

SCIENCE FICTION VIDEO SUPPLEMENTING
EARTH SCIENCE INSTRUCTION

by

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ABSTRACT

The ability to ascertain fact from fiction is becoming increasingly important for the human population. Without a solid foundation of science, mistruths about our world and solar system could be observed in popular science fiction movies and blindly accepted as science facts. The purpose of this study was to observe the effect of supplementing scientific instruction of space with the help of popular science fiction movies. Four chapters were taught alternating non-treatment and treatment. The non-treatment units were given lecture with teacher directed notes, projects associated with content, and an end of chapter test. Treatment chapters were given the same instruction with the inclusion of science fiction media clips with a discussion during and following the clips. Students were given Likert surveys, misconception probes, chapter tests and formative assessment throughout the study. Qualitative and quantitative data was analyzed to see if any changes occurred due to the inclusion of the treatment. Results indicated students enjoyed the inclusion of science fiction media in the classroom, but it did not indicate better test scores.

INTRODUCTION AND BACKGROUND

I teach sixth grade at Lewis and Clark Elementary School in Lewistown, Montana. The school is a fifth- and sixth- grade level school where the curriculum is structured as an elementary school. For this reason, I teach two forty-five-minute sections of Earth science, along with reading, math, and art. In the 2018-2019 academic year 92 fifth grade students and 90 sixth grade students were enrolled in our school and I teach 43 of the sixth graders in science. Of these 43 students, there are 18 males and 25 females. Ethnically, the school is not very diverse with only 6.1% of the students classified as non-Caucasian. The principal also states that we are a Title I school with 44.1% of our students on the free and reduced lunch program (D. Wirtzberger, personal communication, Sep. 20, 2018).

The city of Lewistown is a rural city in central Montana. The population was estimated at 5,870 with information collected in 2010. Of this population 21.7% are over the age of 65, while 20% of the population is under the age of 18. This makes for a generally older population of people. The census data also shows that 17.8% of the population lives under the poverty line (U.S. Census Bureau, 2018). With the older population and high levels of poverty it is difficult to pass mill levies to help fund our rural school district. Therefore, budget cuts seem to affect teachers on a yearly basis.

Earth science can challenge the minds of my students. The ideas and concepts that we discuss are usually so large and abstract that it is difficult for students to comprehend the scale of it. For this reason, I usually try to make models that help my students visualize things that I cannot physically bring into the classroom. This is an excellent practice, but it has its limitations. Sometimes, the movements and ideas of Earth's

processes and of space are too abstract to even imagine, and sometimes it proves to be too expensive for me to provide materials on a weekly basis. Generally, when these ideas and concepts become too large or abstract a teacher can only try to make it come to life with words. These words can be delivered through stories or textbooks, but the magic is seemingly taken out of the subject, especially when resorting to textbooks.

One resource that has been used with some benefit in college as well as secondary classrooms is the use of Hollywood magic to supplement teaching of Earth science. The pocketbooks for Hollywood movies far exceed anything comprehensible by a school district. They are able to produce complex depictions of gravitational weightlessness, severe Earth disasters, and many more fundamental Earth science topics using special effects and other tools of theater. Students are absorbing all of these ideas with little, if any, scientific discussion of the depictions they see. Because of the popularity of movies and screens students may be more enthusiastic about watching clips from the movie, “The Martian,” instead of watching a dry educational video about space travel. It could also be argued that they will remember more of the Hollywood story than the educational videos.

If we foster a critical scientific eye for Hollywood magic, there is a good possibility that students will become more enthusiastic about learning scientific facts, and more adept at catching falsehoods portrayed in movies. This thought process along with many discussions with teaching peers and college professors led me to my classroom research question: How will using popular science fiction media with discussion affect my teaching as well as my student’s understanding of Earth science content knowledge in

my sixth-grade classroom? Besides this main focus question, sub-questions were created as follows:

1. Will student enthusiasm for learning science change?
2. Will students be able to remember scientific fact after a discussion and second viewing of the video clip?
3. Will content knowledge of topics change with inclusion of video clips?

CONCEPTUAL FRAMEWORK

Next Generation Science Standards (NGSS) call for a change in science education. The three dimensions laid out by NGSS focus on science and engineering practices, disciplinary core ideas, and crosscutting concepts. One aspect of the science and engineering practices is engaging in argument from evidence. A key component in argumentation is gathering facts and knowing when false statements are made. It can be argued that scientific literacy is necessary for responsible citizens to actively engage in an argument based on science. For that reason, educators must begin shaping students to have a well developed scientific literacy which will help them refine their ability to spot scientific inaccuracies in all aspects of life. If this practice is effectively done, students test scores could potentially increase dramatically as they grasp scientific concepts with more enthusiasm (NGSS, 2018).

One connection to scientific work that nearly all students have access to is film. As of 2017, 54% of U.S. households had a Netflix account. Even though students may not have a Netflix account, they probably have a friend that does. If Netflix is out of the question, access to public libraries provides another free DVD source. Another 2015 study done by Common Sense Media found that students, age eight to eighteen, spend an

average of 150 minutes per day watching television, digital video disks (DVDs), or videos. This was a stark difference compared to an average reading time of 28.5 minutes for the same age group. The increased availability and affordability of digital content has most likely increased the amount of time watching digital media since the time of the study (Common Sense Media, n.d.).

If students, and eventually adults, cannot determine fact from fiction in film, there is a large possibility that scientific misconceptions will be propagated to today's youth at incredible speed. This is alarming to think about in the scientific community. A pioneering study by Shapiro, Fernandez, & Barriga (2010) sought to see if adults could point out the fiction in science fiction movies. They demonstrate that men and women are indeed able to point out scientific inaccuracies, but men and women pointed out inaccuracies in different areas of the movie. The differences stem from where the science was being displayed and gave rise to the question of learning differences amongst the sexes (Shapiro, et al., 2010). Learning to spot inaccuracies is one step to scientific literacy. With a critical scientific eye, students, and in turn adults, will be able to see through the inaccuracies and false information that is disseminated by interest groups and companies today. This is not a groundbreaking idea but one that has evolved over time with the ever-developing science fiction media.

A progressive professor at Temple University was the first to pioneer the use of film in the classrooms to aid in science instruction. Before the study, he saw the popularity of film and decided to work with the new technology to increase motivation for the sciences as opposed to seeing it as a waste of time. In his study, a group of gifted ninth- and tenth- grade students screened popular science fiction films followed by a

discussion separating fact from fiction. The study's results showed that students were more motivated to learn the science behind the fiction. With the study, the author stressed the importance of watching the whole science fiction movie as opposed to short clips. His reasoning was based in the thought that the whole movie gave students more context and time to process the information seen (Dubeck, 1988).

Various resources for teachers are available to use science fiction movies in supplementing science teaching. For example, one study showing a video clip of a fictionalized tornado to a group of students can start discussion about important scientific facts (Cavanaugh, 2002). Additionally, an instructional text similar to Dubeck's study in how it was structured utilizes popular science fiction films followed by a discussion topic. The change with this text comes from the inclusion of experiments to further the knowledge of scientific concepts explored in film (Cavanaugh & Cavanaugh, 2004).

This idea of using film in the classroom was also examined and presented as an action research project for the Master of Science in Science Education program through Montana State University. The graduate student wanted to ascertain whether the inclusion of film clips increased student motivation, and helped with testing. Before watching the clip, he would give out a Likert questionnaire to get a baseline on student's attitudes towards science. He would then show a science fiction movie clip at the beginning of a unit and discuss the fact and fiction that was portrayed by the clip. After he gathered his data, both quantitative and qualitative, he found that there was an increase in motivation to learn, but it did not provide sufficient evidence for an effective increase in test scores (Tang, 2014).

