

INVESTIGATING THE EFFECTS OF ANTHROPOMORPHISM IN SCIENCE
COMMUNICATION REGARDING SPACE EXPLORATION

A Capstone Project Presented to the Faculty and Staff of
SCHOOL

In Partial Fulfillment of the Requirements for the Scholar's Diploma

By
NAME

Table of Contents

Table of Contents.....	2
Glossary.....	4
List of Tables.....	5
List of Figures.....	6
Acknowledgments.....	7
Abstract.....	8
Chapter 1: Review of Literature.....	9
Introduction.....	9
History of Anthropomorphism.....	10
Anthropomorphism and Space Exploration.....	13
Conclusion.....	17
Chapter 2: Methodology.....	18
Science Fair Experiment.....	18
The Articles.....	18
The Questionnaire.....	20
Data Collection.....	20
High School and Middle School Lessons.....	21
High School Lesson.....	21
Middle School Lesson.....	22
Chapter 3: Findings and Data Analysis.....	24

Science Fair Experiment.....	24
Data.....	24
Analysis.....	26
High School and Middle School Lessons.....	28
Chapter 4: Conclusion.....	30
Supplemental Materials.....	31
Annotated Bibliography.....	34

Glossary

Term	Definition
Anthropomorphism	The attribution of human characteristics to non-human entities, including objects, ideas, animals, and events such as natural phenomena.
Science communication	The practice of taking a complicated science topic and crafting it into informative, compelling, and easy-to-understand content for the general public.
Aware anthropomorphism	A form of anthropomorphism where the entity being anthropomorphized mostly maintains its original structure and imitates the human capacity for thought or inquiry.
Moe anthropomorphism	A form of anthropomorphism originating from Japanese media, in which nonhuman entities are turned into human or humanoid characters with traits intended to invoke the feeling of cuteness and strong affection. Also known as gijinka.
Likert-scale	A rating scale that is primarily used in questionnaires to quantitatively measure people's opinions, attitudes, or behaviors, based on the participant's degree of agreement with a set of statements.
Kruskal-Wallis test	A test that evaluates whether there is a statistically significant difference between several independent groups of data.

List of Tables

Table

1. Sample Questions and Answers From Surveys.....	20
2. Likert Scale Interpretation.....	24
3. Likert Scale Interpretation of Responses to Each Opinion Question.....	25

List of Figures

Figure

1. Political Cartoon Map of Europe.....	10
2. U.S. Army Recruitment Poster.....	11
3. Illustration Depicting the Webb and Roman Telescope.....	14
4. Comparison of a JWST Gijinka and the Spacecraft.....	16
5. Excerpts from the Non-Anthropomorphic and Anthropomorphic Articles.....	19
6. Gijinka Art of Various Spacecraft.....	19
7. Sample of 10th-Grade Activity.....	21
8. Brainstorming Sheet of 7-Grade Activity.....	22
9. Closed-Ended Knowledge Questions.....	24
10. Likert Scale Interpretation of Participants' Answers to Opinion Questions.....	25
11. Likert Scale Interpretation of Participants' Answers to Engagement Questions.....	26
12. Kruskal-Wallis Test.....	28
13. Anthropomorphic Drawings by 10th-Grade Students.....	28
14. Anthropomorphic Drawings by 7th-Grade Students.....	29

Acknowledgments

The completion of this Capstone project would not have been possible without the support of the staff at SCHOOL and my friends and classmates. In particular, I would like to express my gratitude to the following people:

Mrs. NAME, for helping me stay on track and providing me with the resources I needed to complete my science fair project and this paper.

Ms. NAME, for serving as my advisor on the lessons for 7th and 10th-grade students, and coordinating the events.

Mr. NAME, for helping me put together my science fair board. His support is what made the showcases possible.

NAME, for distributing my surveys and gathering participants.

Robin, for chatting with me about anthropomorphism and his experience in the space gijinka community, and allowing me to include his art in this paper.

And a special thank you to the many gijinka artists who showed me the wonders of anthropomorphism and inspired me to take on this project.

NAME, SCHOOL

Abstract

While the American public generally holds a positive attitude towards the U.S. space program, most are unfamiliar with its activities and believe that federal money could be better spent elsewhere. Anthropomorphism—the attribution of human characteristics to non-human entities—has been shown to affect how people behave and think. My research attempts to determine whether the use of anthropomorphism in writing and art could be an effective tool for communicating science and promoting human lunar exploration, which the majority of Americans do not view as NASA’s top priority. For my survey experiment, I created two versions of an article highlighting the scientific, technological, and economic contributions of NASA’s lunar programs, one of which included anthropomorphic depictions of spacecraft while the other did not. Participants were randomly assigned one or no article followed by questions evaluating their knowledge and opinion of human lunar exploration. Those who read the article containing anthropomorphism answered the most knowledge questions correctly and held the most favorable opinion. However, the differences between the three groups were not significant, suggesting that anthropomorphism has little to no effect and therefore would not be an effective tool for science communication. To gain further insights into the role of anthropomorphism in broader science topics, I conducted two interactive lessons teaching small groups of 10th-grade and 7th-grade students the different types of anthropomorphism and its use in science communication. All students felt that anthropomorphizing a given scientific topic helped them understand and retain information better. Further investigation could delve into the potential differences between the effects of anthropomorphic writing and art.

Chapter 1: Review of Literature

Introduction

When referring to objects, we typically use the third-person pronoun “it.” Ships and submarines, however, are a notable exception, as they are traditionally considered female and almost always referred to as “she,” thus anthropomorphizing the entity. In an attempt to understand the world around us, we tend to analyze the behaviors and motivations of other beings as if they were humans. It’s why we say black holes will “eat” everything around them, even though they don’t literally chew or swallow food. Such anthropomorphic language is not without criticism, with some researchers cautioning about the “perils of anthropomorphism,” the misconceptions that can result from ascribing consciousness to something that is not conscious (Wynne, 2004). Nevertheless, from World War I political propaganda to science classrooms, anthropomorphism is everywhere. It appears to have a significant influence on us, being able to change “consumers’ purchase intentions” and “[boost] public support for wildlife conservation” (Cooremans & Geuens, 2019; Yue et al., 2021).

Moreover, anthropomorphism has seeped its way into science communication, The practice of taking a complicated science topic and crafting it into informative, compelling, and easy-to-understand content for the general public. An important part of science communication is trying to convince an otherwise bored audience that something is interesting and worth their time, and anthropomorphism is one of many strategies used. Although most Americans are “in favor of NASA as an organization,” many overestimate the amount of funding that NASA receives and believe that the space program has not brought enough benefits to justify its cost (Launius, 2003). Given that there exist many misconceptions about spaceflight among the general public, it would be helpful for science communicators to know whether

anthropomorphism in writing and art can effectively shape the public's understanding of space exploration and engender support for NASA.

