Bulletin of the AAS • Celebrating the Wonder of Science in the Shadow II

Dance of Shadows: A Unique Way to Study Eclipse Using Household Items and a Bit of Creativity

Juie Shetye[1] Kayla Blundell[2] Margaret Goehring[2] Heidi Sanchez[3]

[1]Department of Astronomy, NMSU, Las Cruces, NM, 88003,
[2]Depart of Arts, NMSU, Las Cruces, NM, 88003, [3]Sunspot Visitor Centre, Sunspot, NM, 88349

Published on: Jan 09, 2025

DOI: https://doi.org/10.3847/25c2cfeb.374dc674

ABSTRACT

We explore the interdisciplinary approach of combining art and science to study and explain solar eclipses through the sculpture "Eclipse" by NMSU undergraduate artist Kayla Blundell. Inspired by observations at the Dunn Telescope, the sculpture features acrylic shapes representing the Sun's spectral wavelengths and a 3D-printed Moon. By reflecting sunlight, it visually demonstrates the interplay of light and shadow during an eclipse, including the chromosphere and corona. Our work highlights how art can effectively communicate complex scientific phenomena, making them accessible and engaging to a broader audience while enhancing public understanding of solar eclipses.

1. Introduction

A solar eclipse is a celestial event that occurs when the Moon passes between the Earth and the Sun, temporarily blocking the Sun's light either partially or entirely. During a total solar eclipse, the Moon completely covers the Sun, revealing the Sun's outer atmosphere, known as the corona, which appears as a glowing halo of light. This rare and awe-inspiring phenomenon has fascinated humanity for centuries, providing not only spectacular visual displays but also valuable opportunities for scientific study (Pasachoff, 2009). This article shows how artists can interpret phenomena by developing a STEAM (Science, Technology, Engineering, Art, and Mathematics) project.

Historically, the distinction between art and science was not as pronounced as it is today. In the Greco-Roman intellectual tradition, art (ars) was associated with the Greek concept of techne, encompassing practical knowledge and creation, including fields like language, medicine, and the arts. Science (scientia), translated as episteme, referred to theoretical understanding within the Aristotelian tradition. These concepts often overlapped and were not necessarily seen as opposites[1].

Solar eclipses are also deeply woven into mythology and cultural beliefs. In many cultures, eclipses are seen as omens or divine messages. The ancient Chinese believed that solar eclipses were caused by a celestial dragon devouring the Sun, and elaborate rituals were performed to chase the dragon away (Zhentao, Yau, & Stephenson, 1989). The Babylonians documented solar eclipses as early as 1375 BCE, interpreting them as signals from the gods (Stephenson, 1997). These mythological interpretations coexisted with scientific observations, reflecting the dual role of eclipses in both culture and science.

The Chinese were among the first to map star positions, as seen in divination records from the Shang dynasty. The Dunhuang Star Map from around 700 CE is one of the earliest known star maps, combining multiple astronomical traditions (Bonnet-Bidaud, Praderie, & Whitfield, 2009). Mesopotamian records from 1700-1500 BCE reference lunar phases, solar eclipses, and planetary movements, with the earliest star charts dating to the 7th century BCE (Evans, 1998). In the Americas, the Mayan Grollier Codex and Dresden Codex are early astronomical texts, with data recorded on stelae and buildings centuries earlier. The Mayans meticulously recorded solar eclipses, using them to align their calendar systems and enhance their astronomical knowledge (Bricker & Bricker, 2011).

During the Middle Ages in Western Europe, astronomy was rooted in Aristotelian philosophy and Ptolemaic theories. Geometric reasoning was highly valued, as was the study of computus, the study of calendrical calculation for determining Easter. The English monk Bede's "De Temporibus" from around 703 and the universal system under Charlemagne in the 9th century were significant contributions (Ramírez-Weaver, 2017). Increased contact between East and West during the Crusades led to the rapid advancement of astronomy in Europe, as the ancient Greek texts, as mediated by Arabic translations and mathematics, were reintroduced in Latin. Observations of solar eclipses continued to be significant in verifying and refining astronomical theories during this period. These events were documented meticulously, contributing to the broader dissemination and validation of astronomical knowledge across cultures (Kunitzsch, 2017).

