nerdy or loners, and that they are thus more mainstream. Overall, the researchers find that the TV programs provide more wishful identification characteristics for boys than for girls, since there are still more male characters, and they are portrayed as more violent and independent. They suggest that programs portray more female scientist characters, and that they be shown as caring and balancing their work with a family. They note that more research needs to be done to see if this suggestion would be effective.

Effects on Science Literacy

David Kirby notes that the viewpoint that fictional media is a corrosive influence on science literacy is widely accepted with the scientific community despite a lack of evidence one way or the other (2008, p. 48-49). Many articles argue against directly aiming to improve scientific literacy through media, but some do study how fictional programming may affect people's understanding of scientific concepts. Effects on scientific understanding may be especially strong with children and students. Barnett et al. studied how the 2003 science fiction disaster film *The Core* impacted middle schoolers' understanding of earth science concepts (Barnett et al., 2006).

All of a teacher's five science classes participated in an earth science unit, and then three of the five classes watched *The Core*. The students took a post-test and participated in post-interviews. The researchers found that the students remembered the movie images much more than their hands-on science experiences from the unit. This was helpful for learning some aspects that the movie got right, like the figure of the Earth's interior and why the Earth has a magnetic field; the students who watched the movie were more likely to correctly understand these topics. However, the movie also taught the students wrong concepts, like the role of the Earth's magnetic field, and there being giant diamonds in the outer core. This was because the movie made everything seem so plausible, and used a character with scientific authority. Because the main character was a science professor and he correctly explained the model of the Earth's interior, something the students had learned from class, the students readily believed the

character when he talked about the loss of the magnetic field resulting in the Earth being fried by microwaves.

Barriga et al. studied how context and gender affect whether a person believes incorrect science information presented in a movie (2010). There is little evidence of the specific influence of movie science on scientific literacy, but it is possible for movies to affect one's scientific understanding despite being a fictional source, because over time people forget that the knowledge came from a fictional source. They had participants at a shopping mall watch movie clips where the centrality of science was manipulated to be a central role or a background role. They found that men detected more inaccurate science facts when they thought science was central to the plot, and women detected more inaccurate science facts when they thought science was peripheral to the plot. The limits of this research were that it did not have a no-movie control group, and it did not address accurate science facts in the movies.

Effects on Public Participation in Science

Though many articles argue against the deficit model of science communication in favor of involving the public as citizen scientists, few study media's effect on public participation in science. As Dhingra explains, "scientific citizenship exists when there is widespread public participation in decision-making about emerging science related issues and a recognition both of the indivisibility of science, society, and citizenship and the complexities of most science related social issues" (2006). The messages viewers interpret from a TV show are complex and really depend on the individual person, and any resulting actions from the viewers are hard to determine. Dhingra cites one 2003

study where media did foster informed participation on science-related issues. Interestingly, the study found that people with more scientific knowledge had unconditional trust in science and did not feel the public should play a role in science decision-making, which is at odds with other studies saying that more educated people are more politically active. Dhingra recommends that educational content be part of a narrative so that it is easier to contextualize, and that the content be referred to multiple times from multiple perspectives. She brings up questions for future research such as: With more niche programming, how can TV be used to mediate local, community-relevant science-related knowledge?

Studies of Specific TV Shows

Researchers have looked at several specific TV shows to either analyze specific effects that TV show can have or as examples of more general effects. Ley et al. study how CSI portrays DNA testing and its potential effects on the justice system (2010). Previous studies have looked at how the show affects public understanding in judicial processes, and found that CSI viewers expected more high-tech evidence, thought they understood the forensics and DNA evidence better, and perceived DNA evidence as the most reliable. In reality, DNA takes a while to be processed, the processing centers are usually underfunded and understaffed, and there is a backlog of DNA testing. CSI may help shape perceptions of forensic evidence through cultivation theory, and may prime pieces of information to be more accessible in viewers' memories, which can influence subsequent judgments. These researchers found that CSI portrays the collection of DNA evidence as routine and highly successful, and the analyzing of DNA as routine, quick

and easy, cool and appealing, and highly successful. DNA helped solve a case in 94% of the episodes. CSI has portrayed DNA evidence as very important to prosecutors and jurors, and has mentioned the pressure to collect DNA evidence even when it's not completely necessary to solve the crime. CSI also sometimes discusses DNA's broader meanings, such as the relationship between genes and personhood. The portrayals of DNA evidence on CSI may contribute to the backlog at DNA processing facilities and explains why viewers perceive DNA evidence as reliable and expect more high-tech evidence at trials.

Lindy Orthia studies the portrayals of science in Doctor Who and its cultural function (2010a; 2010b). Doctor Who has presented both pro-rationalist and anti-rationalist messages over the years, such as "To the rational mind nothing is inexplicable, only unexplained," and "Logic, my dear Zoe, merely enables one to be wrong with authority" (Orthia, 2010a). The show's themes address to some degree four goals of placing empowerment in science governance, having equal access to opportunities in science workplaces and careers, having democratic choice about the role of technology in our lives and societies, and having democratic freedom to choose our beliefs and worldviews on the universe. Orthia argues against the notion of science villains representing negative attitudes toward science, because audience reception can vary widely.

Another article looks at how successful the UK drama-documentary *If... Cloning Could Cure Us* was at achieving its goals of educating, informing, and interactively engaging with its viewers (Reid, 2011). The dramadoc shows a fictional court case set in 2014, where a scientist is charged with doing therapeutic cloning research on embryos

older than the 14-day limit, interspersed with documentary material and real scientists providing background information for the drama. At the end of the original broadcast, the viewers were asked to call a phone number to vote on whether they thought the scientist was innocent or guilty. The viewers were also encouraged to go to their website to share what they thought about this type of research. Through 20 focus groups, the author found that viewers had significant increases in knowledge about the topic, but were still confused about the difference between therapeutic cloning and embryonic stem cell research and whether the 14-day limit law was real or fiction. An increased understanding did not necessarily translate into increased support for therapeutic cloning, and people's opinions were mostly dependent on their religion. The dramadoc was largely successful in its efforts to educate and inform, but the interactive engagement was lacking. The feedback should have real effects; for example, the producers could have sent the votes and feedback to the Chief Scientific Advisor. Producers should perhaps choose scientific topics that are still in their early stages of development, so that viewers' opinions can have a real influence in the shaping of the science policies.

Another study tried to look at how viewers responded to an episode of *The Simpsons* (Orthia et al., 2011). The researchers use the episode "Lisa the Skeptic", where Lisa is pitted "against the townsfolk in an ideological battle over what appears to be a fossil angel" (Orthia et al., 2011). Viewer responses to the episode were widely varied. Their interpretations of the core meaning of the text were substantially different; interpretations included the need for a balance between spirituality and science, both sides being irrationally blinded to the other side, and the blind following of religion hampering the scientific process. Viewers identified with different characters, and it was

not evident that one character represented the good side. Viewers also had different definitions of science, and different opinions of whether science was even represented in the episode. The researchers use these findings as a basis to argue against the deficit model in general, because people do not "absorb fiction's content in a linear, passive and credulous manner" and the model "is an inappropriate characterisation of how people process the science in fiction" (Orthia et al., 2011).

Other TV and Film Topics

Like with theatre, there can be collaboration between art and science in film. The Alfred P. Sloan Foundation encourages this collaboration with programs such as the Sloan Award at the Sundance Film Festival (Valenti, 2006). A panel of three judges selects the best film that accurately portrays science and/or communicates science in a non-stereotypical manner. Only a few films a year meet the Sloan science standard. The award is meant to encourage the use of science in narrative films, not just documentaries. The awardee in 2005 was Casa de Areia ("House of Sand"), a Brazilian film that incorporates into the storyline an international scientific expedition to observe a solar eclipse in order to prove Einstein's theory of general relativity. The Alfred P. Sloan Foundation funds programs at six film schools, and awards production grants and science advisers to those who submit film scripts that incorporate science. The foundation also provides grants for science-related TV, radio, book, and theater projects.

Scientists can collaborate with filmmakers as science consultants. Filmmakers often hire science consultants to give credibility and a sense of realism to a film, as a way of legitimizing their work and being credible enough to avoid audience disenchantment

(Kirby, 2003b). Scientists provide suggestions and information, but decisions lie with the filmmakers, and ultimately the drama and storyline come first. A lot of people think that incorrectly portrayed science in fictional TV and films is detrimental to the public understanding of science, like Neil deGrasse Tyson who often complains about minor inaccuracies. Kirby argues that entertainment science encourages excitement or fear about science and creates an image, rather than directly affecting scientific knowledge – minor scientific inaccuracies are not the point. "Whether the surface of Mars matches the 'real' Mars or not does not matter if the film is able to inspire people about the possibility of Mars exploration," he explains (2003b, p. 275). There are a variety of motivations for why scientists may choose to consult – fame, financial gain, to promote their ideas, for their own amusement, to take the opportunity to counteract a perceived negative portrayal of science, to promote scientifically-based social movements, or as a service to science. Some consultants are well-compensated, but most feel it is unethical to take personal funds for what they see as their duty, and instead take grants for continued science research. Scientific institutions, however, gladly accept compensation for their collaborations, unless they are a government organization like NASA, in which case they only take reimbursements for the use of their facilities and scientists. NASA established an entertainment industry liaison in the late 1960s, and has been involved with several fictional films, such as Deep Impact, Mission to Mars, and Space Cowboys.

During their collaborations, consultants offer information such as how alien signals should sound on Contact, the correct composition and density of a comet on Deep Impact, or the fact that a virus cannot move and writhe on Outbreak. Consultants also help teach the actors how to act like scientists. The actors may try to study the

mannerisms of their science consultants, and try to determine the psychological motivations for their characters. The scientists help the actors pronounce and understand the scientific jargon. The science consultants also help make the set look like a real science workspace. For example, a lab technician helped build the molecular biology lab for Jurassic Park, so other than the colorful liquids and dinosaurs, it was set up like an actual lab. One tell-tale sign to knowledgeable viewers that the lab was set up by someone who knew what he was doing was the inclusion of Kimwipes. In many cases, the consultants are asked about well-established scientific facts, but sometimes the consultant must give his own view to a disputed question, such as the feeding habits of a T. Rex. A film only allows for one vision to be presented as natural and factual. Presenting this one vision as reality may even have an effect on other scientists (Kirby, 2003a). Scientists can use films to promote their ideas to other scientists by visually showing evidence for their theory in a compelling format, such as showing Jack Horner's theory of birds evolved from dinosaurs in Jurassic Park. Illustrating a theory as reality in a film can help create consensus around that idea.

One 2013 article discusses the effect of television on interest in science. Retzbach et. al say that little is known about how interest in science develops. They cite a previous article where a German animated TV series was shown to increase children's interest in science (Fisch, 2009), and an evaluation of a documentary that showed its viewers reported an increased interest in science (McPherson, Houseman, & Goodman, 2008). Retzbach et. al performed a study to test whether viewers' interest in science increased more when science research was portrayed with certainty or with uncertainty. The subjects watched features from German science TV magazines over a six-week period.

They found that the subjects who watched the certain portrayals had an increased interest in science, and those who watched the uncertain portrayals had a stagnant interest in science (Retzbach, Retzbach, Maier, Otto, & Rahnke, 2013).

Other Interesting Articles

There are other interesting articles that do not quite fit into the topics discussed thus far. Koolsra et al. compare the use of TV and internet for science communication (2006). They argue that TV should still be the number one medium for science communication, because people use TV more frequently than the internet in their leisure time (at least at the time of this writing in 2006), because TV is more effective in transferring messages to the public, and because people trust TV as a more reliable information source, though I suppose this would depend on the context. They estimated that it would be at least another five years before the internet would surpass TV in usefulness, because of its increased ability to stream video content. This amount of time has already passed, and indeed the internet is widely used for streaming video including TV shows. A 2011 Nielsen report stated that TV viewership was still increasing, and that even the lowest quintile of TV viewers still averaged an hour of TV consumption per day. The report also noted that TV viewing through mobile devices and internet streaming was rapidly increasing (Nielsen, 2011, p. 1). This suggests that Koolsra et al.'s argument for TV being the number one medium for science communication still holds, and that the internet actually increases the effectiveness of TV reaching an audience.

Bruce Johansen explores the interaction between politics and science communication through the case of global warming communication at NASA in 2006

(2006). James Hansen, the director of the Goddard Institute for Space Sciences, has a history of combating government's attempts to prevent communicating with the public and of trying to better utilize the media in science communications. President George W. Bush read Michael Crichton's State of Fear, which pictures global warming as a hoax, and invited Crichton over to the White House to discuss it. Crichton also testified before the Senate as an expert witness. This is an interesting example of science fiction affecting politicians and policy. In January of 2006, Hansen said that NASA Headquarters wanted public affairs to review all of his public communication, and that "they feel their job is to be this censor of information going out to the public" (Johansen, 2006). The public affairs officer in charge of monitoring Hansen's public statements, George Deutsch, was appointed to the position by President Bush. Deutsch rejected a request from NPR for an interview with Hansen, and another public affairs officer claims Deutsch said that NPR was the most liberal media outlet in the country and his job was to make the President look good. Other NASA scientists have said they've dealt with the same thing, where political appointees tried to influence the communication of scientific information. NASA Administrator Griffin emailed all the NASA employees saying that it is not the job of public affairs officers to alter or filter scientific material. He then released a new policy saying that it is recommended but not required for scientists to have a public affairs officer when they speak to the media.

Mike Schafer analyzed a sample of 215 publications on the media's coverage of science, and found that the research thus far has been biased in three ways (2010). The research mainly focuses on the communication of natural sciences, especially biosciences and medicine. The research looks mostly at communication in Western countries. These

publications analyze mostly print media. My study will have the first two biases, but I will focus on film and television instead of print media.

CHAPTER III

HISTORIC PERSPECTIVE

Several pioneers of the space age are said to have been inspired by entertainment media. Of course, in the late nineteenth and early twentieth century, television and movies were not yet a prominent source of entertainment, so this media came primarily in the form of science fiction novels. To understand what role entertainment media can currently play in inspiring interest in space and science, it is useful to look at a historic perspective. This chapter will briefly examine the early lives of Konstantin Tsiolkovsky, Walter Hohmann, Robert Goddard, Hermann Oberth, Wenher von Braun, and Arthur C. Clarke and what got them interested in space exploration.

Konstantin Tsiolkovsky

Konstantin Eduardovich Tsiolkovsky was one of the first pioneers of modern rocketry. Primary sources on Tsiolkovsky are in Russian and not readily available in the United States, so much of the accessible information on his early life comes from short biographies with few direct citations. Tsiolkovsy was born on September 17, 1857 in a Russian village about 200 kilometers from Moscow (Stoiko, 1974, p. 29). He was an energetic young boy who liked to camp, daydream, and read. Around the age of nine, he got scarlet fever and lost almost all his hearing, which Tsiolkovsky claimed "'made me a victim of ridicule to the rest of the boys in the neighborhood'" (Stoiko, 1974, p. 30). He left school and began self-educating himself from books, mastering math and physics.

During his teenage years, he became interested in experiments and inventions, and his father decided to scrape together some money to send him to Moscow for higher education. He continued learning math and science, eventually becoming a schoolteacher while doing experiments and writing science fiction on the side. It was not until Tsiolkovsky was around 40 that he started seriously experimenting with rockets and considering them as a means for space travel. Stoiko says Tsiolkovsky wrote in one of his papers:

> "For a long time I viewed rockets like everyone else, from the point of view of diversion and minor applications. I don't clearly remember how I first got the idea of performing calculations on rockets; I have the impression that the first seeds, ideas, were planted in my mind by Jules Verne's well-known fantasy, which set my brain to work along now familiar lines." (1974, p. 37).