History of Anthropomorphism

Today, “anthropomorphism” is best described as the attribution of characteristics that people “intuitively perceive to be uniquely human” to nonhuman entities including objects, ideas, animals, and events such as natural phenomena (Waytz et al., 2010). It is impossible to determine when the concept first emerged, as it appears to be an innate behavior humans use to interpret and understand the world. The phenomenon of anthropomorphism can be observed as far back as Ancient Greece, where in Greek culture their gods took on the form of a human being, albeit an ideal physique (Dietrich, 1988).

Throughout history, anthropomorphism has been widely used in political propaganda, in the form of national personification. Figure 1 illustrates a political cartoon created in 1870 by artist Paul Hadol, a satirical map depicting the political affairs in Europe, where an anthropomorphic figure represents each country. In Figure 2, a war poster illustrated by James Montgomery Flagg, Uncle Sam, the national personification of the U.S. government, stands with his finger pointed at the viewer above the political message: “I want you for U.S. Army.” Both examples demonstrate the use of anthropomorphism to convey a political message with the aim of eliciting a specific response from the audience, the latter being used for military recruitment.

Figure 1

Political Cartoon Map of Europe



Note. Image taken from the French National Library online catalog. Bibliothèque nationale de France. (n.d.). *Lot de deux cartes satiriques de l'Europe, l'une pour l'année 1870, l'autre pour 1914.* <https://catalogue.bnf.fr/ark:/12148/cb40780666x>

Figure 2

U.S. Army Recruitment Poster



Note. Image taken from the Library of Congress online catalog.
Library of Congress. (n.d.). *I want you for U.S. Army: nearest recruiting station.*
<https://www.loc.gov/resource/ppmsc.03521/>

Additionally, the subjects of anthropomorphism include animals. As Darwin's theory of evolution began to take hold, the barrier between humans and animals began to slowly diminish. Sealey and Oakley (2013, as cited in Wynne, 2007) found that around the late nineteenth century, the targets of anthropomorphism, which were primarily angels and gods, came to include animals. Humans tend to inadvertently use their personal experiences to quantify the behavior of other creatures. The complexity of animal behavior naturally prompts people to use words that they are familiar with—words they use to describe themselves and other humans—to describe animals (Wynne, 2004). For example, Charles Darwin described cobras as “cunning.” Research by Sealey and Oakley (2013) concludes that the use of anthropomorphic language to describe animals is to some extent unavoidable. This is especially prevalent in nature documentaries. From a tired lion father annoyed by the shenanigans of his kids to a sneaky cuttlefish devising a plan to woo the ladies, the dramatic flair produced by anthropomorphic language captivates the audience's interest by drawing parallels between animal and human experiences (Sealey & Oakley, 2013). However, not everyone is on board with this idea. Wynne (2004) warns against an anthropomorphic approach to animal behavior in scientific research and education, noting that characterizing animals as having human-like consciousness will always come with a degree of inaccuracy.

Over the years, a great deal of research has been conducted on the effects of anthropomorphism. According to Cooremans and Geuens (2019), people tend to buy fewer misshapen foods due to the perception that abnormality is inherently bad. They found that this bias can be mitigated by placing a poster depicting positive imagery of anthropomorphic

misshapen produce next to the actual products. The implication of anthropomorphism influencing human thinking and behavior is powerful. Anthropomorphism also has a role in science education. To explain the formation of a sodium chloride molecule, a teacher may say a sodium ion is *stealing* an electron from chlorine because it *wants* to have a full outer shell. The anthropomorphic language used here visualizes a complicated process and frames it in a way familiar to the audience. While such a description may not be entirely accurate, Watts and Bentley (1994) argue that adding an anthropomorphic flavor to school science is no different from using simplifications, approximations, and analogies. Anthropomorphic explanations are simply a tool to help students understand the material. The idea that anthropomorphism can be a helpful tool extends to science communication: science education, but aimed at the general public who may not care about the given topic. However, experiments conducted by McGellin et al. (2021) found no evidence of potential communicative benefits of anthropomorphism, as anthropomorphic science writing had essentially no effect on people's knowledge and connection to the topic, other than making examples more vivid and memorable. The effects of anthropomorphism remain unclear. Nevertheless, it continues to be heavily utilized in science communication, particularly regarding space exploration.

Anthropomorphism and Space Exploration

Anthropomorphic depictions usually fall into two categories: aware anthropomorphism and moe anthropomorphism. The former is prevalent in writing and science communication, while the latter occurs almost exclusively in the form of visual arts. DiSalvo et al. (2004) define aware anthropomorphism as “[imitating] the human capacity for thought, intentionality, or inquiry.” In other words, the anthropomorphized entity is given a human-like consciousness.

NASA's social media accounts are one of the main ways the agency communicates news and updates about its missions to the public. Various NASA accounts on X (Twitter), including the Voyager Program, Mars Curiosity Rover, and Mars Perseverance Rover, make posts from a first-person perspective as if the spacecraft are the ones writing them (Daines 2024). In visual depictions, the aware anthropomorphic character more or less resembles its original structure, as shown in Figure 3, where the James Webb Space Telescope (JWST, left) and Nancy Grace Roman Space Telescope (right) are dressed in Halloween ghost costumes. The post uses anthropomorphic language and familiar holiday narratives to inform the public about the technical capabilities of the Roman Space Telescope. In addition to social media communications, the European Space Agency and NASA have produced educational cartoons featuring anthropomorphic depictions of spacecraft, with notable examples including *Lucy's Journey* and *The Epic Adventures of BepiColombo*. Anthropomorphism breathes life into otherwise inanimate spacecraft, making science more relatable and engaging for the general public.

Figure 3

Illustration Depicting the Webb and Roman Telescope



Galactic Ghosts

Roman is going to be one of the best ghost hunters in the galaxy! Since microlensing relies on an object's gravity, not its light, it can find all kinds of invisible specters drifting through the Milky Way. That includes rogue planets, which roam the galaxy alone instead of orbiting a star...

Note. Image taken from a post by the official NASA Tumblr account. NASA. (2022, October 28). *Scary space stories to tell in the dark*. Tumblr. <https://nasa.tumblr.com/post/699364400700719104/scary-space-stories-to-tell-in-the-dark>

Interestingly, unlike aware anthropomorphism, the majority of moe anthropomorphic depictions of spacecraft come from fans of spaceflight. Originating from Japanese media, moe anthropomorphism, or “gijinka,” turns nonhuman entities into human or humanoid characters with “moe” characteristics designed to invoke the feeling of cuteness and strong affection. An example of this can be seen in Figure 4, which shows a gijinka of the JWST. It is worth noting that the first operational year of the JWST received significant mainstream media attention and an influx of gijinka fanart. In January 2024, following the successful landing of SLIM, Japan’s first-ever moon lander, many artists created fanart featuring gijinka characters based on the spacecraft. Official use of moe anthropomorphism exists, too, as seen with NASA hosting the

“GPM Anime Challenge” in 2015, which challenged artists to design an anime character based on the Global Precipitation Measurement (GPM) satellite mission and its themes of weather, climate, and technology (NASA, 2015). The winning character designs were later developed into an educational comic. This is science communication in action: anthropomorphism as a technique for engaging the public. Judging by the response from enthusiastic fans, anthropomorphism is the way to go.