A similar study done in 2015 sought to observe the changes that science fiction narratives played in an educational setting. The study was done in Greek speaking countries and they used the young adult science fiction book and adapted movie, *The City of Ember*, to aid their teaching of science. Before implementing the change, researchers were trained in how to use the book and movie in designing curriculum. They then administered many pre- and post- interviews providing reactions of students. The study stated that it only took qualitative observations. The results found the implementation of the unit greatly increased student excitement and involvement with participation in classroom activities. The only downfalls pointed out in this study were the lack of time for teacher design, and the lack of resources to aid in curriculum creation. Overall, the researchers found that science fiction should be used in the classroom to help aid in student excitement and participation, but more work needed to be done to help teachers in planning (Vrasidas, Avraamidou, Theodoridou, Themistokleous, & Panaou, 2015). Since that time, there have been several resources to aid in curriculum design. Some websites that have been helpful in finding media clips and developing curriculum have been; www.astrosociety.org/education, teachersinstitute.yale.edu/curriculum, biology.kenyon.edu/slone/bio3/bio03syl.htm, www.sfccenter.ku.edu/young-SF.htm, teachwithmovies.org/.

Though extraordinary results have not been cited by any of these references, there does seem to be an increase in motivation to learn and slightly better testing results. Skeptics may see the watching of films in the classroom to be a waste of time. If science was not being portrayed accurately then students could assimilate the misconceptions that are being presented by these science fiction movies. It seems though, with discussion and

instruction, students may benefit greatly from its adoption into the classroom. With the ease of access as well as the positive results, teaching science with the help of science fiction films deserves to be studied more thoroughly.

METHODOLOGY

This study implemented popular science fiction media to supplement instruction during a unit dealing with space in a sixth-grade classroom. The treatment included interspersed popular science fiction clips during an eight-week unit on space and space exploration. Two separate classes took part in this study, the first being a class of 21 students, and the second being a class of 22 students. Of those two classes there are 18 boys and 25 girls. Both classes received 45 minutes of Earth science instruction 5 days of the week. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

Before the treatment began, students were asked to complete a Likert survey entitled Attitude of Science (modified from Weinburgh & Steele, 2000; Appendix B). This was done to get a baseline on the students' feelings towards multiple topics in science including Perception of the Science Teacher, Anxiety toward Science, Value of Science in Society, Self-concept of Science, Desire to do science, and Feelings towards Science Fiction. For responses, students were given choices of Strongly Disagree 1, Disagree 2, Agree 3, and Strongly Agree 4. The Attitude of Science Likert survey was used to compare responses prior to and after concluding the treatment to ascertain if any change in attitude had occurred. This data was analyzed using Wilcoxon Sign Rank Test. Scores below 0.05 would indicate a significant change in student attitude.

Prior to treatment, students were also asked to complete a misconception probe created with popular science fiction movies in mind. The probe was titled What Would Really Happen? (Appendix C). Pre- and post- treatment responses were analyzed by comparing normalized gains. For a comparison of normalized gains pre- and post-treatment scores were compared, small gains are indicated by a score of anything below 0.3, medium gains are indicated by 0.3-0.6, and large gains are indicated by scores over 0.7 (Hake, 1998).

All students participated in two non-treatment sections and two treatment sections. This was done to compare performance over the course of the study. Formative assessments continued throughout the study. One formative assessment was a Weekly Favorite (Appendix D). This assessment was an expedient route asking students what their favorite part of science class was for the week. Weekly favorites were completed during the treatment weeks and were analyzed looking for frequency of response and common themes.

The course of the study for both groups alternated between non-treatment and treatment switching at roughly the same time. This rotation happened twice in the study. The purpose of this rotation was to gather equal amounts of data for both a treatment and non-treatment in the same unit. Both classes participated in a treatment or non-treatment at the same time, to assure the treatment has reached students only through primary means. The chronological order of sections in the study were as follows; (non-treatment) radiation, telescopes and early space travel, (treatment) the Solar System, (non-treatment) Sun, Earth, and Moon relationship, (treatment) the Universe.

For the non-treatment section of the study, students were taught vocabulary, given lecture with teacher-directed notes, participated in hands-on activities, and took an open-note test concluding the entire section. The first of these non-treatment sections was a section on radiation, telescopes, and early space missions. The test scores from Radiation, Telescopes and Early Space Missions Test (Appendix E) were analyzed for changes throughout the study. The second and final section of non-treatment dealt with the Sun, Earth and Moon relationship and again concluded with an open-note test (Appendix F). These test scores were analyzed by comparing averages, median scores, and range of scores compared to the treatment sections. Likewise, the first non-treatment and treatment test scores were analyzed using a two sample t-test, this was also done with the second non-treatment and treatment test scores. A p-value less than .05 was used to determine significance (Snedecor & Cochran, 1989). This was done to see if there were any significant changes in the means of the scores from non-treatment to treatment.

For the treatment sections of the study, students received the same instruction, but they also received short clips of science fiction media. Clips were then discussed by students in small groups and as a whole group activity.

The first treatment group occurred during the section on the Solar System. Regular instruction took place until November 28, 2018 when a group of clips were shown to the class. For the first video of the treatment I chose to use *Ice Age: Collision Course*. This animated movie has bits of science fiction mixed for comedic relief. I thought it would be a good start to show students that science fiction can be intermixed with other genres. I chose out five sections (Thurmeier, Tan Chu, Berg, & Wilson, 2016, 0:00:44-0:05:16, 0:12:17-0:14:26, 0:19:00-0:20:15, 0:27:00-0:28:05, 0:32:50-0:34:50) of

the movie that dealt with one of the characters travelling through space. The five sections lasted around 15 minutes in total. The scientific theories that are shown, and usually exaggerated, were the formation of the solar system and constellations, the idea of g-force, how water acts in space, the idea of artificial gravity, meteor collisions, magnetism, and teleportation. Students were asked to write down anything they found to be science related during the clips. After the viewing was completed students were asked to pair up and briefly talk about what they wrote down and why. Next these groups of two were asked to come up with something that was not scientifically accurate about the clip. These pairs then shared with the whole class what they wrote down. Then as a large group there was discussion why some ideas that were shown were inaccurate and were asked to use reasoning from information we read in class. At the conclusion of the discussion students were asked to write a Minute Paper (Appendix G) about what they remembered to be inaccurate from the clip and why. This was done to quickly gather common ideas that the class remembered as a whole. Minute papers were analyzed for common themes and revisited topics. Weekly favorites continued throughout this time. At the conclusion of the section an open-note section test was administered (Appendix H). Again, these scores are averaged and compared to the other section tests.

For the second round during the first treatment, I chose to use clips from three different science fiction movies. The movies chosen were *Star Wars: A New Hope* (Lucas, 1977, 1:03:00-1:04:00, 1:46:35-1:57:30), *Star Trek* (Abrams, Orci, & Kurtzman, 2009, 0:01:00-0:03:30) and *Passengers* (Tyldum & Spaihts, 2016, 0:00:01-0:06:30, 0:11:00-0:13:00, 1:18:10-1:20:10, 1:27:00-1:29:00). All three of these movie clips deal with space travel. Scientific topics covered were similar to the ones above with the

addition of cryosleep/long-term hibernation, flying dynamics, and black holes. Again, the sections lasted for approximately 15 minutes while the discussion about the science behind the film lasted around 30 minutes. Procedure for Minute papers and weekly favorites continued as before.