Jules Verne, a French novelist, wrote *De la terre à la lune* (*From the Earth to the Moon*) in 1865. The novel features a group of weapons aficionados who launch three people in a projectile from a cannon aimed at the Moon. The fictional story was ahead of its time by having mostly accurate calculations and by placing the launch in Florida. Stoiko's chapter does not make it clear when this French novel made its way to Russia and into the hands of the budding rocketeer, but according to the autobiographical quote, Tsiolkovsky first became interested in the theory of rockets around 1896 (1974, p. 37).

Walter Hohmann

Walter Hohmann, namesake of the famed Hohmann orbit transfer, was a German structural and civil engineer who liked to calculate equations for space travel in his free

time. There is little information available in English on Walter Hohmann. However, there is some additional biographical information in a 1994 edition of Hohmann's 1925 publication *Die Erreichbarkeit der Himmelskörper* (*The Attainability of the Celestial Bodies*), provided in a preface by Hohmann's daughter, Marga Hohmann. Hasso Hohman, Walter's grandson, says his mother knew Walter well and that her information is reliable (H. Hohmann, personal communication, June 13, 2013).

Hohmann was born on March 18, 1880 in Hardheim, Germany. At the age of six, he and his family moved to South Africa. Hohmann had several engineering interests as he grew up, such as bridges and ballistics, but he also had an interest in space from an early age. His father would show him the southern constellations in the sky. As soon as Hohmann read the science fiction books by Jules Verne and Kurd Laβwitz, he wondered, "How do you get up there?" (Hohmann, 1994, xii). That question drove his subsequent efforts to conceptualize the feasibility of spaceflight. The inspiration of Jules Verne was both a blessing and a curse, because while science fiction books inspired a lot of interest in spaceflight for both the public and upcoming space pioneers, it also resulted in many scientists not taking the subject matter seriously. When Hohmann was submitting his work to a publisher in 1925, the publisher agreed that spaceflight was an important problem, but also warned Hohmann to lower his expectations because: "Sie der Ansicht sind, daβ es sich um Jules Vernesche Utopien handelt," or "[Many professionals] are of the opinion that it is a Jules-Verne-like Utopia" (Hohmann, 1994, xiii). Of course, these naysayers were soon proven wrong.

Walter Hohmann always had rather cosmopolitan viewpoints, and disliked patriotism, war, vanity, and pride. When asked in 1932 to provide an autobiography for a

book on space pioneers, he refused (Hohmann, 1994, xv), which may be part of why it is difficult to find much information on him outside of his family's records. Hohmann gradually distanced himself from rocketry in the 1930s, not wanting to have any part in their militaristic applications.

Robert Goddard

Robert Hutchings Goddard is considered to be the United States' father of rocketry. Goddard was born on October 5, 1882 in Worcester, Massachusetts (Clary, 2003, p. 6). Most of what is known about Goddard's early years is what he wanted us to know through his autobiographical statements (Clary, 2003, p. 8-9). This portrayal is generally of an idealized young genius, unrelentingly encouraged by his grandmother, who overcame numerous setbacks and poor health (Clary, 2003, p. 9). He only started leaving a paper trail with a diary around the age of fifteen. According to Clary, "the early entries reveal, instead of the frail boy genius of family lore, a normal, bright, self-conscious, and inquisitive fifteen-year-old. … Nothing there evokes a sickly, scholarly youth" (2003, p. 12-13). Around the same time, Goddard's mother was diagnosed with tuberculosis and the family moved back to their hometown so they could be closer to relatives.

His overanxious grandmother took over watching him and often kept him confined as if he were sickly, and so Goddard started reading a lot of books from the library (Clary, 2003, p. 13). He devoured science fiction books such as *From the Earth to the Moon* and was excited about the new story in 1898 about Martians invading Earth, H.G. Well's *The War of the Worlds*. According to Clary, reading that book influenced

his imagination in an experience that Goddard would forever remember as "Anniversary Day" (2003, p. 13). On October 19, 1899, at the age of 17, Goddard climbed a cherry tree behind his barn and started to saw off dead limbs. While in the tree, he imagined how wonderful it would be to create a device that could possibly ascend to Mars and what it would look like if sent up from the meadow below him (Clary, 2003, p. 13). This experience apparently provided the rest of his life with purpose. According to Clary, "he reread Verne and Wells many times, and never shook off the sense of infinite possibilities that they inspired, in a period when Percival Lowell described signs of civilization on Mars and Wells produced yet another way to get to the Moon" (2003, p. 15).

Hermann Oberth

Hermann Oberth, one of Germany's first rocket pioneers, was born June 25, 1894 in the Transylvanian Alps, then part of the Austro-Hungarian Empire and now part of Romania (Stoiko, 1974, p. 83-84). His obituary in *The New York Times* stated Oberth was born near Nuremburg; unless one considers 1,300 km as "near", this was incorrect ("Hermann Oberth," 1989). According to Stoiko, Oberth read Verne's *From the Earth to the Moon* around the age of 12 (1974, p. 84). The story got Oberth obsessed with the idea of spaceflight and traveling to the Moon, and with figuring out which details from Verne's book might actually be possible. Oberth thought that Verne's idea to use rockets in space to slow down the spacecraft was good, but that the idea of launching the spacecraft out of a cannon was impossible because the initial G-forces would most definitely kill the passengers, despite their water-filled cushion (Stoiko, 1974, p. 84).

Oberth concluded that any feasible launch system would have to have a much more gradual acceleration.

Fast forwarding to Oberth's late 20s, Oberth started working with the rocket car builder and author Max Valier to try to popularize rockets, in an attempt to create enough public interest for the scientific community to take rockets seriously (Stoiko, 1974, p. 90). The two of them worked on calculating dimensions of Jules Verne's cannon in an effort to drum up interest. These efforts paid off, and in a domino effect got Willy Ley interested in space, who then took the ideas and wrote an even more popular and easily understandable book, which got even more people interested in space (Stoiko, 1974, p. 90). Soon there was an entire group of men in Germany who were seriously enthusiastic about spaceflight who in 1927 formed the Verein für Rarumschiffahrt, or Society for Space Travel. Oberth's work became popular enough that it inspired Fritz Lang to direct one the first movies about space travel, *Frau im Mond*, or *A Girl in the Moon*, and Oberth accepted Lang's invitation to be technical director (Stoiko, 1974, p. 92). According to Neufeld, the film had limited success because of Thea von Harbou's melodramatic screenwriting and because the silent film was soon overshadowed by the first talkies (1990, p. 740-741).

Wernher von Braun

Wernher von Braun, one of the most well-known rocket scientists of all time, is sometimes said to have been inspired by Jules Verne or Kurd Laβwitz. However, biographies on von Braun do not point to science fiction as a major contributing factor to his interest in space and rockets. Wernher Magnus Maximilian Freiherr von Braun was

born March 23, 1912 in a province that was ceded to Poland after World War I. According to Stuhlinger and Ordway III, von Braun started thinking and writing about rocket-driven spaceships to the Moon after reading Jules Verne at the age of 14 (1994, p. 161). That was the only mention of Verne in that biography, however, and none of the biographies mention Laβwitz. Multiple biographies instead point to his confirmation gift from his mother as the starting point of von Braun's interest in space (Stuhlinger & Ordway III, 1994, p. 10; Neufeld, 2007, p. 21; Piszkiewicz, 1998, 22-23). Von Braun's mother was seriously interested in science, even holding the family nickname "Madame Curie." When von Braun finished his Lutheran confirmation studies around his thirteenth birthday, his mother decided to give him not a customary gold watch but a small telescope (Neufeld, 2007, p. 19-21). Von Braun eagerly took up observing and became fascinated with astronomy.

Later that year, von Braun came across something that directed his intense interest toward rockets and space exploration – the second printing of Hermann Oberth's *Die Rakete zu den Planetenräumen* (Neufeld, 2007, p. 21-24). Von Braun initially could not understand all the complex formulas in the publication, and so set his mind to learning math and physics so that he could understand how to journey into space. As a high school student, von Braun was obsessed with the dream of flying into space, which Neufeld in passing calls a "romantic urge" propelled by science fiction and the German rocket fad of the late 1920s, though he never details any influence science fiction might have had (2007, p. 32). In his last year of high school, von Braun and his classmates made a parody movie influenced by *Frau im Mond* for Mardi Gras (Neufeld, 2007, p. 36).

Arthur C. Clarke

Sir Arthur Charles Clarke is well known as a science fiction writer, but he also has contributed to satellite communication and has served as chairman of the British Interplanetary Society. Clarke was born on December 16, 1917 on the west coast of England. During childhood visits to Clarke's grandmother's home in the coastal town of Minehead, a neighboring family introduced Clarke to science fiction magazines. The first one 11-year-old Clarke saw was the 1928 issue of *Amazing Stories* depicting earthlings visiting Jupiter's moons (McAleer, 1992, p. 5). As a teenager, Clarke observed the dark skies with his family's small telescope, which stirred his imagination and "influenced Clarke's budding cosmic consciousness" (McAleer, 1992, p. 10). His physics and math teacher encouraged Clarke to experiment with rockets (McAleer, 1992, p. 12). When he was 17, he created his first major experiment in communications, transmitter that could transmit sound with a beam of light (McAleer, 1992, p. 13).

Meanwhile, he kept reading science fiction. The March 1930 issue of *Astounding Stories of Super-Science* got Clarke truly hooked on these stories. McAleer quotes Clarke, "'I read that March 1930 *Astounding* from cover to cover, doubtless when I should have been doing [other classwork]'" (1992, p. 17). He spent his lunchtimes scouring the local store for copies of any science fiction magazines he was missing, finding it frustratingly difficult to get complete sets of the American works in England. He also read several novels, including the classic works of Verne and Wells, but he claimed the most impactful book was W. Olaf Stapledon's *Last and First Men*, a story with a timeline stretching across five billion years (McAleer, 1992, p. 19). Another

favorite of Clarke's was David Lasser's *The Conquest of Space*, a story focused on the more practical and immediate aspects of rocketry and space travel (McAleer, 1992, p. 20). These books and stories inspired much of his future writing.

CHAPTER IV

METHODS

With a lack of literature specifically addressing how entertainment media influences people's interest in science, I created an anonymous online survey to serve as a starting point for finding the detailed issues and questions pertaining to this topic. My survey narrows in on the television component of entertainment media in order to have a manageable number of titles about which to ask the participants. This survey is meant to be suggestive, exploratory research, not statistically representative research.

Survey Objectives

As I was preparing my survey, I created a list of objectives that the data in my survey should accomplish. "Scientists" are here defined as participants who claim to have higher education in a science, technology, engineering, or math (STEM) field or who self-identify themselves as having a significant interest in a STEM field. "Non-scientists" are here defined as participants having neither higher education in a STEM field nor a significant STEM interest. I wanted to survey both scientists and non-scientists in order to have a broad view of what influences people's interests and to be able to compare the television viewing of scientists to what other people watch.

Objective 1: Find an array of factors that influence a person's primary interests.

Objective 1.1: See if and how this varies for scientists versus non-scientists.

Objective 1.2: See if television and film are a major motivating factor.

Objective 1.2.1: See if and how this varies for scientists versus non-scientists.

Objective 1.2.2: Look at the factor of television and film specifically for participants who identify an interest in a space-related field.

Objective 1.3: If television and film are not a major motivating factor, find out why.

Objective 2: Measure the overall scientific literacy level of participants.

Objective 2.1: See if and how this varies for scientists versus non-scientists.

Objective 2.2: See if and how this varies according to the television shows the participants watch.

Objective 3: Look at which science-related television shows participants watch.

Objective 3.1: See if and how this varies for scientists versus non-scientists.

Objective 3.2: See if interest in science is associated with specific genres.

Objective 3.3: Look at which television shows are watched specifically by participants who identify an interest in a space-related field.

Objective 4: Determine if and how Objectives 1 through 3 vary for demographic factors such as gender, age, socio-economic upbringing, affiliation, ethnicity, or education level.

Survey Creation

I created this survey through the University of North Dakota's subscription to the Qualtrics Research Suite, an online research software that enables users to custom create surveys through a wide variety of data collection tools. Qualtrics is often used in professional and academic journals. I created the questions to accomplish the four

objectives listed above. I paid special attention to the question wording and answer choices to make sure the questions provided all possible options and did not potentially exclude any participants. I tried to ensure that the meanings of the questions were easily understood and that the question wordings did not bias a reader toward a particular answer choice.

One advantage of digital surveys over paper surveys is the use of logic displays – the ability to give participants a particular set of questions based on their answers to previous questions. Logic displays allowed me to create a somewhat complex survey that catered to both scientists and non-scientists. My survey went through a few different versions as I tested it with select family members, friends, and my thesis committee. They checked for any errors or confusion in the questions and answer choices, checked the logic displays to make sure they worked as intended, and provided advice regarding a reasonable order to the questions and any additional questions they thought I should include.

For full screenshots of the the final version of the survey, go to Appendix A. The first page is comprised of demographic questions, including age, gender, education level, ethnicity/race, socio-economic upbringing, and location/affiliation. Those who select the University of North Dakota as their location/affiliation are directed to a page asking for their status at the university. Everyone then continues to a page with standard science literacy questions. I took my 13 questions directly from the 14 questions listed in Appendix A in Cook et al.'s "Scientific literacy and attitudes towards American space exploration among college undergraduates" (2011, p. 51-52). These questions were part of a survey of undergraduate students at Syracuse University, and were taken from a

2006 survey by J. Miller that is no longer accessible online. The questions have also appeared in the National Science Foundation's Science and Engineering Indicators Polls. Question 7 in their Appendix – "Does the Earth go around the Sun, or does the sun go around the Earth?" – was immediately answered in Question 8 – "How long does it take for the Earth to go around the sun?" – so I took out Question 7 and used the remaining 13 questions. I also revised the wording of Question 8 to ask for the time in units of years, in an attempt to simplify the grading process.

The next page asks the participants if they are working towards or have obtained a degree in a STEM subject, and if they have a significant interest in a STEM subject. If participants answered "Yes" to either question, they receive the "scientist" versions of the remaining questions. If they answer "No" or "Unsure" to both questions, they receive the "non-scientist" versions of the remaining questions. Scientists are then asked to identify in one or two words their primary STEM subject. They are then asked to write a sentence explaining what inspired their interest in that STEM subject. Meanwhile, non-scientists are asked to think of a strong interest they have, such as a career, degree, or outside hobby, and to identify this interest in five or fewer words. They are then asked to write a sentence explaining what inspired that interest.

Next, both scientists and non-scientists are provided a list of factors and asked to rank how much each inspired their interest in the subject they identified. The factors include family/friends, books, TV/movies, classes/teachers, games, museums, personal experiences, the news/current events, websites or online videos, and an option to list an "other" factor. The rankings include "This is the only reason I pursued this subject," "Very much so inspired my interest," "Somewhat inspired my interest," "There might

have been a little inspiration," "Not at all," and "This actually DISCOURAGED my interest." The non-scientists are then asked an additional question. Given the same list of factors, they are asked to select which factors, if any, discouraged them from having interest in STEM.