Figure 4

Comparison of a JWST Gijinka and the Spacecraft



Note. Left: art by Robin W.. Right: Artist's render, NASA.
W., R. (n.d.). *James Webb (JWST)'s gallery*. Toyhouse.
<https://toyhou.se/14002377.james-webb-jwst/gallery>
NASA. (2022, July 12). *Where is Webb?*. NASA.
<https://www.jwst.nasa.gov/content/webbLaunch/whereIsWebb.html>

Conclusion

Apollo, the landmark program of NASA that put the first humans on the moon, is looked back fondly by many. However, it never received strong public support—only 53% of people thought the program was worth its expense at the time of the first moon landing—and it would likely not have been realized under normal political circumstances (Launius 2003). Today, NASA is attempting to accomplish a similar feat by returning astronauts to the moon through the Artemis program, at a time when only “12% of Americans say sending human astronauts to explore the moon should be a top priority for NASA” (Kennedy & Tyson, 2023). The use of anthropomorphism in science communication and outreach activities related to space exploration has potential. Understanding the effects of anthropomorphism could be the key to changing public perceptions and increasing support for space exploration, as anthropomorphism has been and will continue to be used as a means of conveying ideas, spreading information, and persuading people.

Chapter 2: Methodology

Science Fair Experiment

To determine the effectiveness of using anthropomorphic writing and art for communicating science and promoting human lunar exploration, I took on a survey experiment approach. The surveys were designed to evaluate the effects of anthropomorphism on the general public's knowledge and opinion of human exploration of the Moon. Moreover, I assessed whether anthropomorphism can make the material more engaging. (To see the full surveys, refer to Supplemental Materials at the end of this paper.) I hypothesized that anthropomorphic depiction of spacecraft does not significantly increase people's knowledge of human lunar exploration, but can positively influence their opinion on the subject.

The Articles

I wrote an article that is a synthesis of multiple NASA sources, focusing on the scientific, technological, and economic contributions of NASA's lunar programs, as well as the differences between the Apollo and Artemis programs. Then, I wrote an anthropomorphic version of the same article, which contains anthropomorphic language and art. Figure 5 provides an excerpt from each article, showcasing the difference between the two articles. In total, I created 3 surveys: Survey A contained the non-anthropomorphic version of the article; Survey B, the anthropomorphic version; Survey C, no article.

Accompanying the anthropomorphic article are images showing anthropomorphic depictions of spacecraft. I designed and illustrated moe anthropomorphic characters based on the various spacecraft mentioned in the article (see Figure 6). These art are featured prominently next to excerpts of the corresponding topic.

Figure 5

Excerpts from the Non-Anthropomorphic and Anthropomorphic Articles

Apollo used the powerful Saturn V rocket (left below) to send astronauts to the moon, whereas Artemis has the Space Launch System (SLS, right below). The Saturn V is powered by liquid fuel, while the SLS is powered by both liquid and solid fuel. Its core stage is flanked by two solid rocket boosters. The SLS will generate 15 percent more thrust than the Saturn V and will launch Artemis astronauts on missions to the Moon, Mars, and beyond.



The spiritual successor to the mighty Saturn V rocket (left below) of the Apollo program is the Space Launch System (SLS, right below). Unlike her predecessor, who only uses liquid rocket fuel, SLS uses both liquid and solid fuel. Her main body (core stage) is flanked by two solid rocket boosters. With 15 percent more thrust than the Saturn V, SLS is geared up to propel Artemis astronauts on ventures to the Moon, Mars, and beyond.

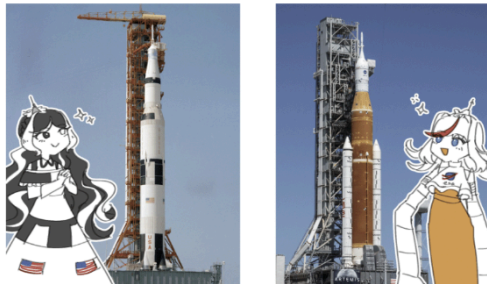


Figure 6

Gijinka Art of Various Spacecraft



Note. From left to right, the spacecraft being anthropomorphized are: Orion spacecraft, Apollo command and service module, Blue Moon MK2, Starship HLS.

The Questionnaire

For the survey, I created three sets of questions. Closed-ended knowledge questions evaluated participants' knowledge of the subject, opinion questions evaluated participants' opinion of human lunar exploration, and enjoyment questions evaluated how much the participants enjoyed reading the article. The closed-ended knowledge questions are yes–no questions, while the rest are multiple choice questions with answers ranging from “strongly disagree” to “strongly agree.” The table below (Table 1) showcases a sample question and response from each question type.

Data Collection

I created three Google Form surveys and a redirect link where participants were randomly assigned one of the surveys. Participants assigned to Survey A and B read the article (non-anthropomorphic and anthropomorphic versions, respectively) and answered the full questionnaire. Meanwhile, Survey C contained no article and participants assigned to it answered the questionnaire without the engagement questions.

Table 1

Sample Questions and Answers From Surveys

	Closed-ended Knowledge Questions	Opinion Questions	Engagement Questions
Example	Q: Is NASA planning to establish a space station around the moon? A: Yes.	Q: International collaboration is important in lunar exploration. A: Agree.	Q: I would describe this article as very interesting. A: Disagree.

High School and Middle School Lessons

Anthropomorphism is not only prominent in science communication but also in science classrooms. To investigate the role of anthropomorphism in science education, I conducted two interactive lessons that involved teaching small groups of 10th-grade and 7th-grade students at our school about anthropomorphism in science communication. In the lesson, students learned how to communicate scientific topics using anthropomorphic art.

High School Lesson

To introduce the topic of anthropomorphism, I asked the students to name a story where animals or objects behave like humans and list at least two of these human characteristics. Through analyzing a series of images and videos containing anthropomorphism, students discussed and learned about the two types of anthropomorphism (moe and aware). As part of the front-loading, the students performed a “case study” in which they looked at five examples of the usage of anthropomorphism in science communication. They were asked to work with their partner to identify words that anthropomorphize the entity and discuss the implications of such language.