The second treatment occurred during the section on the Universe. The same format was followed as the first treatment group. For the second treatment, and third viewing, I chose to show another few clips from J.J. Abram's *Star Trek* (Abrams, Orci, & Kurtzman, 2009, 1:03:55-1:04:50, 1:16:17-1:19:39, 1:49:05-1:53:16), as well as a clip from *Guardians of the Galaxy Vol. 2*. (Gunn & Abnett, 2017, 0:15:24-0:17:00, 0:18:10-0:21:50) The first clips deal with a fictional substance called, "red matter." This matter has the ability to create black holes. A planet and ship are devoured by the emerging black hole. This brings on interesting talking points of what a black hole was, and if anything can escape. The second clip was an ever-popular space chase, where the protagonists must escape a golden, egotistical race of vengeful humanoids. During the chase, space sounds, explosions, and a quantum asteroid field bring many talking points of what can, and what cannot happen in space. Both clips lasted around six minutes a piece, the discussion that followed lasted around 15 minutes. Again, this left the lesson to approximately thirty minutes. Procedure for Minute papers and weekly favorites continued as before. At the conclusion of the section students were given another open-note test on the Universe (Appendix I). This test was analyzed and compared to other section tests.

On the 17th of January, for the final viewing during the second treatment, I chose to show clips from *Spiderman 2* (Raimi, Lee, & Ditko, 2004, 0:18:53-0:21:08, 0:33:07-

0:39:03), where the villain, Doc Ock explains his idea for thermonuclear fusion to provide energy for the entire world. This movie discussion goes well with our discussion of stars, and how stars produce energy. It also allows me to bring up the current ideas on thermonuclear energy and where science was in its evolution. I also chose three small clips from *Armageddon* (Bay, Hensleigh, & Abrams, 1998, 0:00:00-0:05:00, 0:25:45-0:26:10, 1:10:50-1:12:45) where they explain the size of the asteroid thought to have caused the extinction of dinosaurs. There was also a scene where space shuttles are shown banking turns through air in space. These clips go along with our discussion of the vacuum of space, and the size of asteroids in our solar system. The clips lasted approximately 12 minutes and the discussion took around 25 minutes. Procedure for Minute papers and weekly favorites continued as before.

Student interviews took place after completion of the entire unit. Four individuals, two from each class were randomly selected and separately asked questions from the Interview Questions (Appendix J). These interviews were given to provide insight into student thoughts towards the treatment and effectiveness of science fiction to help aid in teaching an understanding of scientific concepts in the classroom. Responses were transcribed using voice recognition software provided by Google Docs and analyzed for common themes.

At the completion of the sections students were again asked to complete the same Modified ASTI, (Appendix B), to see if attitudes towards anything related to science had changed. Scores were compared to pre- treatment attitudes and examined through Wilcoxon Sign Rank Test. They were also asked to complete the misconception probe, What Would Really Happen? (Appendix C), that was administered at the beginning of

the study. Individual questions from this probe were compared by calculating normalized gains.

Data collection tools that were used to assess primary and secondary questions are outlined in Table 1.

Table 1

Science Fiction in the classroom Triangulation Matrix

Research Question	Data Source 1	Data Source 2	Data Source 3
How will using popular science fiction media with discussion affect my teaching as well as my student's understanding of Earth science content knowledge in my sixth-grade classroom?	Teacher Journaling	Student weekly favorites	Minute papers following discussion
Will student enthusiasm for learning science change?	Pre-Treatment Likert survey on attitudes towards science.	Interviews and formative assessment.	Post-Treatment Likert survey on attitudes towards science.
Will students be able to remember scientific fact after a discussion and second viewing of a similar video clip?	Pre-Treatment Science Misconception Probe	Minute papers after discussion	Post-Treatment Science Misconception Probe
Will content knowledge of topics change with inclusion of video clips?	Pre-Treatment Average scores	Unit Tests	Post-Treatment Unit Average Scores

DATA AND ANALYSIS

The results of the Pre-treatment What Would Really Happen Misconception Probe (WWRH) shows all students having an average score of 54%, a median score of 52.6%, and a total range of scores being 37% ($N=42$). The results post treatment showed

an average score on the same test of a 71%, a median score of 74%, and a range of 47% ($N=40$). This increase in mean and median scores after the treatment indicates that students corrected several preheld misconceptions found in many science fiction movies. The average normalized gain by the entire treatment group was 0.37, which is a medium normalized gain for the misconception probe.

The most significant gains from the WWRH Misconception Probe were found analyzing the data comparing normalized gains. Question number four, “We have created artificial gravity on our space shuttles” reveals a normalized gain of 0.86. Question number five, “Explosions like on movies can happen in space” shows a normalized gain of 0.71. Question number 10, “The closest planet to the sun was the hottest planet” produces a normalized gain of 0.57. Question number 17, “Black holes work like a vacuum” receives a normalized gain of 0.57. These are all questions that received medium or large gains from pre- to post- treatment (Table 2).

Table 2

What Would Really Happen Misconception Probe

Questions	Pre-Treatment	Post-Treatment	Normalized Gain
We have created artificial gravity on our space shuttles.	29%	90%	0.86
Explosions like on movies can happen in space.	40%	82.5%	0.71
The closest planet to the sun was the hottest planet.	31%	70%	0.57
Black holes work like a vacuum.	2%	57.5%	0.57

Note. Normalized gains low < .3, medium .3-.6, large > .7 (Hake, 1998). ($N=42$)

Other questions with high percentage correct answers from the WWRH misconception CAT are shown below with pre- and post- treatment scores from the entire treatment group (Table 3). These questions were ones visited in the science fiction video clips most often. They were also topics that corresponded directly to the student's Minute Summary CATs. For example, one student wrote, "a person gets sucked outside the ship, sound goes silent like in space" in regards to the question "What do you notice that was scientifically accurate?" during the treatment watching *Star Wars*, *Star Trek*, and *Passengers*. Another example of this from a different student was exemplified by their answer, "There was no fire in space. No explosions can happen on the outside of a spaceship without air." This was in response to the question, "What do you notice that was incorrect scientifically?" in regards to the same treatment on the Minute Paper CAT. Normalized gains for these questions remained low due to high numbers correct in the pretreatment assessment.

Table 3
Other Notable Changes, What Would Really Happen Misconception Probe

Questions	Pre Treatment	Post Treatment
Fire was a possibility in space.	69%	95%
Scientists have discovered alien life.	93%	93%
Humans grow while they are in space, regardless of their age.	45%	72%
Black holes come from stars.	64%	93%
A person can hear sounds in space without their spacesuit.	73%	98%

Formative assessment showed more significant changes as opposed to chapter content assessments which produce an average normalized gain of -0.53 from non-treatment sections to treatment sections in the first treatment group ($N=20$). The second treatment group produced a normalized gain of -0.06 from non-treatment to treatment content assessments ($N=21$). Combined, the classes performed with a normalized gain of -0.21. Results from the first two sample t-test gave a p-value of .19234 which supports a null hypothesis ($N=41$), but the second sample t-test gave a p-value of .001332 which is a significant value rejecting the null hypothesis ($N=41$). What this means, is there was a significant change from the third non-treatment test to the fourth treatment test, but there is not significant evidence that the treatment was the cause of this change. Figures 1 and 2 show average scores for both classes as well as upper quartiles, lower quartiles, lowest score and highest score. The combined average scores for the entire group were 83.4 % on the first, 86.7% on the second, 90.2% on the third, and 81.4% on the fourth ($N=41$).