Astronomy was also understood differently in popular culture, relating to agriculture and medicine, with celestial movements, including solar eclipses, believed to impact health. The "zodiac man" diagrams in numerous manuscripts illustrate this correspondence (Curth, 2005; Wee, 2015). Solar eclipses were often seen as powerful omens or divine messages, influencing agricultural practices and medical treatments. The Copernican revolution and the invention of the telescope transformed astronomy, more clearly separating art and science. However, astronomy remains closely linked to art through contemporary projects like Harvard's Aesthetics & Astronomy initiative, artist residencies at astronomical labs, university courses combining art and astronomy, and various pre-university STEAM initiatives. These initiatives highlight the ongoing connection between art and science toward understanding astronomical phenomena, with solar eclipses continuing to captivate the public and providing valuable opportunities for scientific research, bridging the gap between art and science.

In this article, we aim to merge the science of solar eclipses with artistic expression through the development of a sculpture titled “Eclipse” in an attempt to merge STEM with art as the ancients did. This sculpture, created by Kayla Blundell, is designed to visually represent the celestial phenomenon of a solar eclipse, using elements to illustrate the interplay of light and shadow, as well as the Sun's spectral wavelengths and the appearance of the Moon during an eclipse. Furthermore, we explore the educational impact of the sculpture by conducting a study involving diverse participants. This study assesses what educational understanding participants take away from their interaction with the sculpture. This allows us to effectively determine how the sculpture communicates complex scientific concepts related to solar eclipses. The feedback from this varied demographic will help evaluate the sculpture’s effectiveness as an educational tool, thus bridging the gap between artistic appreciation and scientific literacy.

2. Creating the Sculpture

The eclipse sculpture's creation process involved multiple steps and the utilization of various fabrication techniques, as its components were built from different materials (mixed media). The circular pieces were cut with a water jet machine for the pendant that hangs from the ceiling (see Figure 1, bottom left panels). Then, the side wall ring was cut and welded to attach all the pieces together. A suitable light source was found to achieve the desired luminosity.

The acrylic shapes extending from the pendant focused on the Sun's characteristics and how it appears during an eclipse. They were designed digitally, and a CAD program was used for laser cutting. The sculpture includes 14 strings, each 4 feet long, with 10 shapes per string, totaling 140 shapes, spaced evenly at 1.8 inches. They are connected together with nylon cord. The top left two images in Figure 1 show a closer view of the acrylic sheets, now grouped and prepared for assembly. This step includes the attachment of nylon strings or other components needed to hang the acrylic shapes.

Figure 1
Steps involved in building the sculpture with artist Kayla Blundell building it. Top left panels shows the acrylic sheets and design. Top right panels show moon cutout.

A 3D Moon model from NASA was modified, printed in four segments, and then glued, spray-painted, and sealed with epoxy resin. The bottom half of the Moon involved precise cutting, welding, and rod fitting. In the center, hand-cut acrylic half-moons were added with the artist's Dremel and glued to the metal (top right panels of Figure 1).

The base is made of steel rods and sheet metal. The circle faces of the base were cut with a water jet for precision. After cleaning and welding, the base was polished, and a circular pattern design was added using a wire brush on a grinder. Finally, a light pewter patina was applied for an antique look (bottom panels in Figure 1).

Figure 2
Top panel shows Pictroglyph of solar eclipse seen at Chaco Canyon dated AD 1097 (Image credit: Courtesy of University of Colorado) and Bottom Panel shows image of solar eclipse by the astronomer Gugleimo Temple in Spanish Observatory (Image credit: Courtesy of University of Colorado). Right panel shows Kayla Blundell's solar eclipse sculpture from 2024.

3. Studying Aspects of Solar Eclipses

In Figure 2, we present a journey through the artistic and scientific representations of solar eclipses across different historical periods, illustrating how ancient art has influenced contemporary artistic ideas and scientific understanding. The top panel of Figure 1 shows a petroglyph of a solar eclipse seen at Chaco Canyon, dated AD 1097. This ancient artwork exemplifies how indigenous people documented and interpreted celestial events, using their observations to create a lasting record. The petroglyph captures the awe and significance of the solar eclipse, reflecting the blend of art and astronomical observation that characterized ancient cultures. This depiction likely served both an artistic and a functional role, helping to preserve the knowledge of solar eclipses and their cyclical nature for future generations.