In the activity, students were tasked to design and draw an anthropomorphic character based on what they learned in the front-loading lesson and a concept they learned in AP Biology: stem cell, DNA, RNA, bacteriophage virus, or prokaryote. They were given a description card and a brainstorming sheet (Figure 7) to help them create the character.

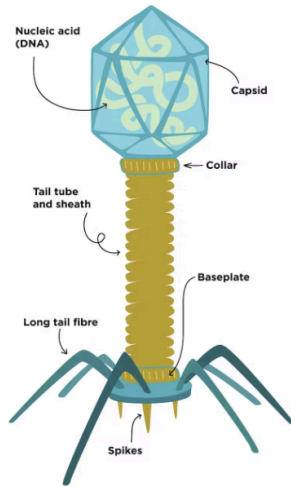
Figure 7

Sample of 10th-Grade Activity

Bacteriophage Virus

Description: A virus that infects bacteria by injecting their genetic material into the host cell.

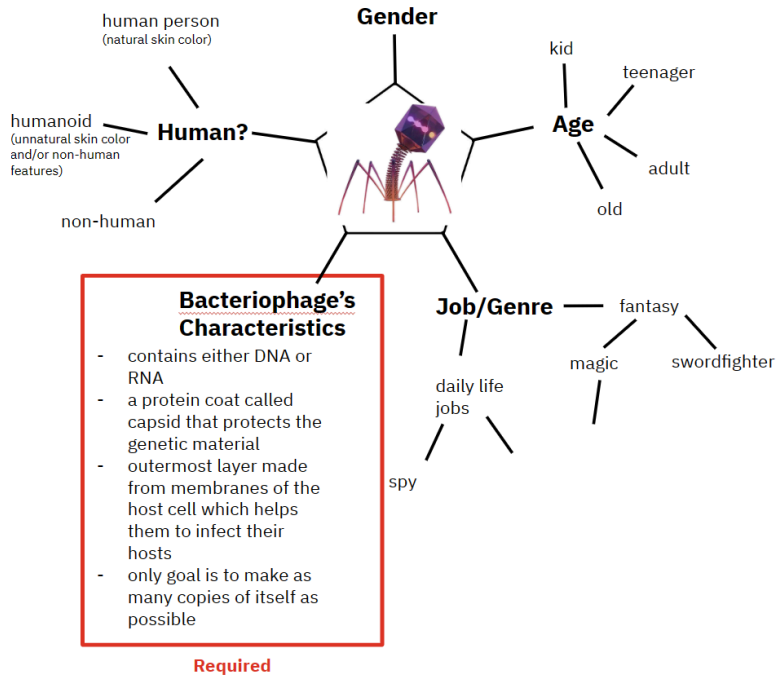
Anthropomorphize this:



◆ Brainstorming ◆

Now is your time to design an anthropomorphic character based on a scientific topic! Here are a few things to consider. Your character **MUST** have features (such as hair, outfit, or job) that reflect/represent the **required characteristics** of the original thing.

Be ready to share your design with the group!



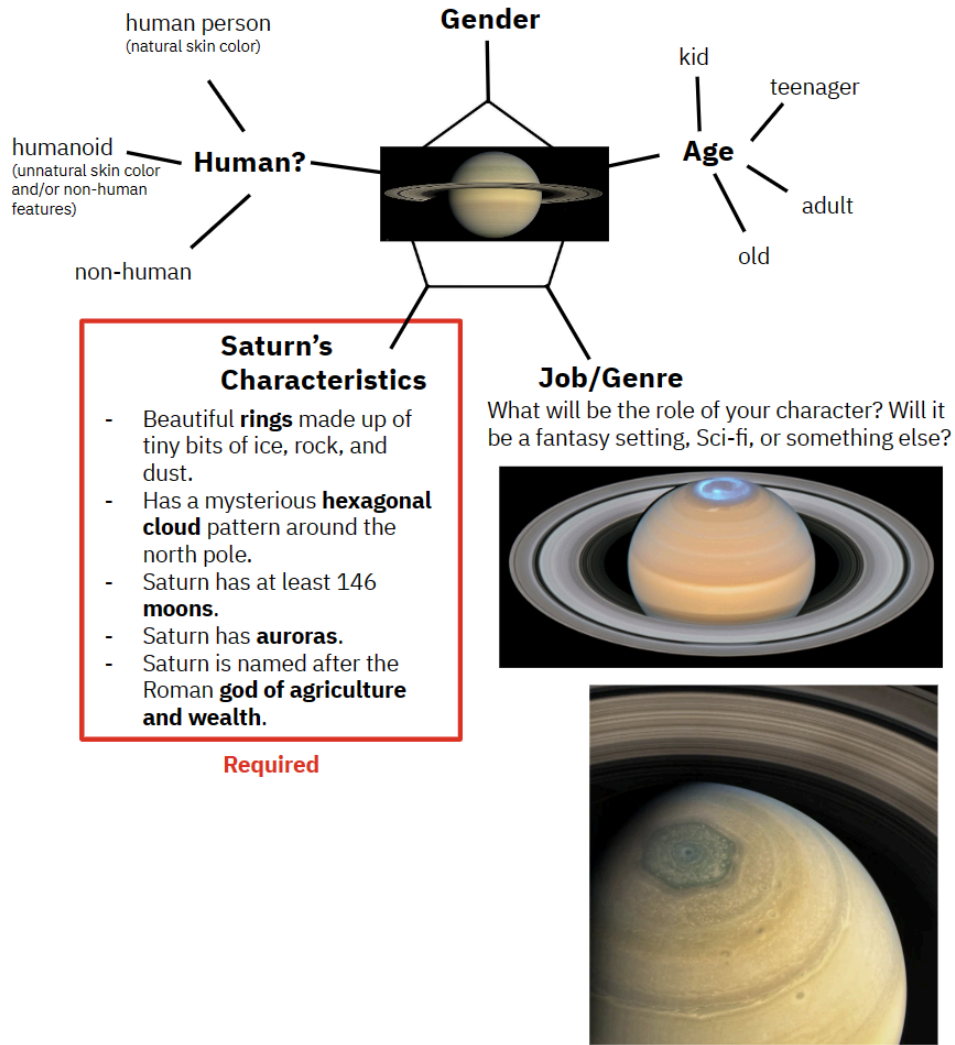
Note. Card (left) and brainstorming sheet (right).

Middle School Lesson

The middle school lesson is the same as the high school lesson, except for two major differences. First, I simplified the language a bit and removed a confusing example from the case studies portion. Second, I designed the activity with flexibility in mind so that it can be tailored to students from both grades. Instead of AP Biology concepts, the students anthropomorphized planets of the solar system (Figure 8), which are concepts they are already familiar with. I also removed the description card for further clarity.

Figure 8

Brainstorming Sheet of 7-Grade Activity



Note. This is one of five options that the students could've chosen to anthropomorphize. The other options are Jupiter, Mars, Earth, and the Sun.