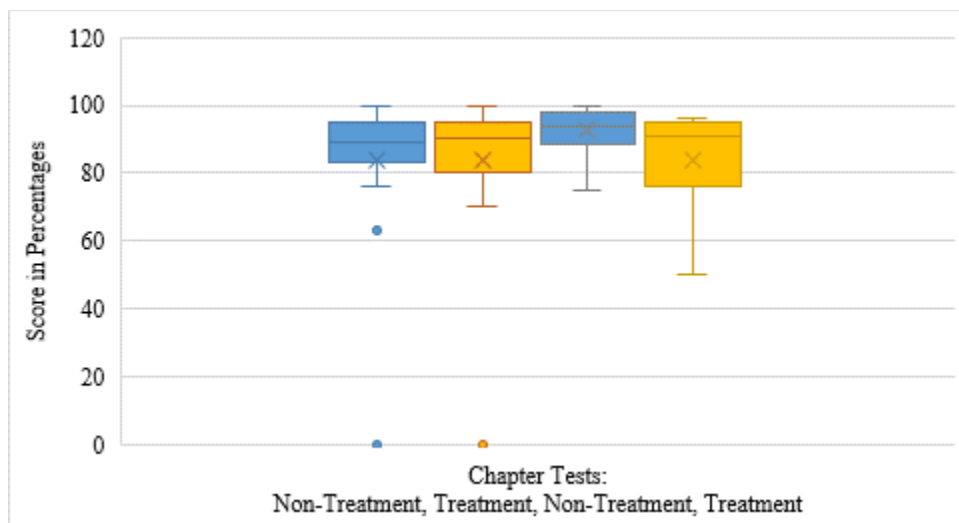


Figure 1. Group 1 content assessments Ch. 22 (Radiation, Telescopes, Early Space Missions), Ch. 23 (Sun, Earth, Moon Relationship), 24 Ch. (Solar System), 25 Ch. (Stars and Galaxies), ($N=20$).

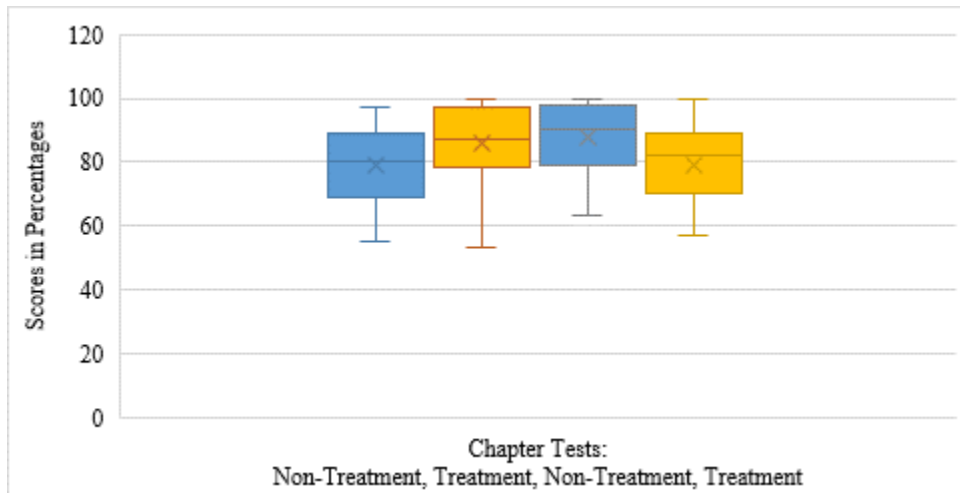


Figure 2. Group 2 content assessments Ch. 22 (Radiation, Telescopes, Early Space Missions), Ch. 23 (Sun, Earth, Moon Relationship), Ch. 24 (Solar System), Ch. 25 (Stars and Galaxies), ($N=21$).

Weekly Favorites (WF) from treatment weeks showed a favorite of science fiction response percentages ranging from 75.6% to 46.3% from a combination of both classes. The highest percentage of science fiction being 75.6% ($N=41$) going along with the first treatment of *Ice Age: Collision Course*. The lowest being 46.3% ($N=35$) with the final treatment of *Spiderman 2*. In my journal from the last treatment this slight decrease in excitement was noted, “Students seem a little tired today, or less excited than they usually are for sci-fi Friday.”

Qualitative data from the Attitude of Science Likert Survey (AOS) was analyzed using Wilcoxon Signed-Rank Test. Three questions presented a significant change from pre-treatment to post treatment assessments. The most significant change was shown in Figure 3, the question being “I enjoy science fiction movies and books.” The result from the Wilcoxon test showed a p-value of .008 indicating a significant change to student interest. One student stated in the interview of why they enjoyed science fiction clips, “because everybody seemed to enjoy learning and watching and figuring out what was

right in space and what was wrong.” Another student stated, “I thought it was fun to watch videos in class. It felt like it was movie day” in regards to the same question.

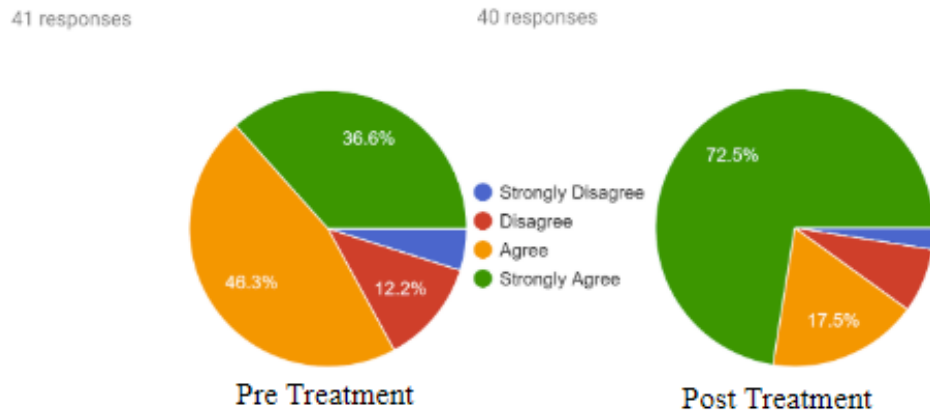


Figure 3. “I enjoy science fiction movies and books,” Likert question, (N=41).

The question, “Sometimes I read ahead in our science book” shows a p-value of .0151 which was also a significant change to attitude towards science (Figure 4). Similarly, the question, “I think science fiction helps me learn science facts” presents a p-value of .02574 (Figure 5). Pie graphs showing pre- and post- treatment class percentages for these questions are shown below. There are varied numbers of responses due to the fact that the survey didn’t have required questions. Some students chose not to answer all of the questions.

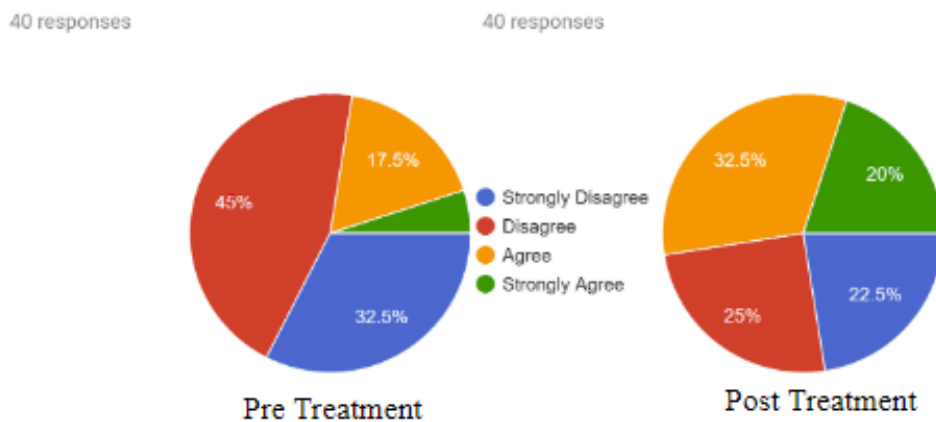


Figure 4. “Sometimes I read ahead in our science book,” Likert question, (N=40).