Both scientists and non-scientists who said TV/movies had at least a little influence on their interest in their identified subject are then asked to list a few TV shows or movies they can think of that inspired their interest. Meanwhile, scientists and non-scientists who said TV/movies had no influence on their interest in their identified subject or that TV/movies had discouraged their interest are asked to list a few TV shows or movies that they have enjoyed. They are then asked why these TV shows or movies have not influenced their interest in their identified subject. Next, all participants are given a list of TV shows and asked to rank how frequently they have watched these programs. The rankings include "Have not watched it or can't remember watching it," "I remember seeing an episode or two," "I have seen at least a few episodes," "I have watched it somewhat regularly, and have seen several episodes," "I have watched it regularly, and have seen most or all episodes," and "I am or was fanatic about this show."

The listed TV shows are loosely grouped by genre, both to assist the participants and to assist the data analysis. The shows listed are "Bill Nye the Science Guy," "The Magic School Bus," "Mr. Wizard (any series)," "DragonflyTV," "Beakman's World," "Other children's science shows," "CSI (any variant)," "Numb3rs", "Other forensics/crime-solving shows," "House," "Other medical shows," "Cosmos," "How It's Made," "The Universe," "Nova (and/or NOVA scienceNOW)," "Horizon," "The World of Jacques Cousteau," "Other science documentaries," "Dr. Who," "The X-Files," "Star

Trek (any version)," "Battlestar Galactica (or spin-offs)," "Firefly," "The Twilight Zone," "Other sci-fi shows," "Mythbusters," and "The Big Bang Theory."

All participants are then asked if they have any additional comments. They are then thanked for their time, provided the address for the research website and blog – http://TVandScience.wordpress.com – and provided a link to another survey form where they may submit an email address to enter a drawing for one of two $50 Amazon gift-cards. This is to ensure that their email address is not directly connected with their data, since they took the survey under condition of anonymity. I provided the two $50 Amazon gift-cards myself.

Sampling Method

The target subject population for this survey was anybody at least 18 years of age. Ideally the survey would have been distributed to a wide variety of people nation-wide, but practically speaking most participants were accessed through the University of North Dakota population. I wanted representation from both scientists and non-scientists. I did not recruit participants from populations likely to be vulnerable to coercion and undue influence.

According to Sue and Ritter's *Conducting Online Surveys*, "Most statistical texts advise against using nonprobability techniques or suggest they be reserved for exploratory research. While this advice is theoretically sound, in online and mobile survey research, it is often impractical" (2012, p. 43). My research is exploratory in nature, and meant to be suggestive of relationships and not representative of a population. Therefore, I am using a convenience sampling technique. Sue and Ritter describe

convenience sampling as "a nonsystematic approach to recruiting respondents that allow potential participants to self-select into the sample… The questionnaire is posted on a website for anyone to fill out" (2012, p. 44).

This sampling technique is not meant to show a scientific representation of a set population, but it is sufficient for creating suggestive findings on the factors influencing interest in science and non-science and which TV shows may be more frequently associated with interest in science. According to Sue and Ritter, "Convenience sampling requires less time and effort than generating probability samples; however, statistical inference is problematic. Respondents who self-select into web polls are not representative of any underlying population; they tend to be individuals who have a particular interest in the survey topic. Online polls employing convenience samples should not be presented as legitimate scientific research" (2012, p. 44).

There are no statistical formulas for estimating an adequate sample size when using a nonprobability sample, but Sue and Ritter do offer a few rules of thumb. A justifiable sample size is usually between 30 to 500, or about 10% of the parent population for each sample or subsample. A sample size should be at least ten times larger than the number of variables. Generally, larger sample sizes are better than smaller ones. One way to check if your sample size is large enough is to randomly split the sample in half and see if the data analyses on both halves are consistent with each other.

For my own sample, since I do not have a set parent population, I cannot apply the 10% rule. If I consider my primary variables of scientist vs. non-scientist, in addition to all of the demographic variables, that would give me a total of 43 variables. Realistically, some of the demographic variables would be grouped together into larger

bins or disregarded in the analysis. For example, I may look at "white vs. non-white" instead of each individual race, or "under 40 vs. above 40" instead of each age bin. Since this is exploratory research, I just want to provide all possible options to the participants that select into the survey. If I consider "scientist vs. non-scientist," "male vs. female," and "under 40 vs. above 40" as my minimum number of variables, then my minimum sample size would be 60, according to the "ten times larger than the number of variables" rule of thumb. So in accordance with the rules of thumb, I consider my minimum sample size to be 60, and my maximum sample size to be 500. I planned to close the survey after one month, or after obtaining 500 responses, whichever came first.

Distribution

The primary means of distributing this survey was to email all the department heads at the University of North Dakota and ask if they would send my recruitment message to their department email listservs. The following is the text of my recruitment message, approved by the university's Institutional Review Board (IRB).

> What inspired your career or interests? Whether you are a student, professor, community member, are in a science-related field or a non-science-related field, something influenced your interest. You are invited to participate in a voluntary, anonymous survey that studies the influences of different factors on people's career choices in both science and non-science fields. After completing the survey, you have the option of entering a drawing for one of two $50 Amazon gift cards. The survey may take approximately 10-15 minutes to complete.
>
> You may take the survey here – [link]

The information you enter in the survey is anonymous and will not be connected with any personal identifiers, and you are at liberty to exit the survey at any time without your data being recorded. Anyone at least 18 years old is eligible to participate. This survey is created and administered as part of a thesis project for Katrina Jackson, a graduate student in the UND Department of Space Studies. If you have any questions, you may contact her at katrina.jackson@my.und.edu. You may also learn more about the project at TVandScience.wordpress.com.

I also sent this email to the UND Space Studies community listserv and encouraged people to pass it along to their friends or colleagues. For example, Dr. Laura Munski passed it on to the Dakota Science Center parents email list, and Dr. Seth Shostak passed the message on to some people at the SETI Institute. I also created a Facebook page for the thesis project which works in tandem with the research website/blog on Wordpress – http://TVandScience.wordpress.com. Both have provided updates to the research progress for anyone interested in following along.

CHAPTER V

RESULTS

The survey was open from March 20, 2013 to April 20. 272 participants started the survey, and 251 finished. The participants took an average of 16 minutes to complete the survey; this average includes the few participants who most likely did not complete the survey in one sitting and took an hour or more, so in reality most participants completed the survey in a shorter amount of time.

Demographics

Of the 251 participants, 42% were male and 58% were female. Most participants (71%) were currently in undergraduate or graduate school; 26% were not in school and had already earned a college degree. Participants could select more than one option for ethnicity/race; 228 selected white and 32 selected an option other than white. The largest non-white population was Asian, with a sample size of 11. About half the participants claimed to be from a middle class upbringing; none claimed to grow up in an upper class family. Most (76%) of the participants claimed to be affiliated with the University of North Dakota. Of those at the University of North Dakota, 48% were undergraduate students, 34% were graduate students, 13% were faculty members, and 5% were staff members. 78% of respondents identified themselves as having significant interest or education in a STEM subject. See figures 2a and 2b.

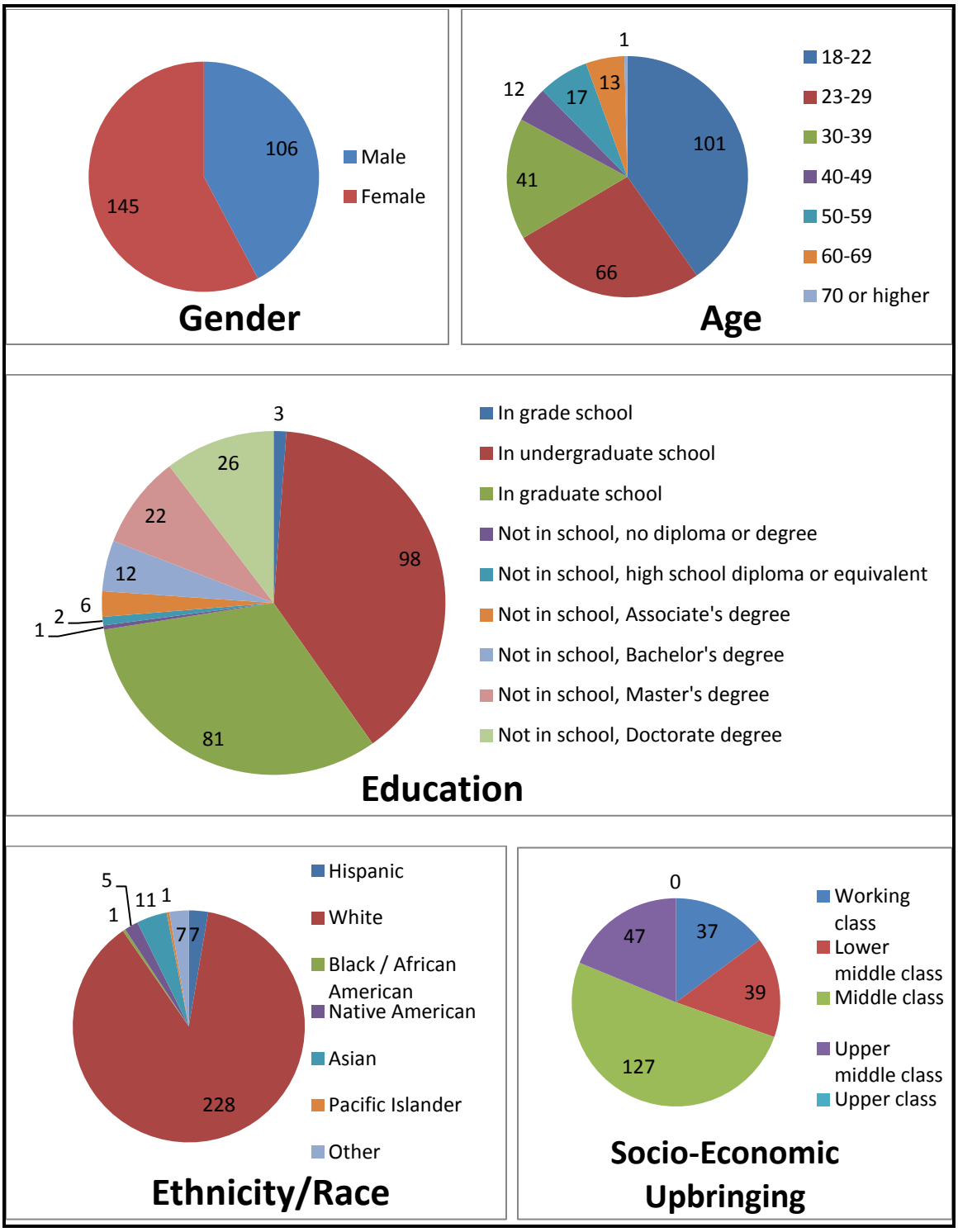


Figure 2a. Survey demographics.

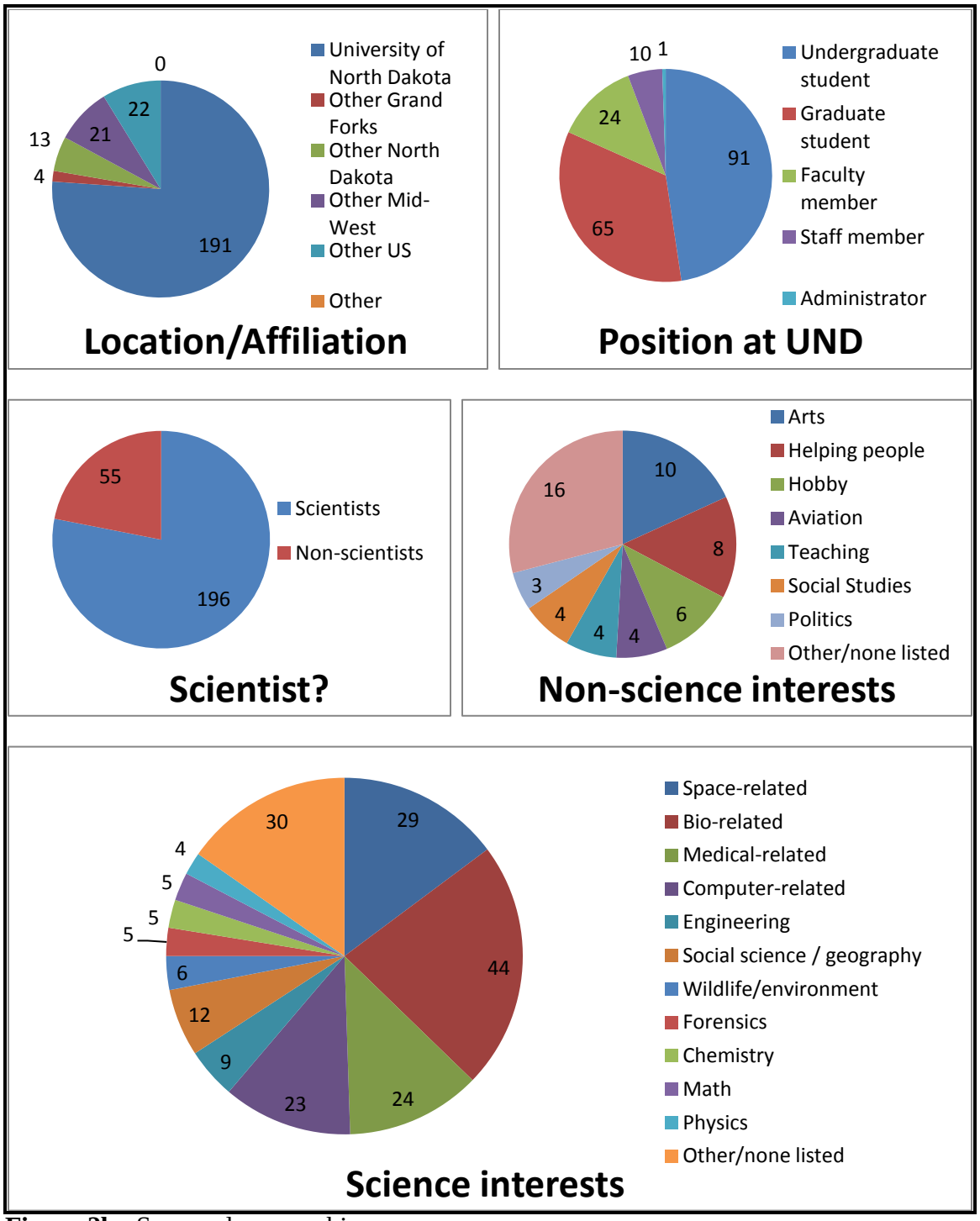


Figure 2b. Survey demographics.

The "Science interests" and "Non-science interests" are based on the participants' short-answer responses. There is some overlap between subject categories, but these charts are just meant to give an idea of the range of fields the participants came from.