The bottom panel showcases an image of a solar eclipse taken by the astronomer Guglielmo Tempel at the Spanish Observatory. This historical photograph represents a significant advancement in scientifically documenting solar eclipses. The image captures the solar corona, revealing details that are crucial for scientific study. This photograph underscores the transition from purely artistic depictions of solar phenomena to more precise scientific documentation facilitated by technological advancements in astronomy.

The right panel of of Figure 2 features Kayla Blundell's 2024 solar eclipse sculpture. Our work is a modern interpretation that integrates artistic expression and scientific insight. Inspired by observations at the Dunn Telescope, our sculpture uses acrylic shapes to represent the Sun's spectral wavelengths and includes a 3D-printed Moon. By reflecting sunlight, the sculpture visually demonstrates the interplay of light and shadow during an eclipse, including the chromosphere and corona.

Figure 3 depicts the completed "Eclipse" sculpture created by artist Kayla Blundell. This impressive installation stands at 10 feet tall and showcases the integration of art and science to represent the solar eclipse and the light spectrum emitted by the Sun. The sculpture is suspended from the ceiling, anchored by a yellow circular light ring at the top. This ring represents the Sun and serves as the primary light source for the installation.

a.) Solar Spectrum: Sunlight is not white but made up of different colors.

Hanging from the light ring are multiple strings of acrylic shapes in various colors. The shapes were carefully arranged to represent different spectral wavelengths of sunlight. The colors transition from violet, indigo, blue, green, yellow, and orange to red, mimicking the dispersion of light into its constituent colors. This arrangement visually demonstrates the spectrum of colors emitted by the Sun, highlighting the scientific principle of light dispersion.

The arrangement of colors in the spectrum represents how different elements are observed from the Sun's atmosphere. The bright center of the Sun represents nuclear fusion, where light is generated from nuclear reactions at its core; this light spreads out into a rainbow of colors as it passes through the Sun's atmosphere.

The sculpture has a bright solar center that represents nuclear fusion where the light is created (see the radiance of the Sun in the right panel of Figure 2). Additionally, the sculpture is made up of colored acrylic shapes to capture the Sun's spectra. Starting from violet closest to the Sun, the colors progress through indigo and blue, green, yellow, orange, and red. This arrangement illustrates the continuous spectrum of the Sun's light and highlights the scientific principles of light absorption and emission by various elements in the Sun's atmosphere.