42 responses

40 responses

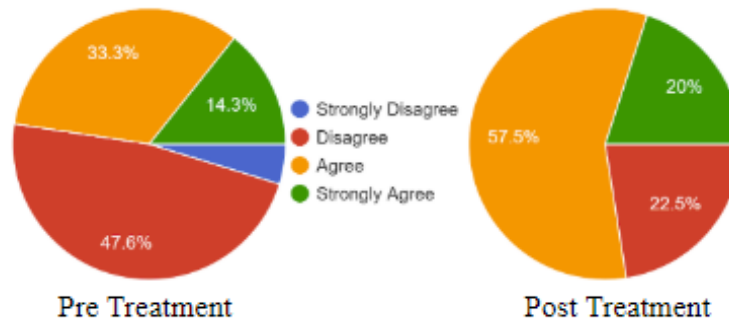


Figure 5. “I think science fiction helps me learn science facts,” Likert question, (N=42).

Two other questions showed values that were very near significant. The question “I have a good feeling towards science,” produces the closest to a significant change with a score of .06288 (Figure 6). The question, “I often think, ‘I cannot do this,’ when a science assignment seems hard,” was less close to significant with a score of .08544 (Figure 7). Both of these questions were related to students’ comfort in the science classroom, as well as self-efficacy in the science classroom.

42 responses

39 responses

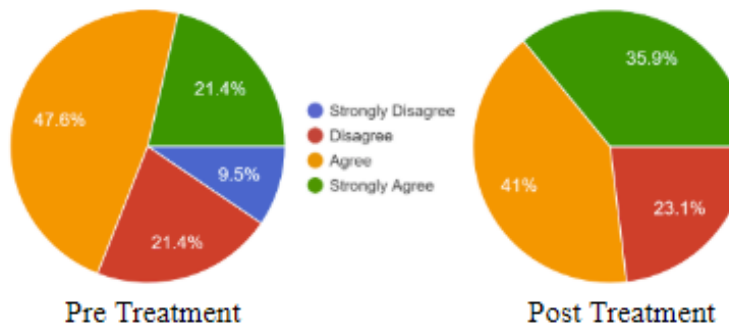


Figure 6. “I have a good feeling toward science,” Likert question, (N=42).

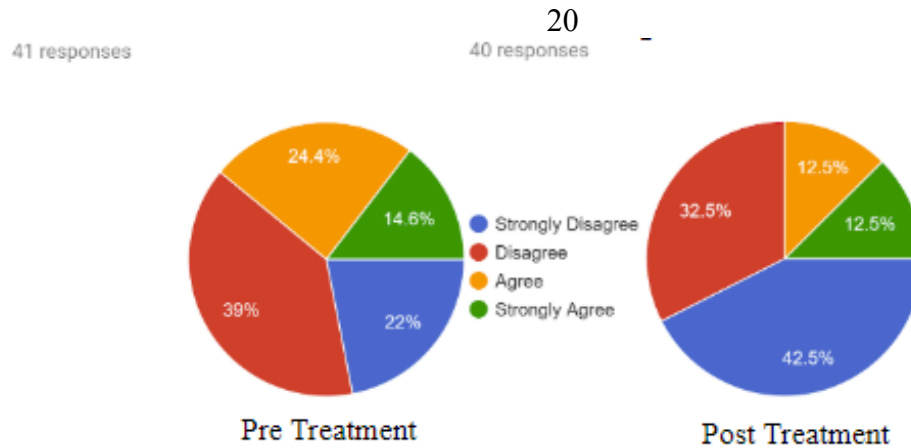


Figure 7. I often think, “I cannot do this,” when a science assignment seems hard. Likert question, (N=41).

INTERPRETATION AND CONCLUSION

This study supports the idea of the inclusion of popular science fiction media supplementing the study of Earth sciences. The Likert data showed significant change in the positive direction to not only questions directly related to science fiction, but also analogous to students’ attitudes towards science class. Students reading ahead in their science textbooks shows interest and anticipation for what students get to learn. It could be argued that teaching is much easier if students are excited and enjoying what they are learning. Changes in these five questions could result from many things in the science classroom, but the timing would suggest that the science fiction clips played a part in the change. I was most surprised to see the change in the questions related to self-efficacy and comfort in the classroom. Maybe these outcomes result from students taking part in discussions related to movies that they personally enjoy as opposed to being completely lost in a strictly science related discussion.

Students showed slightly negative results associated with their chapter tests during the treatment sections. Combined the classes showed a normalized gain of -0.21

from treatment to non-treatment sections. This puzzled me for quite a while, but I think this could be explained by the amount of time allotted to science in the classroom. Forty-five minutes might seem like a lot of time, but with all the interruptions of assemblies, emergency drills, shortened weeks, and student absences this time was drastically reduced in the week. With the inclusion of media clips along with discussion students were missing out of more instruction time. This meant less time in the book, and more time in discussion. I would think that this could be remedied with a more in-depth look at science. If teachers were allowed to cover more in-depth instruction and less curriculum, I think students would show positive normalized gain from the treatment.

Even with the negative normalized gain for chapter test scores, it is important to note the change from the second non-treatment to the second treatment test scores. This round of the testing shows significant change from a two sample t-test. It does not give enough evidence to directly tie the treatment to the better test scores, but the inclusion of science fiction could be part of the reason. Excitement during the learning process is invaluable for a teacher, if science fiction clips increase the excitement of the student population it should be explored in the classroom.

Results of medium to large normalized gains for many questions from the What Would Really Happen Misconception Probe were not very surprising. When I created this misconception probe I did so with popular science fiction movies in mind. I think that students were much more prepared for the probe following the treatment because things shown in clips and discussed were largely repeated throughout the clips. Also, they were the exact same questions. I do not think this was a wasted exercise though, it does

show that students have gained an understanding for the fiction in science fiction. Giving them a more critical eye for scientific inaccuracies was one of the goals of this study.

Student excitement for sci-fi Friday, as it was named, could be felt in the classroom every day we got to watch a media clip. They were engaged with their minute papers, and critically examining fictional movies. I wrote repeatedly in my journal how well behaved and excited they seemed when we got to discuss the media clips. Students who normally shut down during science class were regularly raising their hands and adding their interpretations. Students were always excited to hear a summarized plot of the movie and wanted to watch the rest of the movie when they got the chance.

VALUE

This study, using science fiction movie clips to help aid students understanding in the Earth science classroom, impacted my teaching in a multitude of ways. The purpose of the study was to help students relate things that they were learning in science to a fictionalized context in order to develop their critical evaluation of reality. Argumentation is something that is difficult to teach, and rarely visited in a sixth-grade classroom. With the inclusion of discussion about facts, as well as things that may be exaggerated, students are hopefully beginning to realize the importance of having a critical eye. All the while, they enjoy the exercises with the help of science fiction.