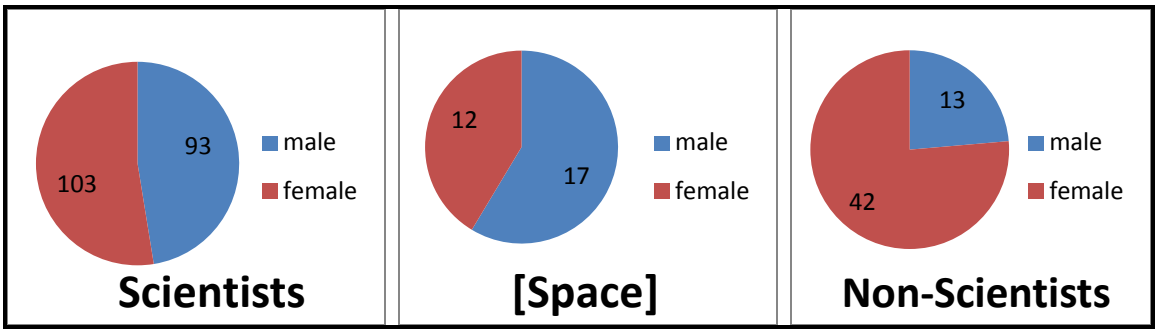


Figure 3. Subject-Gender Demographics

Large portions of the scientists provided space-related fields, biology-related fields, medical-related fields, and computer-related fields as their primary interests. Large portions of the non-scientists provided arts fields, helping people, and hobbies such as gardening or hunting as major interests. Figure 3 looks at the gender distribution of the scientists, space sub-sample, and non-scientists. Males and females are well-represented in the scientist sample and space sub-sample, though not in the same proportions as they exist in the work-force. According to NSF data from 2008, females represented 27% of working scientists and engineers and 10% of physicists/astronomers and aerospace engineers; females held 41% of science and engineering doctoral degrees awarded in 2010 and 24% of doctoral degrees in astronomy and aerospace engineering (National Science Foundation a and b, 2013). The non-scientist participants are disproportionally female; it is not clear why this occurred. It should be kept in mind that the non-scientist group seems to be a poor sample.

Influencing Factors

All the participants were asked to provide a free-response sentence describing what influenced their interest in the subjects they identified. There were a wide variety of responses; some people responded with why they thought the subject was interesting or

important instead of what inspired their interest. This indicates that either they did not understand the question or they found it difficult to answer. The top five responses provided by scientists were classes and teachers; curiosity or attraction to the unknown and exploration; childhood or personal experiences; entertainment media; and parents, family members, or friends. The top five responses for the subsample of scientists interested in a space-related field were entertainment media; curiosity or attraction to the unknown and exploration; classes and teachers; the early space program or Shuttle; and childhood or personal experiences. The top five responses for non-scientists were

Table 1. Influencing Factors – Top Five Free-Response Answers

Science **(n = 196)** Factor (n)	**Space** **(Sub-sample of Scientists)** **(n = 29)** Factor (n)	**Non-science** **(n = 55)** Factor (n)
1. Classes and teachers (38)	1. Entertainment media (8) • (4) Sci-fi • (2) Science popularizers • (1) Books • (1) Videos	1. Parents, family members, or friends (8)
2. Curiosity or attraction to the unknown and exploration (24)	2. Curiosity or attraction to the unknown and exploration (7)	2. Childhood or personal experiences (7)
3. Childhood or personal experiences (21)	3. Classes and teachers (4)	3. Classes and teachers (5)
4. Entertainment media (17) • (6) Sci-fi • (2) Science popularizers • (2) Books • (2) Fiction TV or movies • (1) Videos • (1) Documentaries • (1) Magazines • (1) Internet • (1) Video games	4. The early space program or Space Shuttle (4)	4. The desire to help people (5)
5. Parents, family members, or friends (12)	5. Childhood or personal experiences (2)	5. Books (3)
Other/none: 82	*Other/none: 5*	*Other/none: 29*
***Less frequent responses**: the early space program or Space Shuttle (4); think it's super important (4); attracted to logical and critical thinking (4); job opportunities (3); wanted to be an astronaut (2); prestige of the field (1); surviving in today's world (1)*	***Less frequent responses**: parents, family members, or friends (1); prestige of the field (1); wanted to be an astronaut (1)*	***Less frequent responses**: think it's super important (1); church or faith (1)*

parents, family members, or friends; childhood or personal experiences; classes and teachers; the desire to help people; and books.

The participants were then asked to rank the level of influence of each of the following factors: family/friends, books, TV/movies, classes/teachers, games, museums, personal experiences, the news, websites or online videos, and other. On a scale from 1

Table 2. Influencing Factors – Rankings

Total Factor (Average Ranking)	**Scientists** Factor (Average Ranking)	**Space** **(Sub-sample of Scientists)** Factor (Average Ranking)	**Non-scientists** Factor (Average Ranking)
Personal Experiences (2.2)	Personal Experiences (2.2)	Books (2.4)	Personal Experiences (2.1)
Classes/Teachers (2.6)	Classes/Teachers (2.4)	TV/Movies (2.6)	Family/Friends (2.8)
Books (2.9)	Books (2.9)	Classes/Teachers (2.7)	Classes/Teachers (3.0)
Family/Friends (3.1)	Family/Friends (3.1)	Personal Experiences (2.8)	Books (3.0)
TV/Movies (3.2)	TV/Movies (3.1)	Family/Friends (3.2)	News/Current Events (3.1)
News/Current Events (3.2)	News/Current Events (3.2)	Museums (3.2)	TV/Movies (3.6)
Museums (3.5)	Museums (3.3)	News/Current Events (3.2)	Websites/Online Videos (3.7)
Websites/Online Videos (3.7)	Websites/Online Videos (3.7)	Websites/Online Videos (3.7)	Museums (4.0)
Games (4.1)	Games (4.0)	Games (4.1)	Games (4.4)
Other (3.9)	*Other (3.7)* – *experience coding, science competition, natural curiosity, CERN, Dakota Science Center, nature, scholarly forums, lab classes, got to teach stats, personal curiosity, job outlook, science fiction, dance, natural curiosity, 4H camp, planetarium, school librarian, STEM faculty, environmentally-friendly city, magazines, spending time outdoors, photography, lack of understanding by those around me, national parks, 1st robotics, natural curiosity, survival, the zoo, being an art student, knowledge, service, opportunity*	*Other (3.7)* – *planetarium, personal curiosity, CERN, nature*	*Other (4.3)* – *wasteful people, life events, communication disorders, personal philosophical commitments, Jesus Christ, personal strength*

to 6, with 1 being "This is the only reason I pursued this subject!" and 6 being "This actually DISCOURAGED my interest," the average ranking of each factor is given in Table 2. Non-scientists and scientists both had personal experiences as their average top-ranking influencing factor. The space sub-sample has books as their average top-ranking influencing factor, followed by TV/movies. Classes/teachers was a high-ranking influencing factor for scientists, non-scientists, and the space sub-sample. Scientists, especially the space sub-sample, ranked TV/movies as an influencing factor higher than the non-scientists did. Non-scientists ranked museums lower than the scientists and space sub-sample did. Games were the lowest-ranking influencing factor for all three groups.

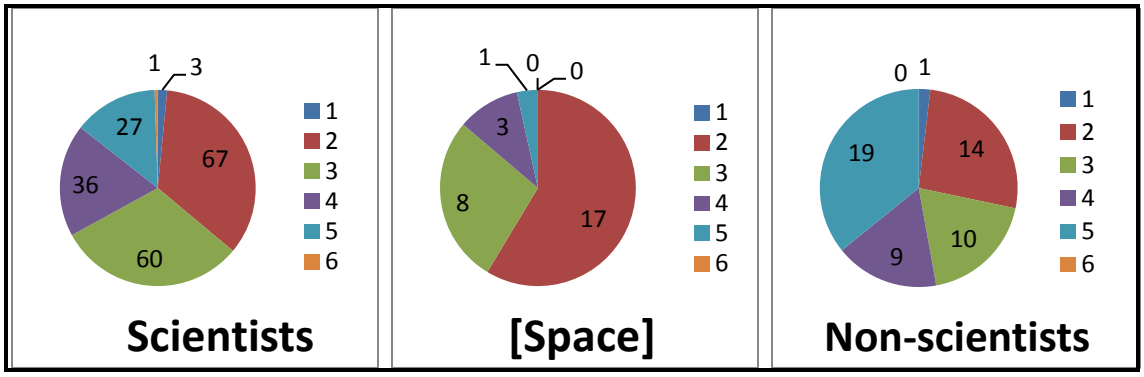


Figure 4. TV/Movies Ranked as an Influencing Factor

Figure 4 looks specifically at the TV/movies factor and compares the rankings between scientists, non-scientists, and the space sub-sample. There appear to be substantial differences; the space sub-sample ranked TV/movies much higher than the overall scientist group did, which in turn ranked TV/movies much higher than the non-scientist group did. Just one participant from the space sub-sample ranked TV/movies as a 1, indicating that TV/movies did "not at all" inspire his interest in space.

Table 3 then shows how many times each factor was ranked as a 6, having discouraged the participants' interest in their own subjects. News/current events was

most frequently ranked as a 6, indicating that those participants pursued their interests despite the news or current events suggesting it was a bad idea. Family/friends was the factor second-most frequently ranked as a 6. TV/movies and museums were each ranked as a 6 only once. Overall there were very few rankings of 6, which makes sense because if participants were significantly discouraged in their subjects, then they probably would not have become interested in them.

Table 3. Number of Participants That Ranked a Factor as Discouraging

	Total (n = 251)	**Scientists** (n = 196)	**Space** (Sub-sample of Scientists) (n = 29)	**Non-scientists** (n = 55)
Family/Friends	4	3	0	1
Books	3	2	0	1
TV/Movies	1	1	0	0
Classes/Teachers	3	3	0	0
Games	3	3	1	0
Museums	1	0	0	1
Personal Experiences	2	2	1	0
News/Current Events	6	5	1	1
Websites/Online Videos	3	3	0	0
Other	9	8 *Sexism in engineering*	0	1

Next, the non-scientists were asked if any of these factors discouraged them from having a strong interest in STEM. Table 4 shows how many times each factor was selected as contributing to their disinterest in STEM. Classes/teachers and personal experiences were the top reasons the non-scientists selected for not being interested in STEM. This is reinforced by the free-responses participants provided in the "other" option, where many indicated that they did not like the classes or that they personally do not find STEM a

good fit. Family/friends was the third-most selected factor. TV/movies was not frequently selected as a reason for disinterest in STEM.

Table 4. Factors that Contributed to Non-Scientists' Disinterest in STEM

Factor	Number of participants (n = 55)
Family/Friends	6
Books	2
TV/Movies	3
Classes/Teachers	21
Games	1
Museums	3
Personal Experiences	19
News/Current Events	1
Websites/Online Videos	0
Other	19
Not personally exciting, doesn't fit personality, no desire, no appeal, classes too demanding, doesn't match intellectual traits, intimidating, perceived academic deficiencies, don't enjoy it, didn't think of it when she was younger, poor teaching, bad at math, weak preparation, boredom, other interests, just went in a different direction	

The survey results from both the free-responses and the rankings do show that TV/movies or entertainment media is one of several major motivating factor factors for people's interests, and that at the very least, it is rarely a discouraging factor. Next, everyone who gave TV/movies a ranking from 1 ("This is the only reason I pursued this subject!") to 4 ("There might have been a little inspiration") were asked to try to name a few TV shows or movies that inspired their interest. There was an extremely wide variety of responses. The TV shows and movies most frequently provided by scientists were *Star Trek*, *Bill Nye the Science Guy*, *Star Wars*, the Discovery channel, *Stargate*, *Contact*, *Cosmos*, *Planet Earth*, *NOVA*, *Apollo 13*, and *CSI*. The titles provided by the space sub-sample were similar but mostly more space-focused. The non-scientists understandably had very little overlap between the titles they provided, but it is interesting to look at which titles correspond to which interests. There are obvious correlations, such as *Top Gun* influencing someone's interest in aviation, and less

obvious correlations, such as *Doctor Who* and *Star Trek* influencing someone's interest in group behaviors. See Table 5 for a full list of the free-response titles.

Table 5. Influencing TV/Movies – Free-Response

Scientists **(n = 144)** Title (number of participants)	**Space** **(Sub-sample of scientists)** **(n = 29)** Title (number of participants)	**Non-Scientists** **(n = 55)** *Subject:* Title
• Star Trek (29) • Bill Nye (18) • Star Wars (13) • Discovery channel (11) • Stargate (9) • Contact (9) • Cosmos (8) • Planet Earth (8) • NOVA (7) • Apollo 13 (7) • CSI (7) • Jurassic Park (6) • The Universe (6) • The Magic School Bus (6) • Grey's Anatomy (6) • House (5) • Battlestar Gallactica (5) • National Geographic (5) • MythBusters (5) • The Big Bang Theory (5) • Avatar (4) • October Sky (4) • Twister (4) • Firefly (3) • Gattaca (3) • E.T. (3) • Through the Wormhole with Morgan Freeman (3) • PBS documentaries (3) • Back to the Future, Land Before Time, Flash Gordon, Blue Planet, The Fifth Element, Man in Space (von Braun), NCIS, Criminal Minds, TED talks, The Right Stuff, The Day After Tomorrow, Modern Marvels, Bones, Wild America, Lorenzo's Oil, Terminator, Numb3rs, Quincy, How the Universe Works, MacGyver, The Six Million Dollar Man, ER, the Animal Planet,	• Star Trek (13) • Star Wars (6) • Contact (6) • Stargate (4) • Cosmos (3) • Apollo 13 (3) • October Sky (3) • E.T., Discovery channel, Firefly, Jurassic Park, The Fifth Element (2) • CBS news coverage, House, Space Odyssey, Minority Report, Space Camp, Back to the Future, Moonshot, Land Before Time, Men in Black, Avatar, Battlestar Gallactica, Flash Gordon, Tom Corbett, Destination Moon, National Geographic documentaries, The Cape, Planet Earth, Blue Planet, Bill Nye, MythBusters, NASA TV, Close Encounters of the Third Kind, Al, Independence Day, Armageddon, Yellowstone Super Volcano, The Universe, The Last Starfighter, Explorers, Man vs. Wild, Survivor Man, Dual Survival, Captain Video, War of the Worlds, They Came From Outer Space, Twister, Mr. Wizard, Man in Space, Zenon, The Absent-Minded Professor, Gattaca, Indiana Jones (1)	• *Acting:* The Following • *Traveling/cultures:* Doctor Who • *Group behaviors:* Doctor Who, Star Trek • *Hunting/fishing:* Outdoor Channel • *Social sciences:* Law and Order, Good Will Hunting • *Teaching social studies:* National Treasure, John Adams • *Nursing:* Grey's Anatomy, House • *Politics:* Fox news, CNN • *Helping others make changes:* Go Ask Alice, One Flew Over the Cuckoo's Nest, Julia, Ordinary People, St. Elsewhere, ER, October Sky, Schindler's List • *Cooking:* No Reservations, the Food Network • *Japanese pop culture:* Pokémon, Howl's Moving Castle, Spirited Away, Summer Wars, Full Metal Alchemist • *Sports:* Miracle, For the Love of the Game • *Gardening:* Home and Gardening • *Military:* The Unit, Blackhawk Down

Table 5. Cont.