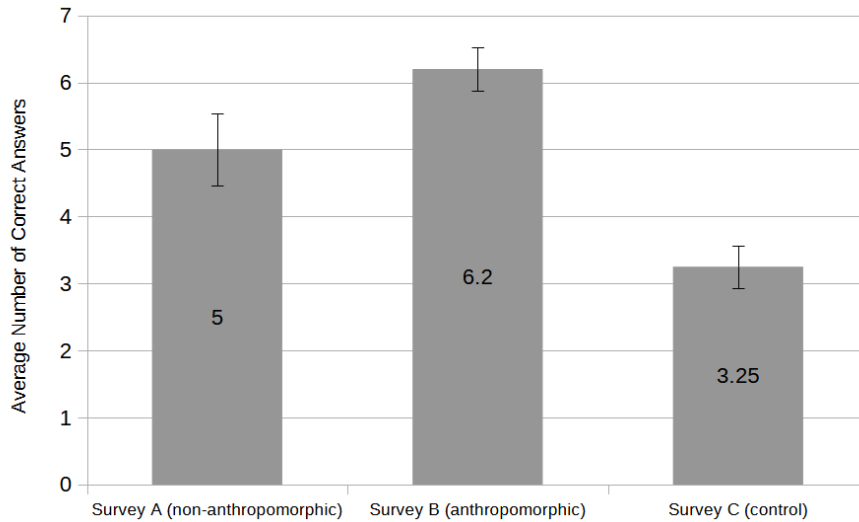
Chapter 3: Findings and Data Analysis

Science Fair Experiment

Data

Figure 9

Closed-Ended Knowledge Questions



Note. The average number of closed-ended knowledge questions answered correctly by participants in each group.

Table 2

Likert Scale Interpretation

Likert Scale	Likert Scale Description	Range
1	Strongly agree	1.00 – 1.80
2	Agree	1.81 – 2.60
3	Neither agree nor disagree	2.61 – 3.40
4	Disagree	3.41 – 4.20
5	Strongly disagree	4.21 – 5.00

Figure 10

Likert Scale Interpretation of Participants' Answers to Opinion Questions

Questions

1. The Apollo program, which landed 12 astronauts on the moon, was worthwhile.
2. The government should fund missions that send human astronauts to explore the moon.
5. I am interested in learning more about future crewed missions to the moon.

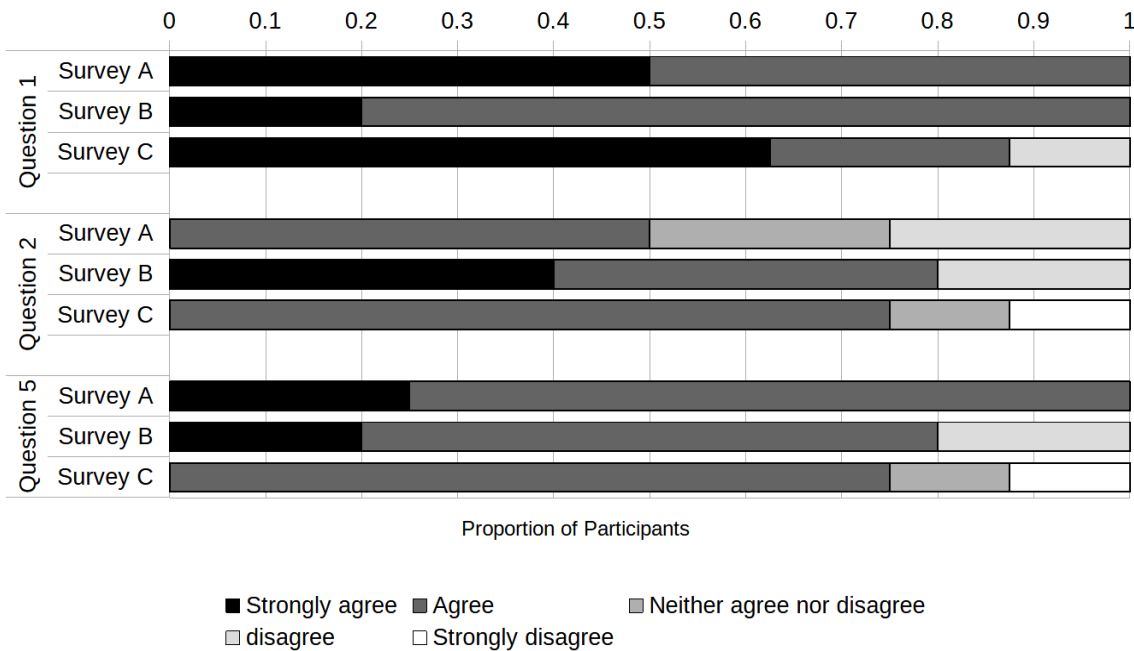


Table 3

Likert Scale Interpretation of Responses to Each Opinion Question

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Overall Favorability
Survey A	Strongly agree	Neither agree nor disagree	Disagree	Disagree	Strongly agree	Agree	Strongly agree	Agree	80%
Survey B	Strongly agree	Agree	Disagree	Neither agree nor disagree	Agree	Agree	Strongly agree	Strongly agree	85%
Survey C	Agree	Agree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Agree	Strongly agree	82.5%

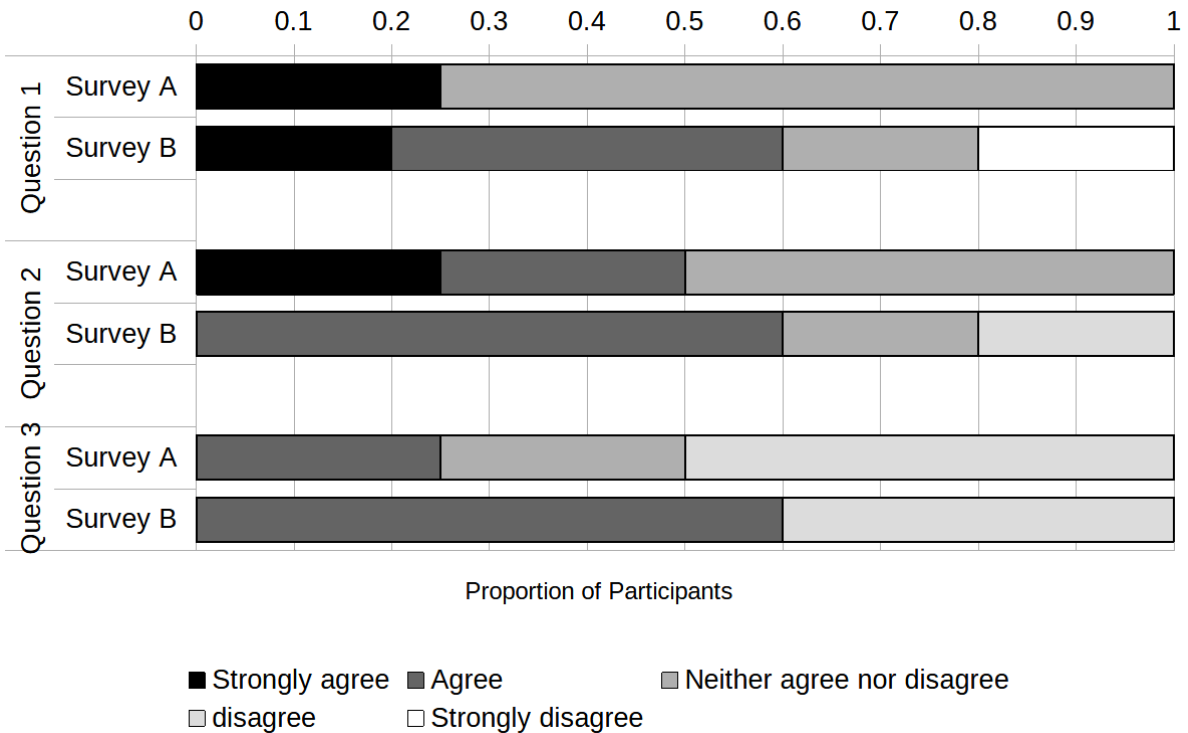
Note. Survey A (non-anthropomorphic version), Survey B (anthropomorphic version), Survey C (Control - no article)