I learned through this study how incredibly useful CATs were in the teaching process. These are an extremely quick and useful tool to get a baseline understanding of what the class, as a whole, processed through discussion. It helps my teaching by giving me clues as to what I need to review, and what I should take more time in discussion during the next class. Minute papers following movie clips are very interesting to go

through, some students wrote ridiculously detailed descriptions of the movie as well as our discussion in a very short amount of time. Other students wrote down things completely unrelated to the previous discussion, not factual nor coherent. This was an excellent insight to the differences in learning in the classroom. It reminds me that not all students are the same, and I might have to try multiple avenues to get students all on the same page. Meaning, I might have to perform movie screenings, scientific observational drawings, comic book discussions, and other options to help all students achieve success and understanding in the classroom.

I was reminded through this study that students are always excited to think they are getting out of class. It seems comical how students think that getting out of the book and into a discussion leads them to skipping class work. We all know the student that comes up with a question that leads a teacher down a rabbit hole of a story that seems totally unrelated to class. Honestly, I think this leads to students building their comprehension skills, as well as building reasoning skills. If done correctly, it helps students build argumentation by streaming together seemingly unrelated points that help paint a wider picture. For example, this study was a slight change to the original schedule with a short 30-minute discussion about popular movies during the week. This change had students looking forward to a discussion about scientific fact and argumentation about reality. I believe this was a positive change in the classroom.

Though these exercises demonstrated positive change with my students, the time it took to develop the curriculum was quite exhausting. My journal was filled with frustrations about how long it took to find specific movie clips that were sixth grade appropriate, while still being relevant to things we have covered in science. I would sit

and watch movies in fast forward until space flight and space travel would appear on screen then critically examine them for inappropriate language, or other mature content while taking notes on things that I saw as incorrect. My journal from the second treatment stated, "I was also amazed at how many times I had to watch the video to get the exact times to watch." I would then delve into the internet and research through blogs, scientific papers, and random articles what would really happen in space. The search and research turned out being hours of my personal week for a 30-minute class showing and discussion. I think this would be easier with older students because they would be able to watch the entire movie, and then revisit specific parts that they saw as incorrect. Though it was frustrating I am glad to have a stockpile of movie clips that I will be able to show and discuss with students in future classes.

Through this study I have learned the importance of relating scientific fact to things that are happening in students' lives. Without that connection, science classes seem unrelated to life. Changing up the schedule and talking about what was factual and what was not in science fiction helped students realize that science was learning about the possibilities of life. I will continue on my path of changing up and challenging the traditional classroom in hopes of reaching all students. Getting students excited about what they are learning shall always remain one of my goals in teaching.

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APPENDICES

APPENDIX A
IRB APPROVAL



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MEMORANDUM

TO: Dylan Buehler and John Graves

FROM: Mark Quinn *Mark Quinn Ch*
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: November 1, 2018

RE: "The Use of Science Fiction Media to Supplement Science Education" [DB110118-EX]

The above research, described in your submission of November 1, 2018, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- ☒ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- ☒ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- ☐ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- ☐ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- ☐ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- ☐ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

ATTITUDE OF SCIENCE LIKERT SURVEY

Modified ATSI

Science Survey

This survey was asking many questions on the different topics in science. Answer as truthfully as possible with the four provided answers (Strongly Disagree, Disagree, Agree, and Strongly Agree). If you feel uncomfortable at any time with questions you do not have to answer.

Participation in this research was voluntary and participation or non-participation will not affect a student's grades or class standing in any way

1. Please type your class number on the line below.

2. Science was useful in helping to solve problems of everyday life.

Mark only one oval.

Strongly disagree

Disagree

Agree

Strongly agree

3. Science was something that I enjoy very much.

Mark only one oval.

Strongly disagree

Disagree

Agree

Strongly agree

4. I would like to do some extra or un-assigned reading in science.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

5. Science was easy for me.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

6. When I hear the word science, I have a feeling of dislike.

Mark only one oval.

Strongly disagree

Disagree

Agree

Strongly agree

7. Most people should study some science.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

8. Sometimes I read ahead in our science book.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

9. Science was helpful in understanding today's world.

Mark only one oval.

Strongly disagree

Disagree

Agree

Strongly agree

10. I usually understand what we are talking about in science.

Mark only one oval.

Strongly disagree

Disagree

Agree

Strongly agree

11. Science teachers make science interesting.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

12. No matter how hard I try, I can not understand science.

Mark only one oval.

Strongly disagree

Disagree

Agree

Strongly agree

13. I feel tense when someone talks to me about science.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

14. Science teachers present material in a clear way.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

15. I often think, "I cannot do this," when a science assignment seems hard.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

16. Science was of great importance to a country's development.

Mark only one oval.

Strongly disagree

Disagree

Agree

Strongly agree

17. It was important to know science in order to get a good job.

Mark only one oval.

Strongly disagree

Disagree

Agree

Strongly agree

18. I like the challenge of science assignments.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

19. It makes me nervous to even think about doing science.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

20. Science teachers are willing to give us individual help.

Mark only one oval.

Strongly disagree

Disagree

Agree

Strongly agree

21. It was important to me to understand the work I do in science class.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

22. I have a good feeling toward science.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

23. Science was one of my favorite subjects.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

24. I have a real desire to learn science.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

25. I do not do very well in science.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

26. I enjoy science fiction movies, and books

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

27. I think things in science fiction movies and books are always science fact.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

28. I think science fiction helps me learn science facts.

Mark only one oval.

Strongly Disagree

Disagree

Agree

Strongly Agree

APPENDIX C

WHAT WOULD REALLY HAPPEN? MISCONCEPTION PROBE

Misconception Probe

Pre-Test Space Exploration

This was a pre-test to see what you know about space exploration before we start our unit.

Please note that Participation in this research was voluntary and participation or non-participation will not affect a student's grades or class standing in any way. Thank you!

1. Please put your first name on the line below.

2. Scientists think that there may be _____ Solar Systems in our galaxy.

Mark only one oval.

Five

One

Billions

Millions

3. There are many galaxies.

Mark only one oval.

True

False

4. We are currently capable of traveling to another galaxy.

Mark only one oval.

True

False

5. We have created artificial gravity on our space shuttles.

Mark only one oval.

True

False

6. Explosions like on movies can happen in space.

Mark only one oval.

True

False

7. Fire was a possibility in space.

Mark only one oval.

True

False

8. Scientists have discovered alien life.

Mark only one oval.

True

False

9. There was lots of water/ice/water vapor in space.

Mark only one oval.

True

False

10. When a person finds themselves without a spacesuit in space, they will _____.

Mark only one oval.

Freeze

Explode

Suffocate

Overheat

Other:

11. The closest planet to the sun was the hottest planet.

Mark only one oval.

True

False

12. Humans can live in the international space station or travel in space for multiple years.

Mark only one oval.

True

False

13. Humans grow while they are in space, regardless of their age.

Mark only one oval.

True

False

14. Nasa stands for National _____ and Space Administration.

Mark only one oval.

Astronomy

Aeronautics

Acrobatic

Aerospace

15. We can teleport people like they do in movies.

Mark only one oval.

Yes

No

Maybe

16. Humans can travel faster than the speed of light.

Mark only one oval.

True

False

17. Tractor beams (beams of light that can catch control objects) are a real thing.

Mark only one oval.

True

False

18. Black holes work like a vacuum

Mark only one oval.

Yes

No

Maybe

19. Black holes come from stars.

Mark only one oval.

True

False

20. A person can hear sounds in space without their spacesuit.

Mark only one oval.