Scientists (n = 144) Title (number of participants)	**Space** (Sub-sample of scientists) (n = 29) Title (number of participants)	**Non-Scientists** (n = 55) *Subject:* Title
Cyberchase, Scrubs, History Channel documentaries (2) • CBS news, Space Odyssey, Minority Report, Space Camp, Moonshot, Men in Black, Tom Corbett, Destination Moon, The Cape, NASA TV, Close Encounters of the Third Kind, Al, Independence Day, Armageddon, Yellowstone Super Volcano, The Last Starfighter, Explorers, Man vs. Wild, Survivor Man, Dual Survival, Captain Video, War of the Worlds, They Came From Outer Space, Mr. Wizard, Zenon, The Absent-Minded Professor, Indiana Jones, Heroes, Inception, Sherlock Homes, Extreme Engineering, Captain Planet, Outbreak, Harry Potter, Mobile Suit Gundam 00, District 9, I-Robot, Into the Universe with Stephen Hawking, Untold Stories of the ER, Airport, Daybreakers, Contagion, China Syndrome, 2001 Space Odyssey, Dr. G Medical Examiner, Trauma: Life in the ER, CNN, Kratt's Creatures, Jack Hannha, Wild Discovery, The Day After, Threads, Total Recall, night of the Twisters, Dante's Peak, Johnny Quest, Alien, Silent Running, Dune, Eagle Eye, TLC, books (Ender's Game, Foundation Series, Heinlein), Jane Goodall My Life with Chimpanzees, Ultraman, Frozen Planet, Robot Chicken, Abby & Brittany, Strong Medicine, Blue Thunder, Knight Rider, Mission Impossible, The Twilight Zone, Lost in Space, The Jetsons, Square One TV, Reading Rainbow, 3-2-1 Contact, Castle, Good Will Hunting, Fringe, Stephen Hawking's Universe, Sneakers, Private Practice, X-Files, Doogie Howser, How It's Made, Pirates of Silicon Valley, Shark Week, Josh Kirby Time Warrior, Captain Vyom, Deep Impact, War Games, The Social Network, James Bond, Swordfish, Eureka, Who Framed Roger Rabbit, IT Crowd, Inner Space, CourtTV, Wonders of the Universe/Solar System (Brian Cox), Beyond 2000, Stand and Deliver, Great Thinkers (Freud and Jung documentary), Little House on the Prairie, Dexter's Lab, Crocodile Hunter (1)		• *Psychology:* CSI, Lie to Me • *Taking care of others:* The Brady Bunch, It's a Wonderful Life • *Travel:* Charade, Roman Holiday, Under the Tucson Sun • *Photography:* Discovery documentaries • *Music:* Foo Fighters' "Back and Forth", MTV/VH1 music videos • *Aviation:* Top Gun • *Social Media:* Law and Order, Veronica Mars • *Helping people:* A Child Called It • *Serving others:* The End of the Spear • *Education:* The Story of Stuff, The Omnivore's Dilemma, Can You Keep Your Faith in College • *Why Republicans have no conscience:* Watergate hearings, Iran-Contra hearings

The participants who ranked TV/movies as a 5 (Not at all) or 6 (This actually DISCOURAGED my interest) were asked to list a few TV shows or movies that they

enjoyed. They provided a wide range of responses; a full list of these titles is in Appendix B. Then they were asked why these shows and movies did not influence their interests. Table 6 lists the main reasons participants provided as to why the TV shows and movies they listed did not influence their primary interests. The most frequent response was that the shows did not relate to their subjects. A few people stated that one or more of the shows actually did influence their interests, indicating that they had possibly mismarked their rankings of TV/movies. Some participants noted that there were TV shows and movies they enjoyed that relate to their subjects, but they came out after they had established their interests.

Table 6. Why the Shows and Movies the Participants Liked Did Not Influence Their Interests – Free-Response

Number of participants that provided the reason
These do not relate to their subjects (n = 18/42)
They view these solely as entertainment (n = 10/42)
Titles related to their subjects did not come out until later in their lives (n = 5/42)
These are not realistic or connected to the real world (n = 4/42)
Some of these actually *have* influenced their interests (n = 4/42)
They do not think you should be influenced by TV/movies (n = 2/42)
These are not a substitute for literary art (n = 1/42)

Scientific Literacy

Of the thirteen science literacy questions included in the survey, one question caused some controversy. On the true or false question "The universe began with a huge explosion," 20% selected the supposedly incorrect answer of false, making this the most missed question in the section. Two participants commented at the end of the survey that the word "explosion" should not be used to describe the Big Bang. There is indeed some controversy among scientists about describing the Big Bang as an explosion. While

personally I think the word "explosion" in its general sense can accurately describe the Big Bang, and while this question has been used on science literacy surveys conducted by the NSF, I decided to throw out this question when tabulating the participants' science literacy scores. The participants could thus score a maximum of 12.

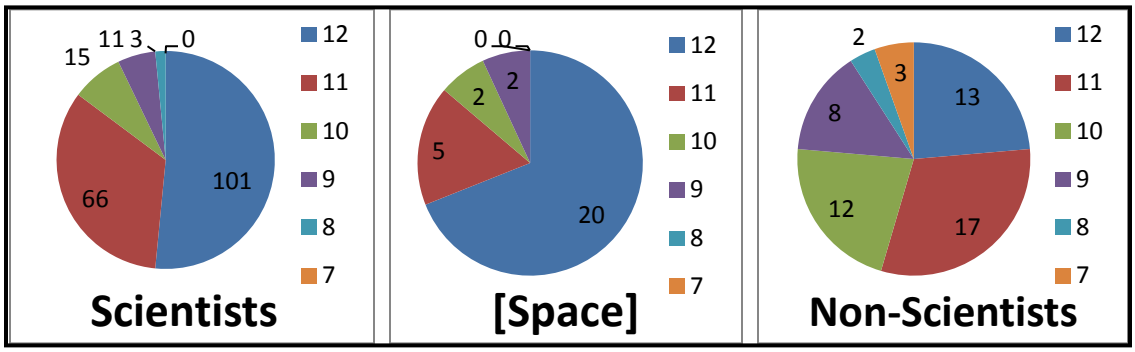


Figure 5. Science Literacy Scores by Subject

Figure 5 shows the science literacy scores grouped by subject. In general, scientists scored substantially higher than non-scientists did, and the space sub-sample scored higher than the rest of the scientists scored. Figure 6 shows the science literacy levels grouped by gender. In general, males scored higher than the females scored. This is consistent with recent NSF surveys. Figures 7a through 7d show the science literacy scores grouped by television show. This looks at the participants who rated the frequency of watching that television show as "I have watched it somewhat regularly, and