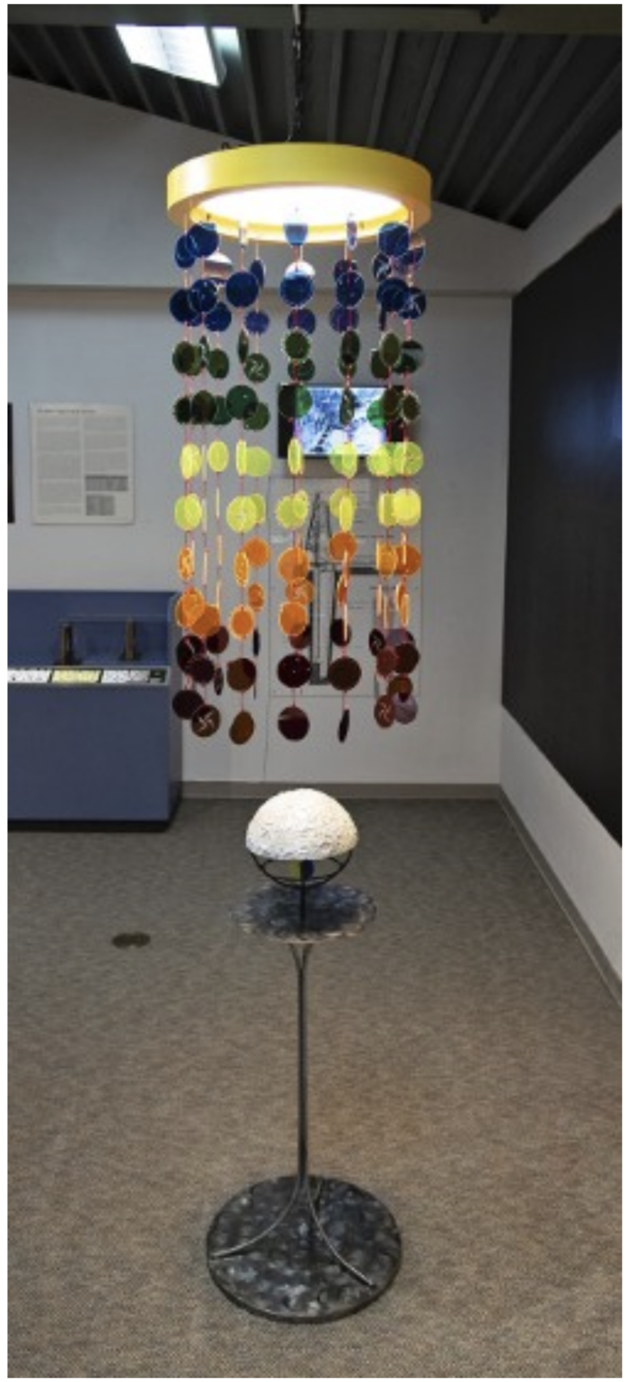

Figure 3
Eclipse sculpture showing the 10 ft setup and light spectrum.

b.) Depicting Moon and shadows:

In Figure 4, we show the 3D-printed Moon at the heart of our sculpture. This Moon is illuminated by sunlight from the center and reflections from the acrylic shapes. We portray the lower half of the Moon with negative space enclosed by metal rods, symbolizing the Moon's darkened silhouette during a total eclipse. This design element effectively captures the essence of a solar eclipse, where the Moon obstructs the Sun's light, casting a shadow on the Earth. The base of the sculpture features a circular pattern, echoing the cyclical nature of eclipses, reminding viewers of the periodic and predictable nature of these celestial events. When viewed from above, the sculpture reveals the Moon with its circular shadow, surrounded by the colored acrylic sheets, simulating the view of an eclipse from the Sun's perspective.

Figure 4
Moon and eclipse shadow setup, showing the 3D printed top surface and negative space showing eclipse.

The reflection of light is a pivotal aspect of our sculpture's design. As sunlight filters through the gallery windows, it bathes the acrylic shapes in a myriad of colors. Each hue represents a different spectral wavelength of sunlight, illustrating the intricate physics of light propagation and dispersion. By harnessing the reflective qualities of acrylic materials, the sculpture creates a visually stunning installation and facilitates a deeper understanding of the complex phenomena inherent in solar eclipses. The colored light cast by the acrylic shapes onto the 3D-printed Moon helps viewers visualize how the Sun's light is composed of various wavelengths, each absorbed or emitted by different elements in the Sun's atmosphere. This process of absorption and emission is crucial for understanding the solar spectrum and the information it provides about the Sun's composition and activity.

Moreover, the negative space on the Moon and the circular shadow pattern reinforce the concept of the umbra and penumbra—the two parts of the shadow during an eclipse. The umbra is the fully shaded inner region, while the penumbra is the partially shaded outer region. By depicting these elements, the sculpture provides an intuitive grasp of how eclipses work, making the science behind them more accessible.

c.) Features in the solar atmosphere:

In Figure 5, we depict various solar phenomena using the acrylic sheets in our sculpture. These phenomena, arranged from left to right, include solar flares, coronal mass ejections (CMEs), the corona, coronal loops, and sunspots from left to right in the Figure. Each feature plays a significant role in solar dynamics and has been simplified through colored acrylic shapes to enhance understanding and visualization.

Solar flares are intense bursts of radiation resulting from the release of magnetic energy associated with sunspots. They are the Sun's most powerful explosions, capable of releasing energy equivalent to millions of hydrogen bombs. These flares can affect all layers of the solar atmosphere (photosphere, chromosphere, and corona) and emit radiation across virtually the entire electromagnetic spectrum, from radio waves to gamma rays (Fletcher et al., 2011). In our sculpture, we represent solar flares with vivid, starry shapes shown on the leftmost side of Figure 5

Coronal mass ejections (CMEs) are significant releases of plasma and magnetic field from the Sun's corona. They often follow solar flares and can eject billions of tons of coronal material into space at high speeds, sometimes reaching Earth and affecting our planet's magnetosphere (Chen,2011). We use an explosion coming out of a circular shape to represent a CME, as shown in the second panel of Figure 5.