True

False

APPENDIX D

WEEKLY FAVORITE FORMATIVE ASSESSMENT

Weekly Favorites

Name _____ Class Number _____

1. What was your favorite activity we did in science this week?

2. Why was this your favorite activity?

APPENDIX E

TOPIC TEST: RADIATION, TELESCOPES, EARLY SPACE MISSIONS

Name: _____ Class: _____ Date: _____

ID: A

Space Exploration**Completion***Complete each statement.*

Use the following words to fill in the blanks below.

electromagnetic spectrum	orbit	rockets	Project Gemini
reflecting telescopes	space shuttle	refracting telescopes	Project Apollo
observatories	space station	satellite	Cassini
space probes	radio telescopes	Project Mercury	

- Most optical telescopes used by professional astronomers are housed in _____.
- The path of a satellite around Earth is called its _____.
- _____ was the final stage of the space program to reach the Moon.
- Any object that orbits another object is a _____.
- The space probe _____ was launched in October 1997 to study Saturn.
- The _____ is the arrangement of electromagnetic waves according to wavelengths.
- As part of _____, John Glenn became the first American to orbit Earth.
- A cosmonaut spent 438 days living and working in the _____ Mir.
- Optical telescopes that use concave mirrors to focus light from objects are _____.
- The Voyagers are _____ that are travelling beyond our solar system.
- Scientists use _____ to study radio waves traveling through space.
- A goal of _____ was to have two spacecraft hook up together while in orbit.
- The _____ is a reusable spacecraft that glides back to Earth after it leaves orbit.
- Reflecting telescopes and _____ are two types of optical telescopes.
- _____ are motors that don't require air to burn fuel.

Testing Concepts*Choose the correct term in parenthesis to complete the sentences.*

- In a _____ (reflecting, refracting) telescope, light passes through convex lenses.
- The Hubble Space Telescope is an example of a _____ (reflecting, refracting) telescope.
- The Voyagers are _____ (satellites, space probes) that have traveled beyond our solar system.

Name: _____

ID: A

19. On a _____ (space shuttle, space station), astronauts can live and work in space for long periods of time.
20. _____ (Optical, Radio) telescopes allow us to study long wavelength electromagnetic waves radiated by the stars.
21. A(n) _____ (artificial, natural) satellite is one that is built and launched by humans.
22. As part of _____ (Project Gemini, Project Apollo), Neil Armstrong and Edwin Aldrin became the first humans to walk on the moon.
23. In the future, the _____ (space shuttle, space station) could be a construction site for ships traveling to the Moon and Mars.
24. Bonus: Only X rays and gamma rays are shorter than _____ waves.
25. Bonus: The electromagnetic radiation with the longest wavelength is _____.
26. Bonus: The electromagnetic radiation with the shortest wavelengths is _____.
27. Bonus: The wavelengths of visible light are _____ than those of X rays.

Short Answer

28. Use these words and phrases to identify the numbered parts of the illustration:

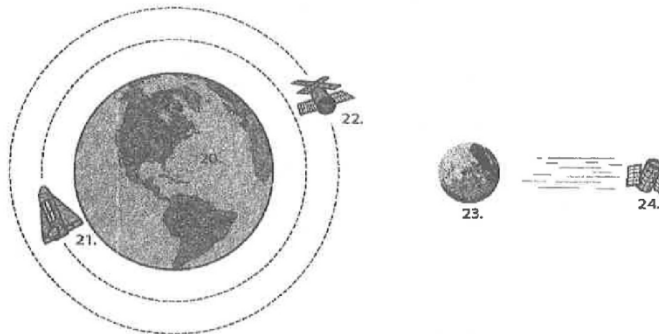
space station

space shuttle

space probe

Earth

Moon



20. _____
 21. _____

22. _____
 23. _____
 24. _____

29. Describe the difference between solid propellant rockets and liquid propellant rockets.

solid- _____

liquid- _____

APPENDIX F

TOPIC TEST: SUN, EARTH MOON RELATIONSHIP

Name: _____ Class: _____ Date: _____

ID: A

Sun, Earth, Moon**Modified True/False***Indicate whether the statement is true or false. If false, change the identified word or phrase to make the statement true.*

- _____ 1. A total *solar* eclipse can be seen by all the people on that side of the Earth at once.

- _____ 2. Night and day on Earth are caused by Earth's *revolution around the Sun*. _____
- _____ 3. Daylight hours are *shorter* for the hemisphere tilted toward the Sun. _____
- _____ 4. People are *more* likely in their lifetime to see a total lunar eclipse than they are to see a total solar eclipse.

- _____ 5. According to the *Impact Theory*, the Moon formed from gas and debris thrown off Earth after a collision.

Multiple Choice*Identify the choice that best completes the statement or answers the question.*

- _____ 6. Earth rotates on its axis about every _____.
A. year C. week
B. month D. day
- _____ 7. In the northern hemisphere, the _____ occurs on June 21 or 22.
A. spring equinox C. summer solstice
B. fall equinox D. summer equinox
- _____ 8. _____ are dark-colored, relatively flat regions of the Moon's surface formed when interior lava filled large basins.
A. Craters C. Volcanoes
B. Maria D. Eclipses
- _____ 9. A _____ occurs when the Moon moves directly between the Sun and Earth and casts a shadow on Earth.
A. lunar eclipse C. waxing gibbous
B. waning gibbous D. solar eclipse

Name: _____

ID: A

Matching*Match the terms below with their definitions.*

- A. when the amount of the Moon's lighted surface seen on Earth increases
- B. waning Moon phase in which only one-half of the lighted side of the Moon can be seen from Earth
- C. the changing appearances of the Moon as seen from Earth
- D. when the amount of the Moon's lighted side that can be seen becomes smaller
- E. waxing Moon phase in which one-half of the Moon's lighted side can be seen from Earth
- F. when all of the Moon's surface that faces Earth is lit up
- G. when Earth's shadow falls on the Moon
- H. when none of the Moon's lighted side can be seen from earth

- _____ 10. full moon
- _____ 11. lunar eclipse
- _____ 12. waning
- _____ 13. new moon
- _____ 14. third quarter
- _____ 15. first quarter
- _____ 16. waxing
- _____ 17. Moon phases

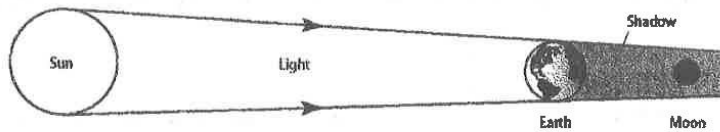
Short Answer*Identify the type of eclipse shown in Figures 1 and 2 Then use the illustrations to answer the following questions.*

Figure 1

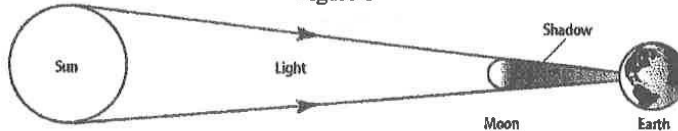


Figure 2

- 18. Figure 1 _____
- 19. Figure 2 _____
- 20. What causes a lunar eclipse?

- 21. What causes a solar eclipse?

APPENDIX G

MINUTE PAPER FORMATIVE ASSESSMENT

Minute paper

Name _____ Class Number _____

1. Movie Title _____
2. What do you notice that was incorrect scientifically?
3. What do you notice that was scientifically accurate?
4. Please write everything you remember from the discussion today.