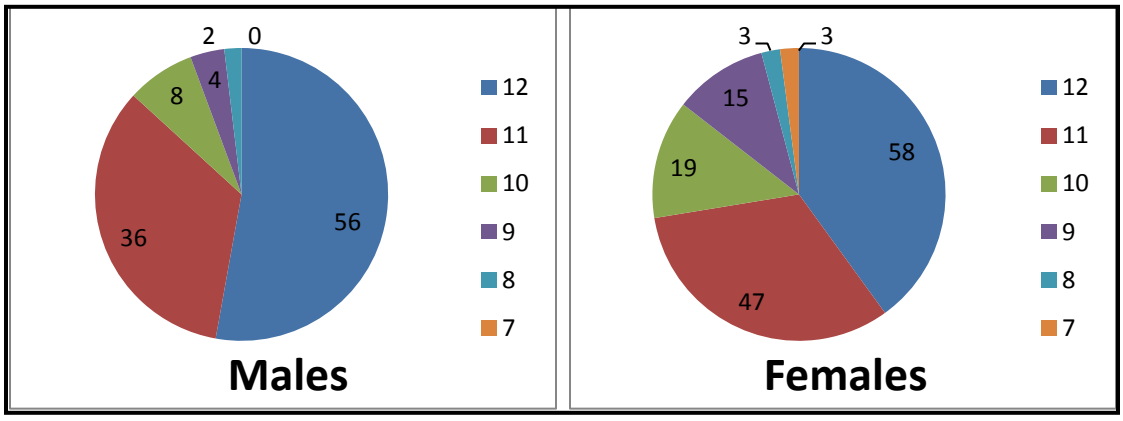


Figure 6. Science Literacy Scores by Gender

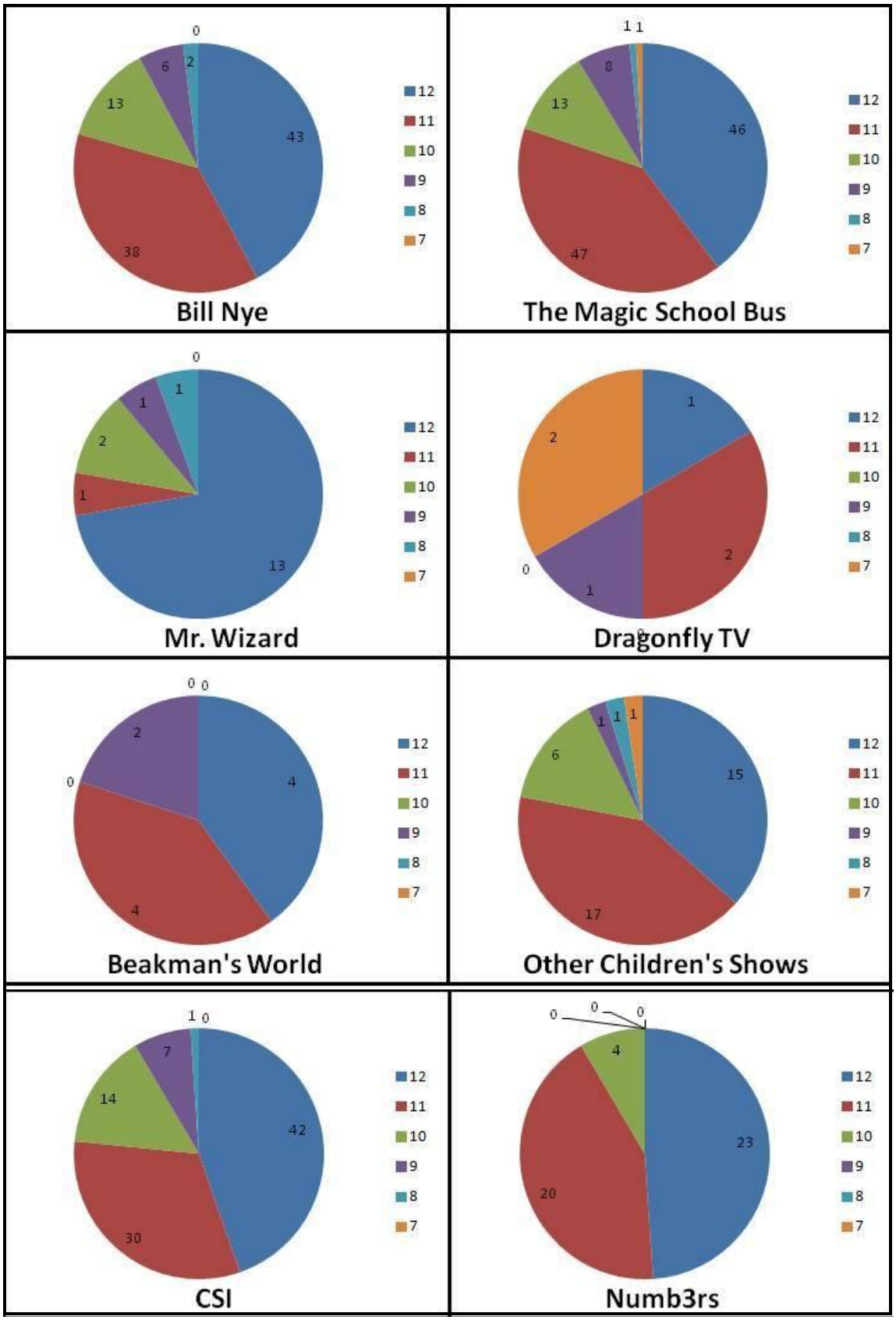


Figure 7a. Science Literacy Scores by TV Show

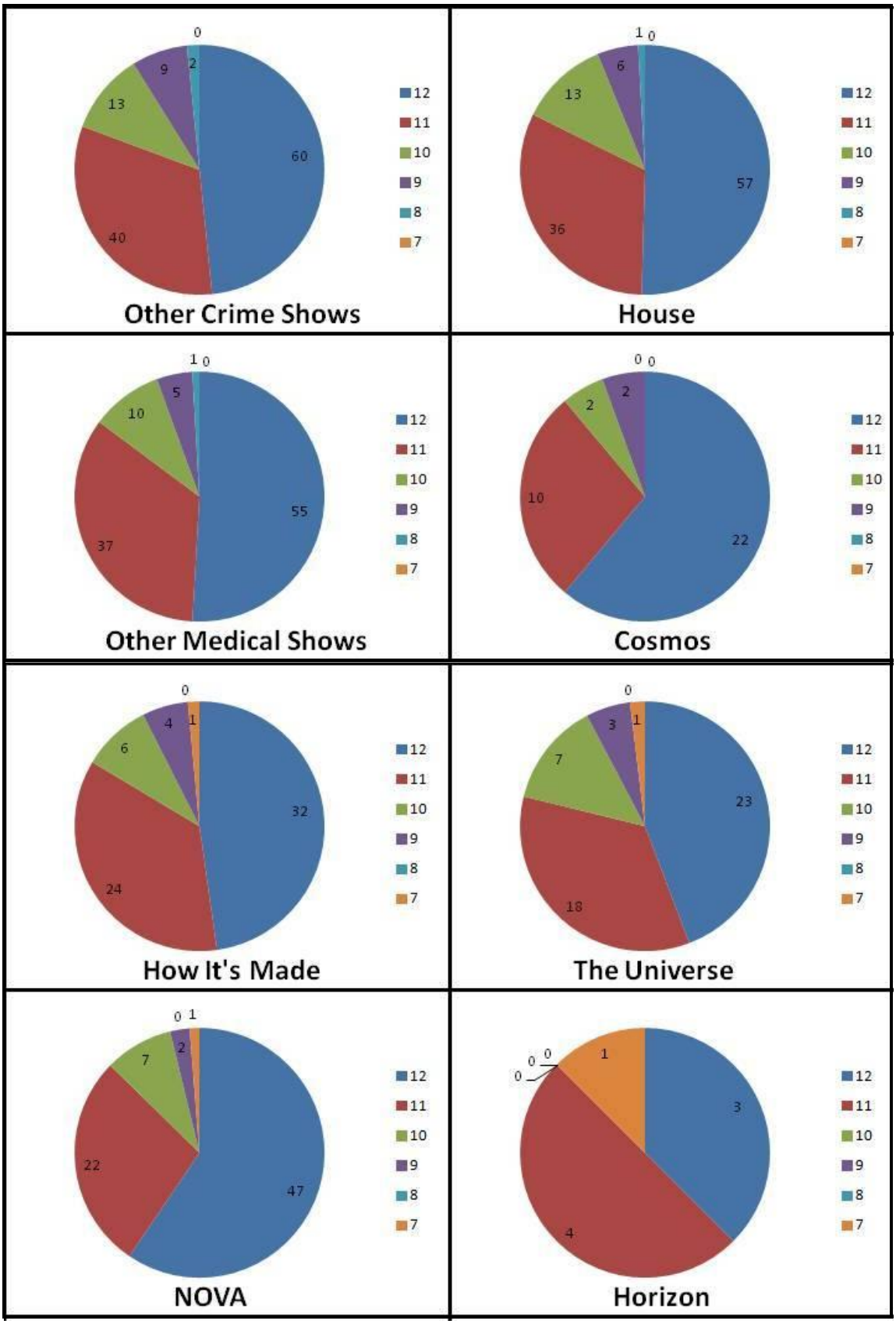


Figure 7b. Science Literacy Scores by TV Show

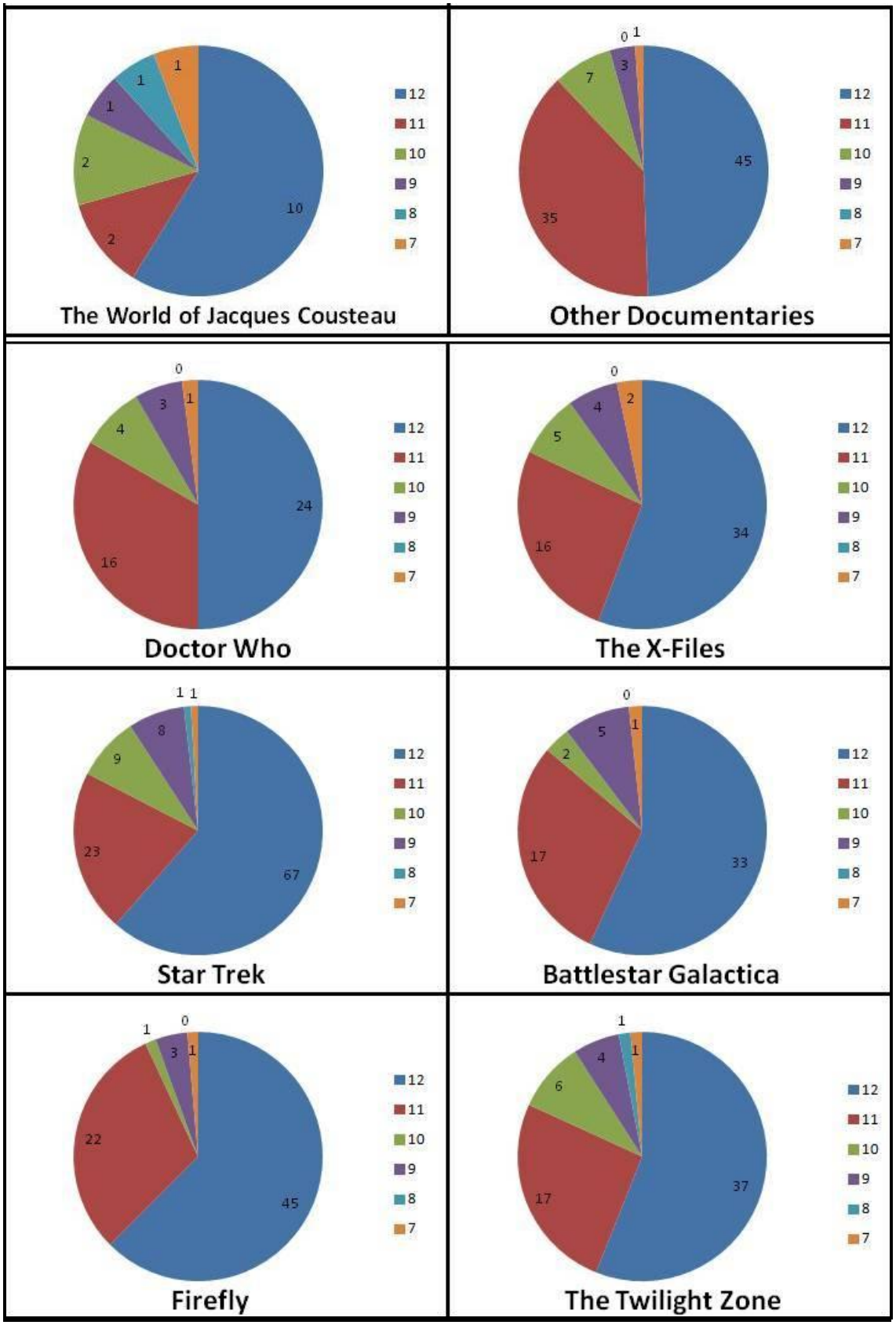


Figure 7c. Science Literacy Scores by TV Show

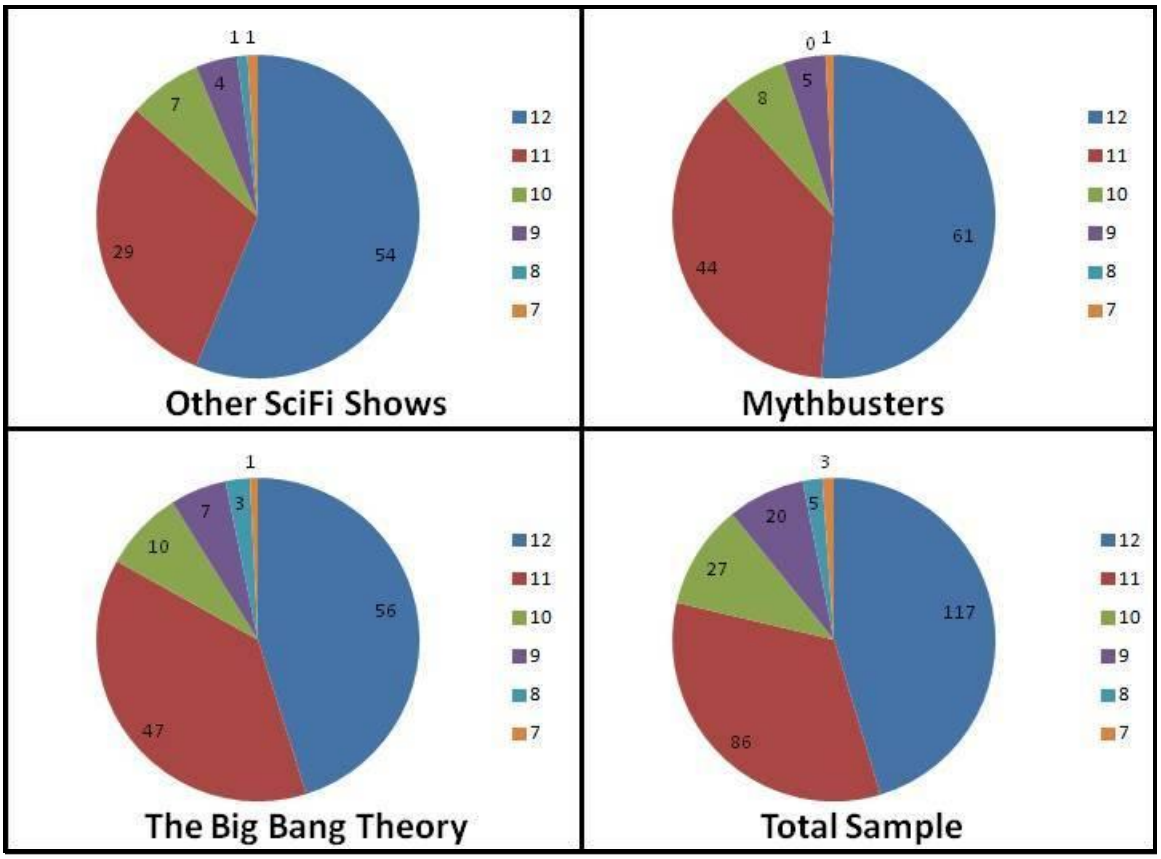


Figure 7d. Science Literacy Scores by TV Show

have seen several episodes," "I have watched it regularly, and have seen most or all the episodes," or "I am or was fanatic about this show." There appear to be only slight variations among shows and genres. The only huge variations are where there was a very small sample size of people who frequently watched that particular show. It looks like among this survey sample, people watching science fiction shows tend to have slightly higher scientific literacy levels than the total sample. Among documentaries, Cosmos and NOVA viewers also performed particularly well on scientific literacy. The chart for The Big Bang Theory is very similar to the chart for the total sample.

Science Television Shows

Table 7 looks at the percentage of participants who rated the frequency of watching each television show as "I have watched it somewhat regularly, and have seen several episodes," "I have watched it regularly, and have seen most or all the episodes," or "I am or was fanatic about this show." There are a few notable differences between

Table 7. Percentage of Participants That Watch Each Show – Grouped By Subject

TV Show	Total Sample (n = 251)	Scientists (n = 196)	Space (Sub-sample of scientists) (n = 29)	Non-scientists (n = 55)
Bill Nye	41	42	45	35
The Magic School Bus	46	49	38	37
Mr. Wizard	7	8	14	6
Dragonfly TV	2	2	3	6
Beakman's World	4	3	7	7
Other Children's Shows	16	18	17	9
CSI	37	38	31	36
Numb3rs	19	19	28	18
Other Crime Shows	49	47	59	58
House	45	46	45	42
Other Medical Shows	43	43	28	42
Cosmos	14	18	38	2
How It's Made	27	29	24	20
The Universe	21	26	31	7
NOVA	31	35	45	18
Horizon	3	4	0	2
Jacques Cousteau	7	8	10	7
Other Documentaries	36	40	38	22
Doctor Who	19	21	21	13
The X-Files	24	23	28	27
Star Trek	43	47	76	31
Battlestar Galactica	23	25	38	16
Firefly	29	31	48	20
The Twilight Zone	26	26	34	27
Other SciFi Shows	38	40	52	33
MythBusters	47	51	48	34
The Big Bang Theory	49	51	62	44

participants in these different groups that watched children's shows, crime shows, and medical shows were mostly similar, but the percentage of scientists that watched documentaries was substantially greater than the percentage of non-scientists, especiallyfor the shows *Cosmos*, *The Universe*, and *NOVA*. The differences between science fiction shows were more varied. There were little differences between the percentages that watched *Doctor Who*, *The X-Files*, and *The Twilight Zone*, but more scientists, especially in the space sub-sample, watched *Battlestar Galactica* and *Firefly* than the non-scientists did. The percentages that watched *Star Trek* varied tremendously; 31% of non-scientists, 47% of scientists, and a whopping 76% of the space sub-sample frequently watched the series, a difference of 45 percentage points between the non-scientists and the space sub-sample. Scientists watched *MythBusters* more frequently than non-scientists did. Participants in the space sub-sample watched *The Big Bang Theory* more frequently than the rest of the scientists and the non-scientists did.

Not including "other" options, the scientists participants most frequently watched *MythBusters* (51%), *The Big Bang Theory* (51%), and *The Magic School Bus* (49%); the space sub-sample most frequently watched *Star Trek* (76%), *The Big Bang Theory* (62%), and *MythBusters* (48%); the non-scientists most frequently watched *The Big Bang Theory* (44%), *House* (42%), and *The Magic School Bus* (37%); and the total sample most frequently watched *The Big Bang Theory* (49%), *MythBusters* (47%), and *The Magic School Bus* (46%).

The same data is grouped by gender in Table 8. There does not appear to be a substantial difference between genders for the children's science shows. Female participants in this survey watched crime and medical dramas more than males did, and

male participants watched documentaries more than females did. In the science fiction genre, the percentages were about the same between males and females for watching *Doctor Who*, *The X-Files*, and *Battlestar Galactica*, but males watched *Star Trek*, *Firefly*, and *The Twilight Zone* more than females did. The male participants watched *Mythbusters* somewhat more than the females did, and the female participants watched *The Big Bang Theory* somewhat more than the males did. Not including "other" options,

Table 8. Percentage of Participants That Watch Each Show – Grouped By Gender

TV Show	Total Sample (n = 251)	Males (n = 106)	Females (n = 145)
Bill Nye	41	37	43
The Magic School Bus	46	42	49
Mr. Wizard	7	11	4
Dragonfly TV	2	0	4
Beakman's World	4	6	3
Other Children's Shows	16	14	18
CSI	37	27	45
Numb3rs	19	15	21
Other Crime Shows	49	37	58
House	45	39	49
Other Medical Shows	43	26	55
Cosmos	14	24	7
How It's Made	27	34	21
The Universe	21	32	12
NOVA	31	34	29
Horizon	3	4	3
Jacques Cousteau	7	8	6
Other Documentaries	36	44	30
Doctor Who	19	19	19
The X-Files	24	23	25
Star Trek	43	50	38
Battlestar Galactica	23	25	21
Firefly	29	35	23
The Twilight Zone	26	36	19
Other SciFi Shows	38	50	29
MythBusters	47	53	43
The Big Bang Theory	49	44	53

the male participants most frequently watched *MythBusters* (53%), *Star Trek* (50%), and *The Big Bang Theory* (44%). The female participants most frequently watched *The Big Bang Theory* (53%), *The Magic School Bus* (49%), and *CSI* (45%).

Other Demographics

Here I look at the rankings of influencing factors for age, education level, socio-economic upbringing, ethnicity/race, location/affiliation, and status at UND to see if there are any huge variations among these demographic groups. Overall, the rankings are similar between the demographics in each of the groups. A few apparent trends are that with increasing age, games and the internet were less inspiring; participants working with post-graduate degrees were less inspired by TV and movies than participants in school or with less education; with increasing socio-economic upbringing, family and friends were more inspiring; participants of minority or mixed races and ethnicities were more inspired by books, TV and movies, news and current events, and the internet than solely white participants were; and faculty and staff at UND were less inspired by TV and movies, games, and the internet than students at UND were. See Appendix C for a full list of tables for these groups.

CHAPTER VI

DISCUSSION

Accomplishing the Survey Objectives

Objective 1 was to find a range of factors that influence a person's interest. The survey data shows that there is a wide array of factors and that there is a lot of variability among individuals. Some of the most popular influencing factors were classes and teachers, personal experiences, an innate curiosity, family members, and entertainment media. Scientists ranked TV and movies higher than non-scientists did, and the sub-sample of scientists in space-related fields ranked TV and movies higher than the rest of the scientists did. In fact, the space sub-sample had entertainment media at the top of the lists of influencing factors for both the free-response question and the factor-ranking question. I did not anticipate such a result, but it does make some sense; space topics are not frequently taught in school, and it is not as likely as for other fields that children would have family members in space-related fields, so it follows that a primary source for inspiration would be entertainment media.

Space scientists and other scientists often cited *Star Trek*, *Star Wars*, *Bill Nye the Science Guy*, *Stargate*, and *Contact* as shows and movies that inspired their interest in their fields. It is interesting that even for scientists as whole, space-related media comprised most of the top influencing shows and movies. Perhaps this is because space-related topics are particularly adept at inspiring imaginations or make for good stories. The small portion of participants who said that TV and movies did not inspire their

interest said that the programs they watched did not relate to their subjects, that they did not connect the programs to the real world, or that programs pertaining to their subjects did not exist until after they became interested in their subjects.

Objective 2 was to determine how scientific literacy level varied between scientists and non-scientists and between viewers of different science-related TV shows. As one might expect, the scientists on average had higher science literacy scores than the non-scientists did. Frequent viewers of science fiction shows tended to have slightly higher science literacy scores than those of the total sample. Frequent viewers of *Cosmos* and *NOVA* also tended to have higher science literacy scores. This prompts the question of whether these shows were watched more by scientists than by non-scientists.

The science fiction shows *Doctor Who*, *The X-Files*, and *The Twilight Zone* were not watched substantially more by scientists than by non-scientists, and yet the viewers still had higher than average science literacy scores. The other science fiction shows, along with *Cosmos* and *NOVA,* were watched substantially more by scientists than by non-scientists. Yet *The Universe* was also watched substantially more by scientists than by non-scientists, and viewers of *The Universe* had average science literacy scores. It does not seem then that the differences in science literacy scores between the television shows can be attributed to different proportions of scientist to non-scientist viewers. There does not seem to be an immediately obvious reason for the science literacy variations between the television shows.

Objective 3 was to look at the variations between which science-related television shows the participants watched. Scientists watched science documentaries more than the non-scientists did, especially *Cosmos*, *The Universe*, and *NOVA*. They also watched

more *Battlestar Galactica*, *Firefly*, and *Star Trek* than the non-scientists did; large percentages of the space sub-sample especially watched these shows. The scientists watched *MythBusters* more than the non-scientists did, and the space sub-sample watched *The Big Bang Theory* more than everyone else did. 76% of the space sub-sample frequently watched *Star Trek* and 62% frequently watched *The Big Bang Theory*, which were the only two instances of a large majority of the group watching a particular television program. Overall, scientists watched science-related television shows more frequently than non-scientists did, and the space sub-sample watched science-related television shows more than the rest of the scientists.