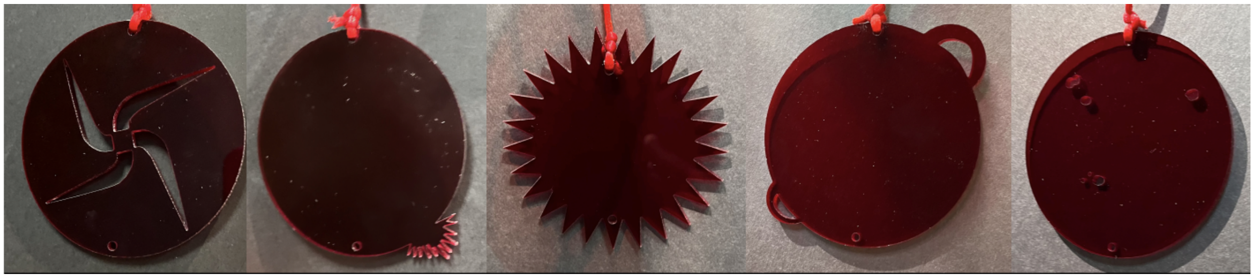

Figure 5
Representation of solar phenomena using acrylic sheets in the sculpture. From left to right, the figure illustrates solar flares, coronal mass ejections (CMEs), the corona, coronal loops, and sunspots. Each phenomenon is simplified and represented through colored acrylic shapes to facilitate understanding and visualization of solar dynamics.

Next, we depict the corona, the outermost part of the Sun's atmosphere, characterized by its high temperature and low density. Extending millions of kilometers into space, the corona is visible during a total solar eclipse as a pearly white halo. It plays a crucial role in space weather, influencing the solar wind and geomagnetic storms (Aschwanden, 2005). This is shown by a starry shape in our sculpture, as seen in the third panel of Figure 5.

Coronal loops are structures of plasma contained within magnetic field lines extending from the Sun's surface into the corona. These loops are associated with sunspots and active regions, often visible in ultraviolet and X-ray wavelengths (Reale, 2014). In our sculpture, coronal loops are represented by curved, looped shapes that rise above the circular shape, as shown in the fourth panel of Figure 5.

Finally, sunspots are dark, cooler areas on the Sun's surface caused by concentrations of magnetic field flux inhibiting convection. These spots appear dark in contrast to the surrounding photosphere and are often precursors to solar flares and CMEs (Solanki, 2003). Our sculpture uses dark, opaque acrylic shapes to represent sunspots, contrasting sharply with the surrounding bright colors to highlight their distinctive appearance.

3. Impact/Assessment

What did the Sunspot Visitor Center (VC) visitors learn about the sculpture?