APPENDIX H

TOPIC TEST: SOLAR SYSTEM

Name: _____ Class: _____ Date: _____

ID: A

Solar System**Modified True/False***Indicate whether the statement is true or false. If false, change the identified word or phrase to make the statement true.*

- _____ 1. The heavily cratered planet closest to the Sun is *Pluto*. _____
- _____ 2. The largest gaseous planet, *Saturn*, has 61 moons. _____
- _____ 3. The Sun and all objects orbiting it make up the *solar system*. _____
- _____ 4. The second planet from the Sun, which has moonlike phases and a surface heat of over 450°C caused by the greenhouse effect, is *Mercury*. _____
- _____ 5. An *astronomical unit* is the average distance between Earth and the Sun. _____
- _____ 6. A large, blue-green, gaseous planet similar to Uranus is *Neptune*. _____
- _____ 7. A large, swirling gas storm on Jupiter is the *Io*. _____
- _____ 8. The *inner planets* are Pluto, Uranus, Neptune, Saturn, and Jupiter. _____

Multiple Choice*Identify the choice that best completes the statement or answers the question.*

- _____ 9. The planet with the lowest density and hundreds of thin rings is _____.
 A. Jupiter C. Saturn
 B. Uranus D. Neptune
- _____ 10. Johannes Kepler discovered that the orbits of planets are _____.
 A. parabolic C. elliptical
 B. circular D. spherical
- _____ 11. The closest moon to Jupiter, _____, is volcanically active.
 A. Io C. Ganymede
 B. Callisto D. Europa
- _____ 12. The planet that averages 150 million km, or one AU, from the Sun is _____.
 A. Mars C. Mercury
 B. Jupiter D. Earth
- _____ 13. The largest known volcano in the solar system is an extinct volcano known as Olympus Mons found on the planet _____.
 A. Mars C. Mercury
 B. Jupiter D. Venus
- _____ 14. A planet that appears reddish-yellow due to iron oxide in its rocks is _____.
 A. Mercury C. Uranus
 B. Jupiter D. Mars
- _____ 15. At times, the planet _____ is actually the farthest planet from the Sun.
 A. Uranus C. Neptune
 B. Saturn D. Jupiter

Name: _____

ID: A

- ____ 16. The Great Red Spot, a continuous storm, is located on the planet ____.
- A. Saturn C. Jupiter
B. Uranus D. Neptune
- ____ 17. Methane gives ____ their blue-green color.
- A. Mars and Earth C. Saturn and Jupiter
B. Uranus and Neptune D. Neptune and Venus
- ____ 18. Two of the inner planets are ____.
- A. Mars and Jupiter C. Earth and Saturn
B. Mercury and Mars D. Uranus and Neptune
- ____ 19. ____ published the Sun-centered model of the solar system in 1543.
- A. Kepler C. Copernicus
B. Magellan D. Galileo
- ____ 20. Pieces of rock that actually strike Earth's surface are called ____.
- A. meteoroids C. meteors
B. comets D. meteorites
- ____ 21. Most asteroids are located in an area between the orbits of ____.
- A. Earth and Mars C. Mars and Jupiter
B. Jupiter and Saturn D. Mercury and Venus

Short Answer

22. What is unique about Uranus?

23. Circle which figure is an **Earth-centered** model of the solar system.

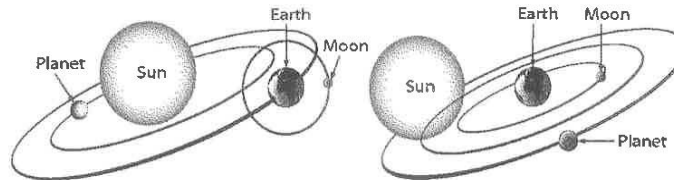


Figure 1

Figure 2

Why did People believe this model was accurate?

24. What is the difference in the formation of the inner and outer planets?

-Inner

-Outer

APPENDIX I

TOPIC TEST: THE UNIVERSE

Name: _____ Class: _____ Date: _____

ID: A

Stars and Galaxies**Multiple Choice***Identify the choice that best completes the statement or answers the question.*

- _____ 1. The positions of the constellations appear to change throughout the year because _____.
 A. Earth rotates on its axis C. the constellations revolve around Earth
 B. Earth revolves around the Sun D. the Sun revolves around the galaxy
- _____ 2. Its _____ makes Sirius the brightest star in the night sky.
 A. apparent magnitude C. temperature
 B. Uranus's magnitude D. absolute magnitude
- _____ 3. About 90 percent of all stars are _____ stars.
 A. nebula C. main sequence
 B. giant D. white dwarf
- _____ 4. Our Sun is all of the following EXCEPT _____.
 A. part of a binary system C. a yellow star
 B. a main sequence star D. of average absolute magnitude
- _____ 5. A galaxy that has a shape similar to a football is a(n) _____ galaxy.
 A. normal spiral C. elliptical
 B. barred spiral D. irregular
- _____ 6. Although it has a greater _____ than Sirius, Rigel does not look as bright in the night sky.
 A. apparent magnitude C. distance from Earth
 B. parallax D. absolute magnitude
- _____ 7. A _____ is an object so dense that nothing can escape its gravity field.
 A. supernova C. black hole
 B. neutron star D. supergiant
- _____ 8. Dark, cooler areas on the Sun's surface are called _____.
 A. Sunspots C. coronas
 B. solar flares D. prominences
- _____ 9. A large group of stars, gas, and dust held together by gravity is a _____.
 A. galaxy C. Local Group
 B. constellation D. elliptical galaxy

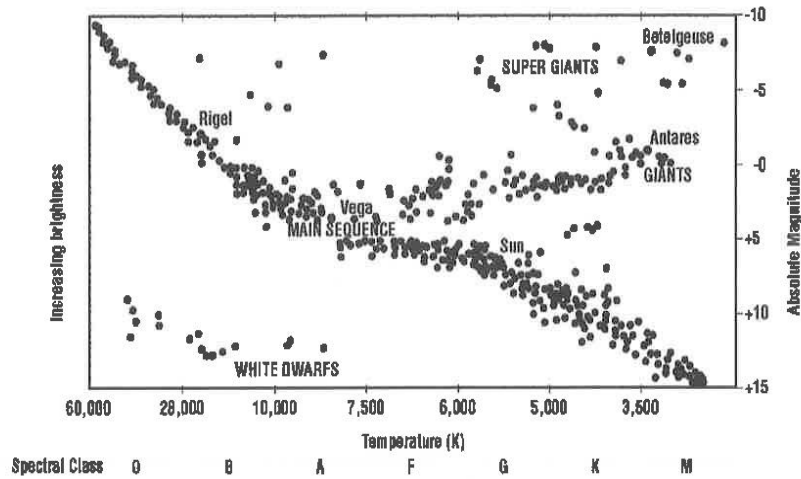
Short Answer

10. How does the Sun produce energy?

11. Number the following events in the order that they would happen.
- _____ a. High-energy particles from solar flares interact with Earth's atmosphere near the polar regions.
 _____ b. Gases near a sunspot brighten up suddenly and erupt as solar flares.
 _____ c. Earth's atmosphere radiates lights called aurora.

Name: _____

ID: A

Interpreting Scientific Illustrations*Directions: Use the diagram to help you answer the following questions.*

12. Are giants hotter than white dwarfs?
13. Is Antares or Vega hotter than the Sun?
14. What type of star is Betelgeuse?
15. Is the Sun brighter than a white dwarf?
16. What color are the hottest stars?
17. What will our sun change to after it moves out of the main sequence?

APPENDIX J
INTERVIEW QUESTIONS

Interview Questions

Name _____ Date _____ Class # _____

- Do you remember watching the science fiction clips in science?

- Did you enjoy watching the science fiction clips?

Can you tell me something you specifically liked?

- Do you think that you can learn science facts while watching science fiction clips?

Why do you think this?

- Was there a specific fact that you can remember from one of the films?
- How do you think the rest of the class likes watching science fiction clips?
- Was there anything else you would like to add?
- What was your favorite clip?