Female participants watched crime and medical dramas more than males did, and male participants watched science documentaries more than females did. Male participants watched *Star Trek*, *Firefly*, *The Twilight Zone*, and *MythBusters* more than females did, and females watched *The Big Bang Theory* more than males did. Overall, male and female participants watched about the same amount of science-related television shows. The most popular science-related television shows for the total sample were *The Big Bang Theory*, *MythBusters*, and *The Magic School Bus*. Considering the young age of most of the participants, it makes sense that more recent shows were the most watched. The space sub-sample and the males were the only groups to have a science-fiction show in their top three most popular science-related shows, showing that other genres can be at least as popular as science fiction and can perhaps reach a broader audience.

Objective 4 was to determine if there were major variations among the demographic groups. Some of the previous sections already addressed gender. Older

participants were understandably less inspired by the internet than younger participants were. Interestingly, participants of mixed or minority races and ethnicities tended to be inspired more by multimedia than solely white participants were. The participants with higher levels of education, including faculty and staff at UND, tended to be less inspired by TV and movies than students and those with less education were. Since there was not a strong trend with age regarding TV and movies, perhaps this would imply that the ones who succeed in academia tend to be those who have not paid a lot of attention to TV and movies.

Suggestions for Further Research

Based on the results from this survey, I propose the following for further research. Are people in space-related fields inspired by entertainment media more than other scientists are? If so, why? How does the influence of entertainment media on scientists compare to the influence on people in non-science fields? Are non-space-related scientists often inspired by space-related media? If so, why? Do people who regularly watch science fiction tend to be more scientifically literate than average? If so, why? Do females really watch more crime and medical dramas than men do? Do people who have watched *Cosmos* and *NOVA* tend to be more scientifically literate than those who watch other science documentaries? If so, why? Do people in space-related fields watch science-related television more than other scientists do? If so, why? Are the interests of Americans of mixed or minority races and ethnicities influenced more by entertainment media than those of solely white Americans are? If so, why?

A couple questions were not explicitly covered in this survey. Are non-scientists who watch more science-related television more interested in science than those who watch less science-related television? Are those who are more interested in science more financially and politically supportive of science organizations and research than those who are not interested? Some questions coming out of this survey are more opinion-based. Should space-related media be used to foster interest in all fields of science, or should greater effort be taken to create more engaging stories related to other science fields, or both? One of the reasons given by the participants who were no influenced by TV and movies was that they viewed the media they watched as purely entertainment and they did not think there was any basis in reality. Should extra effort be taken to make science-related media more realistic, or is the media more influential as entertainment?

One of the top-influencing factors for both scientists and non-scientists were classes and teachers, and I have previously mentioned that perhaps a reason why people in space-related fields ranked entertainment media above classes and teachers was because space topics were rarely taught in school. People not associated with space often cited space-related media as sources of inspiration or frequently watched space-related television shows. This suggests that perhaps space itself is very inspirational. Much of this thesis has been stressing the importance of informal education such as entertainment media, but the survey data also suggests that formal education is still critical to inspiring people's interests. Would including more space topics in school help influence people's interests in not only in space, but also in other science fields and even non-science fields?

Bringing Everything Together

In the introduction, I posed the questions: What sort of relationship really exists between the consumption of television and other entertainment media and a person's primary interests? What is this relationship specifically for space and science? Once these relationships are determined, what role do they serve in science communication? The literature review showed a lack of research in how entertainment media inspires people to pursue science. Several pioneers of spaceflight were at least partially inspired by science fiction stories, showing the importance of entertainment media to the formation of the space industry. The participants of the survey identified TV and movies as one of several influencing factors, along with classes and teachers, personal experiences, and family and friends. The survey data suggests several possible relationships to explore and brings to light questions for further research.

The survey data and historical research make it clear that entertainment media is a major influencing factor for many scientists. The data from the survey shows that this is not confined to one genre, and that science fiction, children's shows, mainstream entertainment, and documentaries all have strong influences on people's interests. My recommendation is that organizations and individuals make a pointed effort to support science-related media by providing funding, consulting, locations, or even more viewers. The scientific details in such media do not matter as much as having engaging and entertaining content and stories. Supporting these media projects can increase interest in adults and the next generation of potential scientists.

APPENDICES

APPENDIX A
Final Survey

Page 1. The first page of the survey asked for demographic information.

To start off, please provide a little background information on yourself.

Your age:

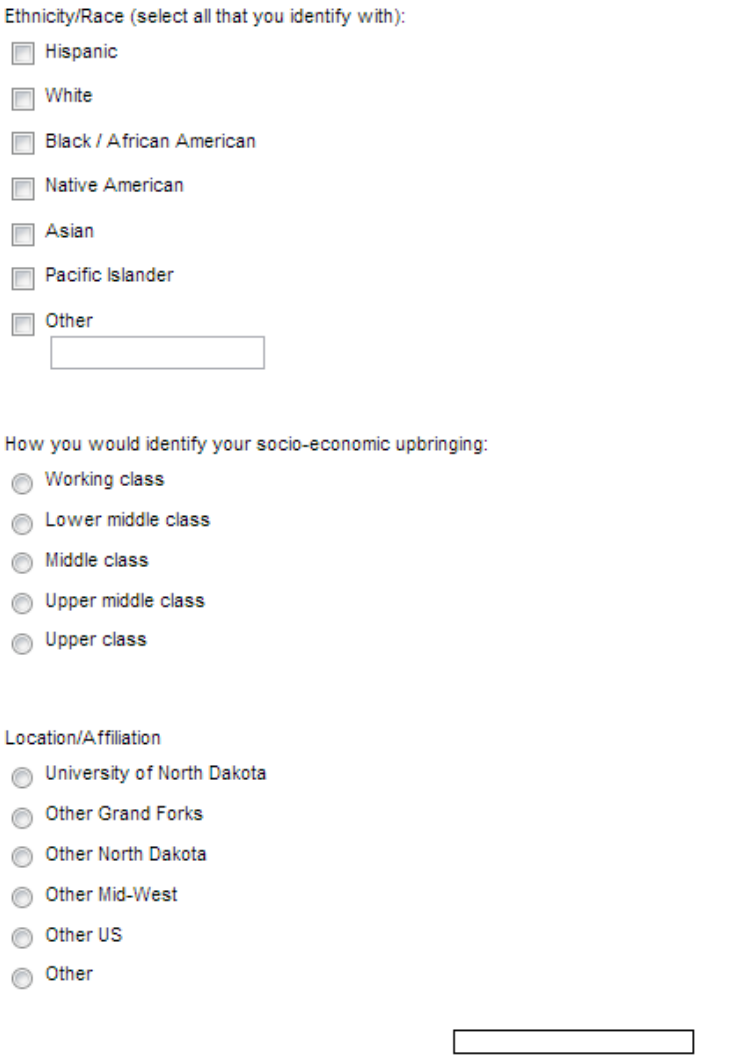
- 18-22
- 23-29
- 30-39
- 40-49
- 50-59
- 60-69
- 70 or higher

The gender you identify with:

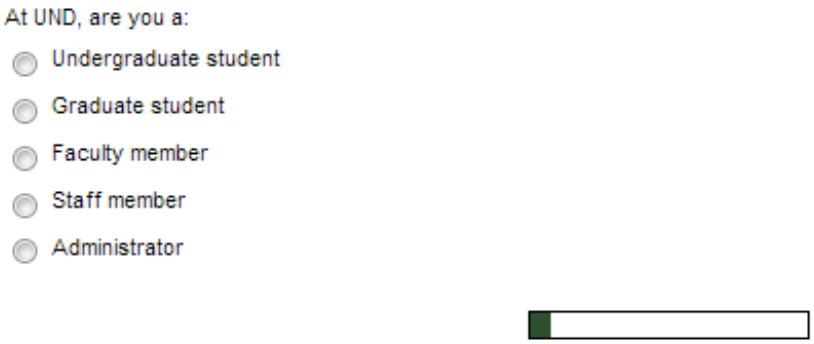
- Male
- Female

Education level:

- In grade school
- In undergraduate school
- In graduate school
- Not in school, no diploma or degree
- Not in school, high school diploma or equivalent
- Not in school, Associate's degree
- Not in school, Bachelor's degree
- Not in school, Master's degree
- Not in school, Doctorate degree



Page 1.5. If the participants selected "University of North Dakota" as their location/affiliation, the following page would appear.



Page 2. All participants then moved on to a page with standard science literacy questions.

The following are some basic true or false and multiple choice questions. This is not a test! Just answer to the best of your ability. And remember, all your data is confidential.

The center of the Earth is very hot.

- True
- False

All radioactivity is man-made.

- True
- False

Lasers work by focusing sound waves.

- True
- False

Electrons are smaller than atoms.

- True
- False

The universe began with a huge explosion.

- True
- False

The continents have been moving their location for millions of years and will continue to move.

- True
- False

How long, in years, does it take for the Earth to go around the Sun once?

It is the father's gene that decides whether a human baby is a boy or a girl.

- True
- False

Antibiotics kill viruses as well as bacteria.

- True
- False

Human beings, as we know them today, developed from earlier species of animals.

- True
- False

A doctor tells a couple that their genetic makeup means that they've got one in four chances of having a child with an inherited illness. Does this mean that if their first child has the illness, the next three will not?

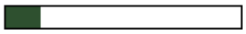
- Yes
- No

A doctor tells a couple that their genetic makeup means that they've got one in four chances of having a child with an inherited illness. Does this mean that each one of the couple's children will have the same risk of suffering from an inherited illness?

- Yes
- No

Two scientists want to know if a certain drug is effective against high blood pressure. The first scientist wants to give the drug to 1000 people with high blood pressure and see how many of them experience lower blood pressure levels. The second scientist wants to give the drug to 500 people with high blood pressure and not give the drug to another 500 people with high blood pressure, and see how many in both groups experience lower blood pressure levels. Which is the better way to test this drug?

- The first way - give the drug to 1000 people.
- The second way - give the drug to 500 people and don't give the drug to another 500 people.



Page 3. All participants then moved on to a page that asked them if they had an education or a significant interest in a STEM field.

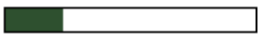
And now let's get to the meat of this survey! Just answer all questions honestly and as best you can.

Are you working towards or have you obtained a degree in STEM (Science, Technology, Engineering, or Math)?

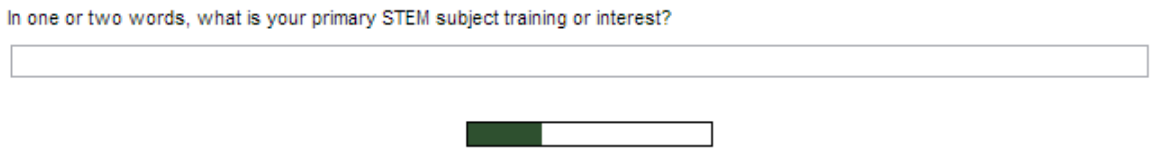
- Yes
- No

Do you have a significant interest in any STEM (Science, Technology, Engineering, or Math) subject?

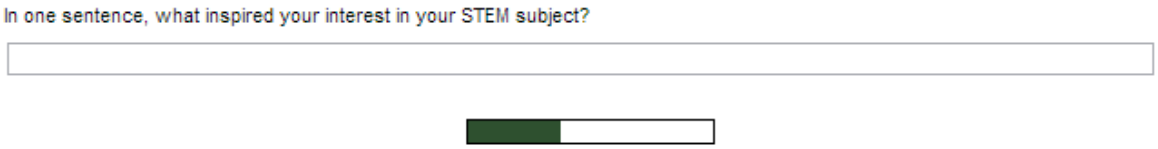
- Yes
- No
- Unsure



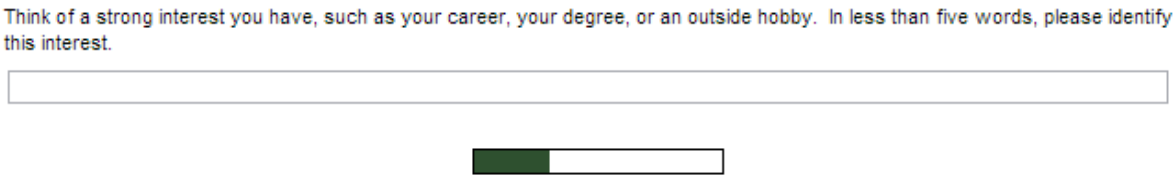
Page 4. If participants answered "Yes" to either question, they were considered a "scientists" for the purpose of this survey. If they answered "No" or "Unsure" to both questions, they were considered "non-scientists" for the purpose of this survey. Most of the rest of the survey had slightly different questions for scientists and non-scientists. Scientists were shown this next page.



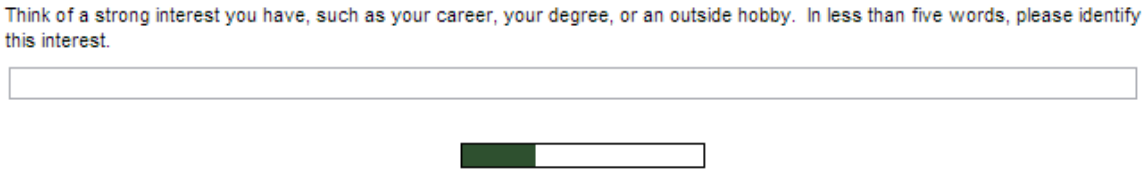
Page 5. Scientists were then shown this page.



Page 4. Non-scientists, however, were first shown this page.



Page 5. Non-scientists were then shown this page.



Page 6. Scientists were next asked to rate the factors that influenced their interest.

If you choose not to provide an "other" option for this question or following questions, you will receive a prompt saying you have not answered the question - just select "continue without answering". But please answer all the other parts of the question!

How much did each of these inspire your interest in the STEM subject?

	This is the only reason I pursued this subject!	Very much so inspired my interest	Somewhat inspired my interest	There might have been a little inspiration	Not at all	This actually DISCOURAGED my interest
Family / friends	○	○	○	○	○	○
Books	○	○	○	○	○	○
TV / movies	○	○	○	○	○	○
Classes / teachers	○	○	○	○	○	○
Games	○	○	○	○	○	○
Museums	○	○	○	○	○	○
Personal experiences	○	○	○	○	○	○
The news / current events	○	○	○	○	○	○
Websites or online videos	○	○	○	○	○	○
Other (please list)	○	○	○	○	○	○

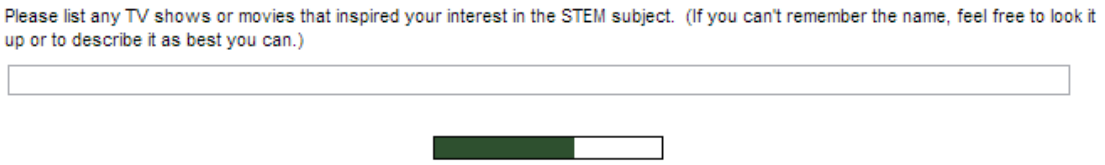
Page 6. Non-scientists were also asked to rate the factors that influenced their interest.

If you choose not to provide an "other" option for this question or following questions, you will receive a prompt saying you have not answered the question - just select "continue without answering". But please answer all the other parts of the question!