Figure 11

Likert Scale Interpretation of Participants' Answers to Engagement Questions

Questions

1. I would describe this article as very interesting.
2. I enjoyed reading this article.
3. I think I understood this article pretty well.



Analysis

The average number of closed-ended knowledge questions answered correctly by participants of Survey A is 5; Survey B, 6.2; and Survey C, 3.25 (Figure 9). Participants who received an article on average were able to answer more questions correctly (Survey A - 5, Survey B - 6.2) than participants who did not receive an article (Survey C - 3.25). Standard deviation and error analysis showed that there is a significant difference. However, per the

Kruskal-Wallis test, shown in Figure 12, which compares the answers of all three surveys, there is no significant difference between non-anthropomorphic and control, non-anthropomorphic and anthropomorphic, and among all three groups.

Survey A & C $\rightarrow H = 1.413, H < 3.841, p > 0.05$

Survey A & B $\rightarrow H = 0.735, H < 3.841, p > 0.05$

Survey A & B & C $\rightarrow H = 4.447, H < 5.991, p > 0.05$

The null hypothesis is rejected because there is a significant difference between the anthropomorphic and control groups. In conclusion, the effect of anthropomorphism on people's knowledge of human lunar exploration was minimal/insignificant. This matches the findings of a similar experiment by McGellin et al. (2021), where it is found that there is "no difference in understanding, enjoyment . . . of anthropomorphic thinking between anthropomorphic and non-anthropomorphic texts."

The opinion and engagement questions were analyzed using a 5-point Likert scale interpretation (Table 2). On average, participants of Survey A (non-anthropomorphic) viewed human lunar exploration 80% favorably; Survey B (anthropomorphic), 85%; and Survey C (control), 82.5%. Participants who did not read any article held a slightly more favorable view of human lunar exploration compared to participants who read the non-anthropomorphic article. Overall, the effect of anthropomorphism on people's opinion of human lunar exploration was minimal/insignificant. All participants, regardless of which article they read, held the same opinions, with Questions 1 and 2 being "agree", and Question 3 "neither agree nor disagree" (Figure 11). This means that the use of anthropomorphism does not detract from the content of the article.

Figure 12

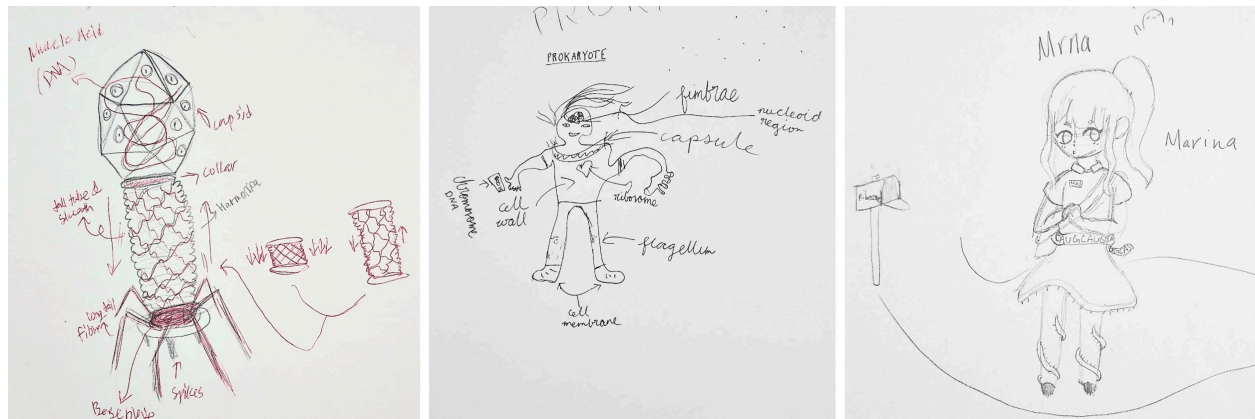
Kruskal-Wallis Test

	Survey A	Survey B	Survey C		Rank	Actual Rank Adjusted for Ties	
	6	8	6		1	1	0
	7	4	6		2	2.5	1
	2	5	6		3	2.5	1
	5	7	2		4	4.5	2
		7	4		5	4.5	2
			1		6	6.5	4
			1		7	6.5	4
			0		8	8.5	5
					9	8.5	5
	11.5	17	11.5		10	11.5	6
	15	6.5	11.5		11	11.5	6
	4.5	8.5	11.5		12	11.5	6
	8.5	15	4.5		13	11.5	6
		15	6.5		14	15	7
			2.5		15	15	7
			2.5		16	15	7
			1		17	17	8
R (rank sum)	39.5	62	51.5		$\frac{12}{17(17+1)} \left(\frac{39.5^2}{4} + \frac{62^2}{5} + \frac{51.5^2}{8} \right) - 3(17+1) = 4.446813725$		
n (sample size)	4	5	8		state alpha: 0.05		
					degree of freedom (df): 2		
					H = 4.447		
					decision rule: 5.991		

High School and Middle School Lessons

Figure 13

Anthropomorphic Drawings by 10th-Grade Students



Note. For further context, refer to Figure 7. From left to right: bacteriophage, prokaryote, mRNA.

Figure 14

Anthropomorphic Drawings by 7th-Grade Students



Note. For further context, refer to Figure 8. From left to right: Jupiter, Jupiter, Saturn, the Sun

Figures 13 and 14 show drawings of anthropomorphic characters designed by students as part of the final activity of the lesson. To assess their understanding, students presented their drawings to the group and explained how their design choices (such as hair or outfit) reflect and represent the characteristics of the original entity. All students felt engaged during the lesson and especially enjoyed the final activity.

One mishap during the lessons with the middle schoolers was the time constraint. Instead of the allotted one hour, because of scheduling issues, the actual time we had to conduct the lesson was closer to 45 minutes. The students had little time to color their drawings and the final discussion questions had to be somewhat rushed. Other than that, it was overall a pleasant experience. Currently, it is impossible to know how much information the students retained from the lesson. It would be interesting to conduct a second lesson revisiting the topic and assessing their knowledge.

Chapter 4: Conclusion

The purpose of this project was to determine the extent to which anthropomorphism affects people's knowledge and opinions, and whether anthropomorphism can be an effective tool for science communication regarding space exploration. My experiment focuses on human lunar exploration, as it currently lacks significant public support. I collected data through surveys, evaluated participants' knowledge and opinions regarding lunar exploration using closed-ended questions and 5-point Likert scale questions, and assessed the significant difference in the data. The results of the experiment suggested that anthropomorphism does not have a significant effect on people's knowledge, opinions, or article quality. Because anthropomorphism has little to no effect—it neither creates misconceptions nor positively affects people's opinions—it does not need to be avoided. Although it may not be effective, it can still be used as a gimmick to engage the general public. Further research can investigate potential differences between the effects of anthropomorphic writing and anthropomorphic art or assess whether anthropomorphism can make a deeper impression and lead to better knowledge retention.

The concept of anthropomorphism has always fascinated me. It's everywhere, but not really talked about. Working on this project has allowed me to research the history of anthropomorphism and understand its origin. Learning about the entanglement of anthropomorphism and science communication regarding space exploration has deepened my appreciation for anthropomorphism in arts and sciences. As an artist, I aspire to continue designing and drawing anthropomorphic characters, particularly spacecraft gijinka. A beautiful product of the creativity and imagination of the human intellect, anthropomorphism has existed since the dawn of time and will continue to exist. I hope to see more of it in science communication and even science classrooms.

Supplemental Materials

Below are all the materials included in the experimental surveys; articles excluded.

Key

Survey A - non-anthropomorphic version

Survey B - anthropomorphic version

Survey C - no article (control)

Description

Survey A and Survey B: We're interested in how different visuals and writing techniques affect how people understand human exploration of the moon. To help us with this study, we need you to answer some questions about your understanding and opinion of NASA's lunar programs.

Survey C: We're interested in people's understanding of human exploration of the moon. To help us with this study, we need you to answer some questions about your understanding and opinion of NASA's lunar programs.

Consent

Description: I agree to participate in this survey being conducted as part of the Capstone Program. I understand that data from my responses will be used in internal reports and papers that may be written by the researcher. I grant permission for the use of such data, with the understanding that my responses will be made anonymous.

Required response (by participant): I understand and agree to participate in this research.

Knowledge Questions

Instruction: Please answer the following questions only from your own knowledge and understanding, and avoid looking up information from elsewhere.

Questions:

1. Is NASA planning to establish a space station around the moon?
2. Is NASA planning to establish a long-term human presence on the moon?
3. Can the Orion spacecraft carry more crew than the Apollo spacecraft?
4. Is NASA building its own lunar lander for the upcoming moon landings?
5. Did the Artemis I mission happen already?
6. Does NASA work with commercial partners?
7. Is the design of the Space Launch System based in part on the Space Shuttle?
8. Is NASA working with international partners in the Artemis program?

Possible answers (multiple choice): Yes / No / I don't know

Opinion Questions

Instruction: Please indicate how much you agree with the following statements.

Questions:

1. The Apollo program, which landed 12 astronauts on the moon, was worthwhile.
2. The government should fund missions that send human astronauts to explore the moon.
3. Human lunar exploration is not relevant to me.
4. Sending human astronauts to explore the moon should be a top priority for NASA.
5. I am interested in learning more about future crewed missions to the moon.
6. Space exploration is important.

7. Human exploration of the Moon will lead to important technological advances and scientific research.

8. International collaboration is important in lunar exploration.

Possible answers (multiple choice): Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree

Enjoyment Questions

Instruction: Please indicate how much you agree with the following statements.

Questions:

1. I would describe this article as very interesting.

2. I enjoyed reading this article.

3. I think I understood this article pretty well.

Possible answers (multiple choice): Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree

Annotated Bibliography

Cooremans, K., & Geuens, M. (2019). Same but different: Using anthropomorphism in the battle against food waste. *Journal of Public Policy & Marketing*, 38(2), 232–245.

<https://doi.org/10.1177/0743915619827941>

In this research paper, Cooremans and Geuens detail their experiments testing whether or not the use of anthropomorphism can affect consumers' purchase decisions, specifically in the context of food preservation. People generally have an "abnormal is bad" bias which applies to misshapen food products. The authors found that anthropomorphism can enhance certain properties of the subject being anthropomorphized, which in this case can make abnormal produce seem tastier. By placing a poster containing positive imagery and anthropomorphic misshapen produce next to the products, people were more likely to purchase misshapen produce. Cooremans and Geuens' experiments are well-researched, designed, and documented. Multiple studies were conducted. I could use a similar strategy to anthropomorphize spacecraft. For instance, instead of using a real-life image of a spacecraft, I could use a cartoonish drawing of an anthropomorphized spacecraft, thereby making the robotic features seem more human-like and endearing.

Daines, G. (2024, April 03). *Official NASA social media accounts*. NASA. Retrieved April 3,

2024, from <https://www.nasa.gov/social-media/>

Dietrich, B. C. (1988). Divine personality and personification. *Kernos*, 1.

<https://doi.org/10.4000/kernos.77>

DiSalvo, C., Forlizzi, J., & Gemperle, F. (2004, November 17). *Kinds of Anthropomorphic Form*.

Design Research Society.

<https://dl.designresearchsociety.org/drs-conference-papers/drs2004/researchpapers/45>

This paper provides an overview of the four kinds of anthropomorphic forms in design: structural, gestural, character, and aware. The authors go over what they are, how they are created, and how they can be used in product design. The image examples included are very helpful in understanding how the four anthropomorphic forms differ. I could potentially utilize different forms of anthropomorphism in my project. For example, making a spacecraft sentient falls under the category of aware anthropomorphism.

Kennedy, B., & Tyson, A. (2023, July 20). *Americans' views of space: U.S. role, NASA priorities and impact of private companies*. Pew Research Center Science & Society.