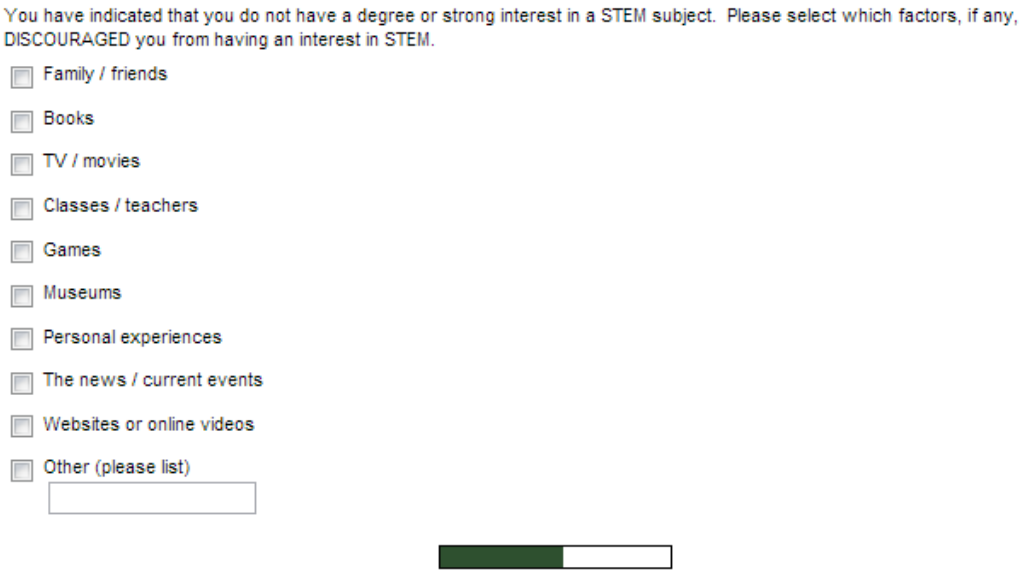
For that same interest, how much did each of these inspire your interest in the subject?

	This is the only reason I pursued this subject!	Very much so inspired my interest	Somewhat inspired my interest	There might have been a little inspiration	Not at all	This actually DISCOURAGED my interest
Family / friends	○	○	○	○	○	○
Books	○	○	○	○	○	○
TV / movies	○	○	○	○	○	○
Classes / teachers	○	○	○	○	○	○
Games	○	○	○	○	○	○
Museums	○	○	○	○	○	○
Personal experiences	○	○	○	○	○	○
The news / current events	○	○	○	○	○	○
Websites or online videos	○	○	○	○	○	○
Other (please list)	○	○	○	○	○	○

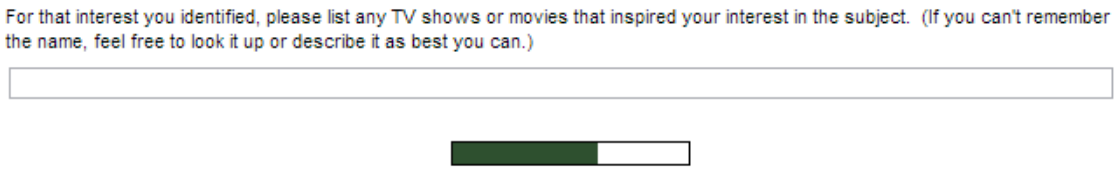
Page 7. Scientists who said there was at least a little inspiration from TV/movies were shown this page.



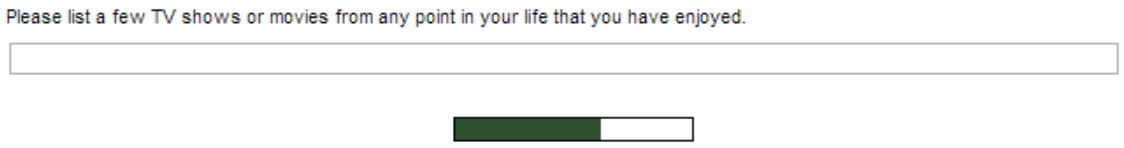
Page 6.5. After ranking their factors, non-scientists were shown this page.



Page 7. Non-scientists who said there was at least a little inspiration from TV/movies were then shown this page.



Page 7. All participants who ranked the inspiration of TV/movies as "Not at all" or "This actually DISCOURAGED my interest were shown this page.



Page 7.5. All of the participants who were not influenced by TV/movies were then shown this page.

Why have these TV shows or movies not inspired your interest in your subject?

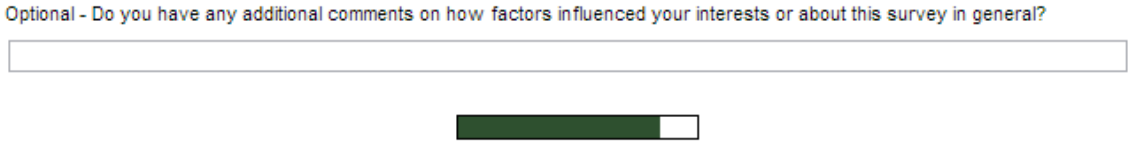
Page 8. Finally, all participants were asked to rate how frequently they watched the listed TV shows.

Which TV shows have you watched?

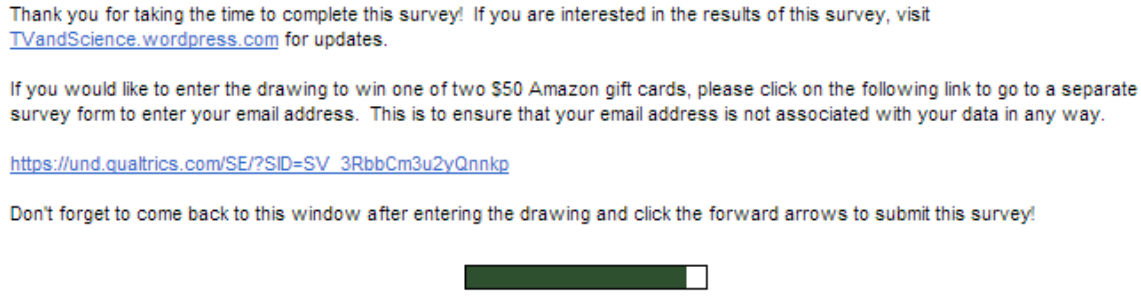
	Have not watched it or can't remember watching it	I remember seeing an episode or two	I have seen at least a few episodes	I have watched it somewhat regularly, and have seen several episodes	I have watched it regularly, and have seen most or all the episodes	I am or was fanatic about this show
Bill Nye the Science Guy						
The Magic School Bus						
Mr. Wizard (any series)						
DragonflyTV						
Beakman's World						
Other children's science shows						
CSI (any variant)						
Numb3rs						
Other forensics / crime-solving shows						
House						
Other medical shows						

	Have not watched it or can't remember watching it	I remember seeing an episode or two	I have seen at least a few episodes	I have watched it somewhat regularly, and have seen several episodes	I have watched it regularly, and have seen most or all the episodes	I am or was fanatic about this show
Cosmos						
How It's Made						
The Universe						
Nova (and/or NOVA scienceNOW)						
Horizon						
The World of Jacques Cousteau						
Other science documentaries						
Dr. Who						
The X-Files						
Star Trek (any version)						
Battlestar Galactica (or spin-offs)						
Firefly						
The Twilight Zone						
Other sci-fi shows						
Mythbusters						
The Big Bang Theory						

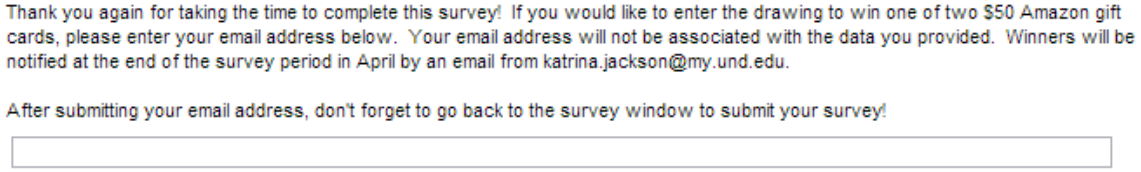
Page 9. All participants were asked if they had any additional comments.



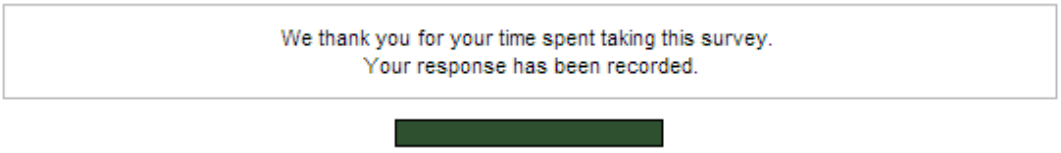
Page 10. All participants were thanked and given a link to enter the Amazon gift card drawing.



Page 10.5. The Amazon gift card link led here.



Page 11. Participants then submitted their surveys.



APPENDIX B

Movie and TV Titles Enjoyed That Did Not Influence Interests

Scientists	[Space]	Non-Scientists
• The Lord of the Rings (4) • Star Wars (4) • MASH (4) • The Big Bang Theory (3) • House (3) • Grey's Anatomy (3) • The Walking Dead (2) • Young Frankenstein (2) • (1) Dexter's Laboratory, Crocodile Hunter, NFL, Prince of Egypt, Toy Story, Indiana Jones, The Librarian, Mary Poppins, ESPN, Airplane, Pokémon, Bones, The Mentalist, 21, The Goonies, Sherlock Homes, 3:10 to Yuma, The Prestige, Animal House, Blues Brothers, Blazing Saddles, Being Human, Ferris Bueller's Day Off, Dirty Dancing, It's a Mad Mad World, Batman, Monty Python's Flying Circus, Modern Family, Community, Doctor Who, Invader Zim, The Simpsons, Beetlejuice, Futurama, Will and Grace, The IT Crowd, It's always Sunny in Philadelphia, South Park, Butter, The West Wing, Star Trek, Gifted Hands, Sound of Music, NOVA, Thirty-Somethings, Dallas, Prison Break, Law and Order, White Collar, Northern Exposure, Twin Peaks, Alien Nation, I Love Lucy, Perot, Trading Places, IQ, Amadeus, Rome, Little House on the Prairie, The Walton's, Jumper, Warehouse 9, Firefly	• (1) Sherlock Holmes, The Lord of the Rings, 3:10 to Yuma, The Prestige	• Star Trek (3) • Lost (2) • Arrested Development (2) • Glee (2) • Downton Abbey (2) • (1) Life of Pi, Mad Men, Blues Brothers, Cannonball Run, Girl with the Dragon Tattoo, ER, Law and Order, The Big Bang Theory, Married with Children, Family Guy, Fight Club, Seinfeld, Mullholand Drive, JAG, True Blood, Jane Austen, Masterpiece Theatre, District 9, The Office, Scrubs, New Girl, Grey's Anatomy, Grease, My Fair Lady, Sherlock Homes, Modern Family, Top Chef, Battlestar Gallactica, X-Files, Psych, 30 Rock, The Walking Dead, SNL, Colbert Report, Daily Show, Land Before Time, Family Matters, Bones, House, Fringe, Twilight Zone, Quincy M.D., Upstairs Downstairs, The Vicar of Dibely, Foyle's War, Libeled Lady, Ninotchka, Dinner at Eight, Night at the Opera, Zelig, Blast from the Past, The Cosby Show

APPENDIX C
Tables of Other Demographics

Rankings of Influencing Factors by Age

	18-22 # = 101	**23-29** # = 66	**30-39** # = 41	**40-49** # = 12	**50-59** # = 17	**60+** # = 14
Family/Friends	2.9	3.2	3.0	2.8	3.3	3.4
Books	3.0	2.8	2.8	2.9	3.2	2.5
TV/Movies	3.1	3.1	3.4	3.1	3.6	3.5
Classes/Teachers	2.5	2.5	2.5	2.9	2.7	2.8
Games	4.0	4.0	4.0	4.2	4.8	4.6
Museums	3.5	3.4	3.6	3.4	3.6	3.3
Personal Experiences	2.2	2.1	2.2	2.3	2.2	2.1
News/Current Events	3.3	3.1	3.4	3.2	3.0	2.8
Websites/Online Videos	3.5	3.4	4.0	4.0	4.3	4.7
Other	4.3	3.5	3.9	4.4	3.7	3.1

Rankings of Influencing Factors by Education

	No college # = 6	**Undergrad student or Associate's** # = 104	**Grad student or Bachelor's** # = 93	**Master's degree** # = 22	**Doctoral degree** # = 26
Family/Friends	3.0	2.9	3.1	3.5	3.3
Books	2.7	3.1	2.7	2.7	2.9
TV/Movies	2.8	3.2	3.0	3.6	3.7
Classes/Teachers	2.0	2.6	2.6	2.8	2.4
Games	3.5	4.0	4.1	4.0	4.5
Museums	3.2	3.6	3.4	3.6	3.4
Personal Experiences	2.5	2.3	2.2	2.0	2.3
News/Current Events	3.3	3.3	3.1	3.1	3.2
Websites/Online Videos	3.7	3.4	3.7	3.8	4.5
Other	3.0	4.3	3.6	3.3	4.1

Rankings of Influencing Factors by Socio-Economic Upbringing

	Working Class # = 37	Lower-Middle Class # = 39	Middle Class # = 127	Upper-Middle Class # = 47
Family/Friends	3.5	3.5	2.9	2.8
Books	2.9	3.0	3.0	2.8
TV/Movies	3.5	3.0	3.2	3.2
Classes/Teachers	2.8	2.7	2.5	2.4
Games	4.3	4.1	4.0	4.0
Museums	3.6	3.6	3.4	3.4
Personal Experiences	2.4	2.2	2.2	2.1
News/Current Events	3.5	2.9	3.2	3.0
Websites/Online Videos	3.9	3.5	3.6	4.0
Other	4.2	3.8	3.6	4.4

Rankings of Influencing Factors by Race/Ethnicity

	Only White # = 220	Minority/Mixed/Other # = 31
Family/Friends	3.1	2.9
Books	3.0	2.4
TV/Movies	3.3	2.7
Classes/Teachers	2.5	2.7
Games	4.1	4.0
Museums	3.5	3.2
Personal Experiences	2.2	2.0
News/Current Events	3.3	2.6
Websites/Online Videos	3.8	3.2
Other	3.8	4.3

Rankings of Influencing Factors by Location-Affiliation

	UND # = 191	Grand Forks and North Dakota # = 17	Midwest # = 21	USA # = 22
Family/Friends	3.1	2.8	2.9	3.2
Books	3.0	2.8	2.8	2.5
TV/Movies	3.3	3.1	3.0	3.0
Classes/Teachers	2.6	2.5	2.6	2.4
Games	4.1	3.9	4.1	4.1
Museums	3.5	3.8	3.6	3.2
Personal Experiences	2.2	2.4	2.0	2.3
News/Current Events	3.2	3.4	3.2	3.2
Websites/Online Videos	3.7	3.6	3.8	3.8
Other	3.9	3.0	4.4	3.8

Rankings of Influencing Factors by Status at UND

	Undergraduate student # = 91	Graduate student # = 65	Faculty # = 24	Staff or Administrator # = 11
Family/Friends	3.0	3.1	3.3	3.0
Books	3.2	2.7	3.0	3.4
TV/Movies	3.3	2.9	3.8	3.7
Classes/Teachers	2.6	2.6	2.3	2.9
Games	4.0	4.1	4.4	4.6
Museums	3.5	3.4	3.3	3.7
Personal Experiences	2.2	2.2	2.3	2.5
News/Current Events	3.2	3.0	3.3	3.4
Websites/Online Videos	3.5	3.5	4.6	4.3
Other	4.2	3.4	3.7	4.9

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