<https://www.pewresearch.org/science/2023/07/20/americans-views-of-space-u-s-role-nasa-priorities-and-impact-of-private-companies/>

In this article, Kennedy and Tyson provide an overview of the findings of a 2018 survey studying the American public's views on various space issues. Topics include NASA's top priorities, views on the private/commercial space industry, space tourism, and engagement in space outreach. Each topic is accompanied by a bar chart visualizing the polling results, making the information easier to digest. An appendix page provides additional charts and information not covered in the overview. This is an excellent resource for researchers looking for data or statistics on the American public's views on space exploration. This article not only helped me identify the problem my research is trying to address, but it also provided data justifying the existence of the problem in the first place. The problem, in this case, is that only a small minority of Americans believe human lunar exploration should be a top priority for NASA.

Launius, R. D. (2003). Public opinion polls and perceptions of US human spaceflight. *Space Policy*, 19(3), 163–175. [https://doi.org/10.1016/s0265-9646\(03\)00039-0](https://doi.org/10.1016/s0265-9646(03)00039-0)

In this paper, Launius explores the evolution of public opinion of the U.S. space program from the 1960s to the 1990s. The topics covered include public support of the Apollo Program, the Space Shuttle Program, and a possible human Mars program, as well as concerns over funding and budget. The author addresses the common misconceptions regarding public perception of spaceflight and either corroborates or refutes those claims with data. Lots of graphs are included in this paper and the conclusion contains bullet points that summarize the main findings of this study. This paper helped identify the gap that my project is trying to fill, which is that although most Americans are in favor of space exploration, they are unfamiliar with the specifics of the space program and believe that federal money could be better spent elsewhere. I want to investigate if anthropomorphism can be an effective tool used in science communication and public outreach to help people become more familiar and knowledgeable about the space program.

McGellin, R. T. L., Grand, A., & Sullivan, M. (2021). Stop avoiding the inevitable: The effects of anthropomorphism in science writing for non-experts. *Public Understanding of Science*, 30(5), 621–640. <https://doi.org/10.1177/0963662521991732>

In this paper, McGellin details his experiment study which aimed to determine the effect of anthropomorphic science writing on non-expert audience's knowledge, confidence in, and connection to the subject of writing. The author found that there was no significant difference between the influence of anthropomorphic and non-anthropomorphic text and that anthropomorphic text only has subtle effects such as making examples more vivid and making the text more enjoyable. The author argues that because anthropomorphism in writing has no negative effects, it should not be avoided in scientific communication.

This paper provides a framework for me to build my experiment on. The statistical analysis methods and supplemental materials provided are great references.

NASA. (2015, October 19). Winners of the GPM anime challenge. Precipitation Education.
<https://gpm.nasa.gov/education/anime-winners>

Riek, L. D., Rabinowitch, T.-C., Chakrabarti, B., & Robinson, P. (2009). How anthropomorphism affects empathy toward robots. *HRI '09: Proceedings of the 4th ACM/IEEE International Conference on Human Robot Interaction*. 245–246.
<https://doi.org/10.1145/1514095.1514158>

This paper details the process and findings of an experiment that examined the effects of anthropomorphism on people's empathy towards robots. Participants in the experiment were shown various videos of robots of varying degrees of anthropomorphism and were given scenarios where the researchers could evaluate their emotional responses to the robots. The authors found that people are more empathetic towards an anthropomorphic or human-looking robot than a mechanical-looking one. The evidence shown by this experiment, that anthropomorphism does indeed have some kind of effect on humans, provides a rationale for my experiment. The experiment also found that in the event of an earthquake, people are more inclined to save the most human-like robot. This is a great example of the effects of anthropomorphism which I could incorporate into my project.

Sealey, A., & Oakley, L. (2013). Anthropomorphic grammar? Some linguistic patterns in the wildlife documentary series *Life*. *Text & Talk*, 33(3).
<https://doi.org/10.1515/text-2013-0017>

In this paper, Sealey and Oakley examine how anthropomorphism is built into spoken and written language as well as storytelling by analyzing the commentary of a wildlife

documentary. The authors focused on the usage of three grammatical features: pronouns, the connective “so”, and the infinitive “to.” The findings of this study corroborate the claim that humans tend to use the human experience to characterize non-human beings, especially animals. This paper provides an interesting insight into the prevalence of anthropomorphism. My takeaway is that anthropomorphism is everywhere and we don’t realize that we’re using anthropomorphic language all the time.

Taber, K. S., Trafford, T. de, & Quail, T. (2006). Conceptual resources for constructing the concepts of electricity: the role of models, analogies and imagination. *Physics Education*, 41(2), 155–160. <https://doi.org/10.1088/0031-9120/41/2/006>

This paper studies the approaches taken by two secondary school teachers in teaching electrical circuits to their students (11–14 year-olds). Students were asked to describe and explain various concepts and inner workings of electric circuits. They were also encouraged to use analogies, which is where anthropomorphism tends to happen. I would’ve liked this paper to include some images or figures that illustrate how a circuit works, as it is highly relevant to the examples provided by the students and teachers. The authors argue that the use of anthropomorphism has its place in science education as long as it isn’t taught as a fact or an acceptable explanation. Since anthropomorphism could be used as a starting point to get people to become more familiar with a subject, I wonder if the findings of my experiment will corroborate this statement.

Taber, K. S., & Watts, M. (1996). The secret life of the chemical bond: students’ anthropomorphic and animistic references to bonding. *International Journal of Science Education*, 18(5), 557–568. <https://doi.org/10.1080/0950069960180505>

In this paper, Taber and Watts discuss students' use of anthropomorphic language and evocation of animism in describing scientific concepts, particularly on the topic of interactions of chemical bonding. This paper features multiple transcripts of the researcher's conversations with multiple students. The goal is to identify the situations in which anthropomorphism can be beneficial and help to increase understanding of a particular scientific topic. I could draw from this paper lots of examples of the use of anthropomorphism in explaining scientific concepts.

Watts, M., & Bentley, D. (1994). Humanizing and feminizing school science: reviving anthropomorphic and animistic thinking in constructivist science education. *International Journal of Science Education*, *16*(1), 83–97. <https://doi.org/10.1080/0950069940160106>

Waytz, A., Epley, N., & Cacioppo, J. T. (2010). Social cognition unbound. *Current Directions in Psychological Science*, *19*(1), 58–62. <https://doi.org/10.1177/0963721409359302>

Wynne, C. D. L. (2004). The perils of anthropomorphism. *Nature*, *428*, 606–606. <https://doi.org/10.1038/428606a>

In this paper, Wynne criticizes the use of anthropomorphic language in scientific research regarding animal behavior. The author cautions that anthropomorphism ascribes consciousness to animals, which may not accurately represent or reflect their true nature. This paper helped me to recognize that anthropomorphism is in part, if not at large, based on assumptions. It could be argued that anthropomorphism is somewhat connected to anthropocentrism, which is an idea I could explore more going forward with my project.