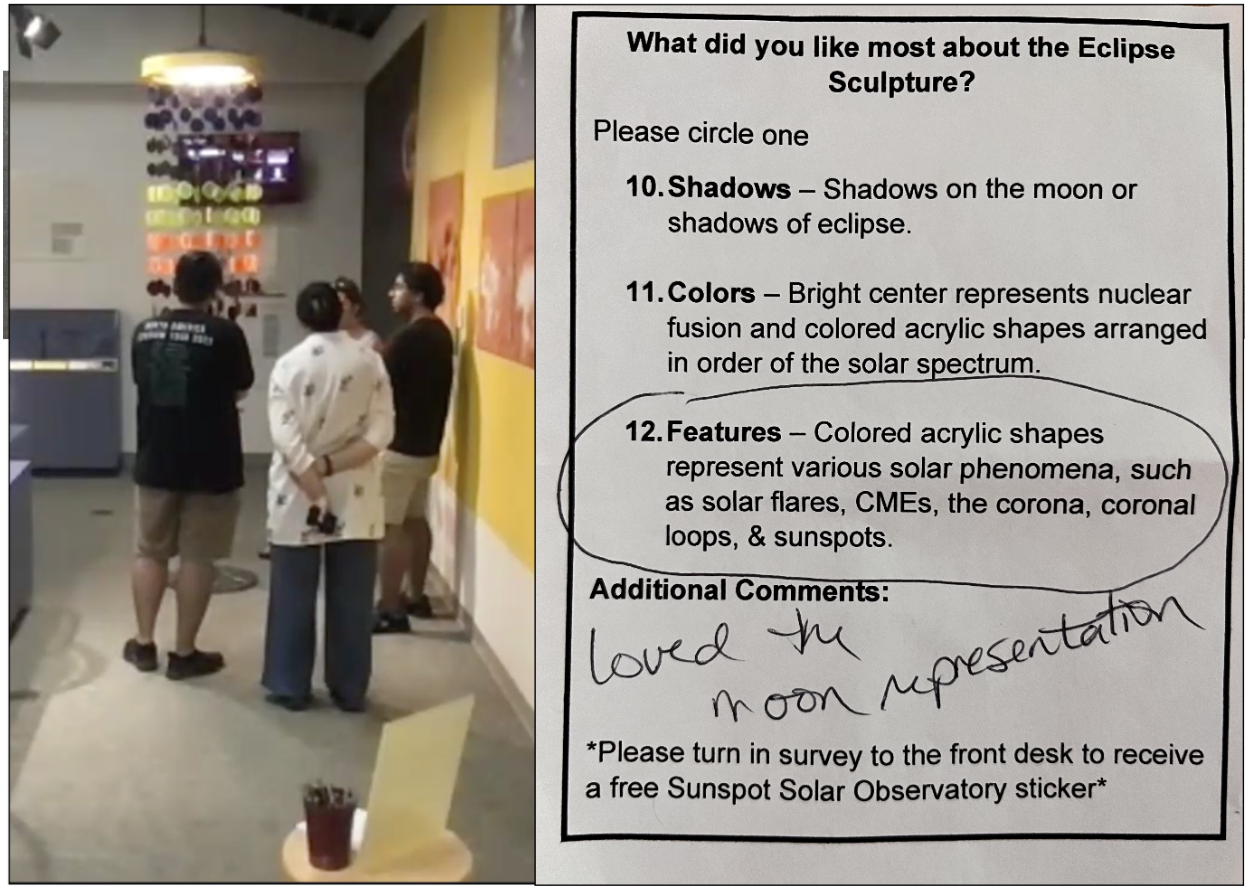

Figure 6
isitors viewing the sculpture. Left panel shows a group of visitors at the sculpture and right hand panel shows surely question.

The Eclipse was installed at the VC between 24 June 2024 and 28 June 2024. The total number of visitors was approximately 200. The data collected here asked the audience to describe one new educational take-away point from the sculpture, something new that they learned from the sculpture Figure 6). The options given were: Moon and shadows, colors/light spectrum, or features. The audience was asked to select one of the following:

a.) Moon and shadows: Shadows on the Moon or shadows of the eclipse

b.) Colors/Solar Spectrum: Bright center represents nuclear fusions, and the colored acrylic is shaped and arranged in order of the solar spectrum.

c.) Features: Colored acrylic shapes representing various solar phenomena, such as solar flares, coronal loops, CMES, and sunspots.

In Figure 7, we show the results of this little experiment. This bar graph illustrates the total number of votes received for each of the three categories: "Shadows, Moon or Eclipse," "Colors/Light Spectrum," and "Features." Each bar represents the number of votes each category received, showcasing the preferences or interests of the participants. Each category is represented by a bar showing the total number of votes it received. The "Colors/Light Spectrum" category, represented by the green bar, received the highest number of votes, with a total of 25. This indicates that the majority of participants were most captivated by the vibrant colors and the scientific concept of the light spectrum depicted in the sculpture. The "Features" category, represented by the red bar, received 20 votes, making it the second most popular aspect. This shows significant interest among participants in the intricate details and specific characteristics of the sculpture. The "Shadows, Moon or Eclipse" category, represented by the blue bar, received the least number of votes, totaling 11. Although it had fewer votes compared to the other categories, it still demonstrated an appreciable level of interest, highlighting that the eclipse and shadow representation had its own appeal to some viewers.

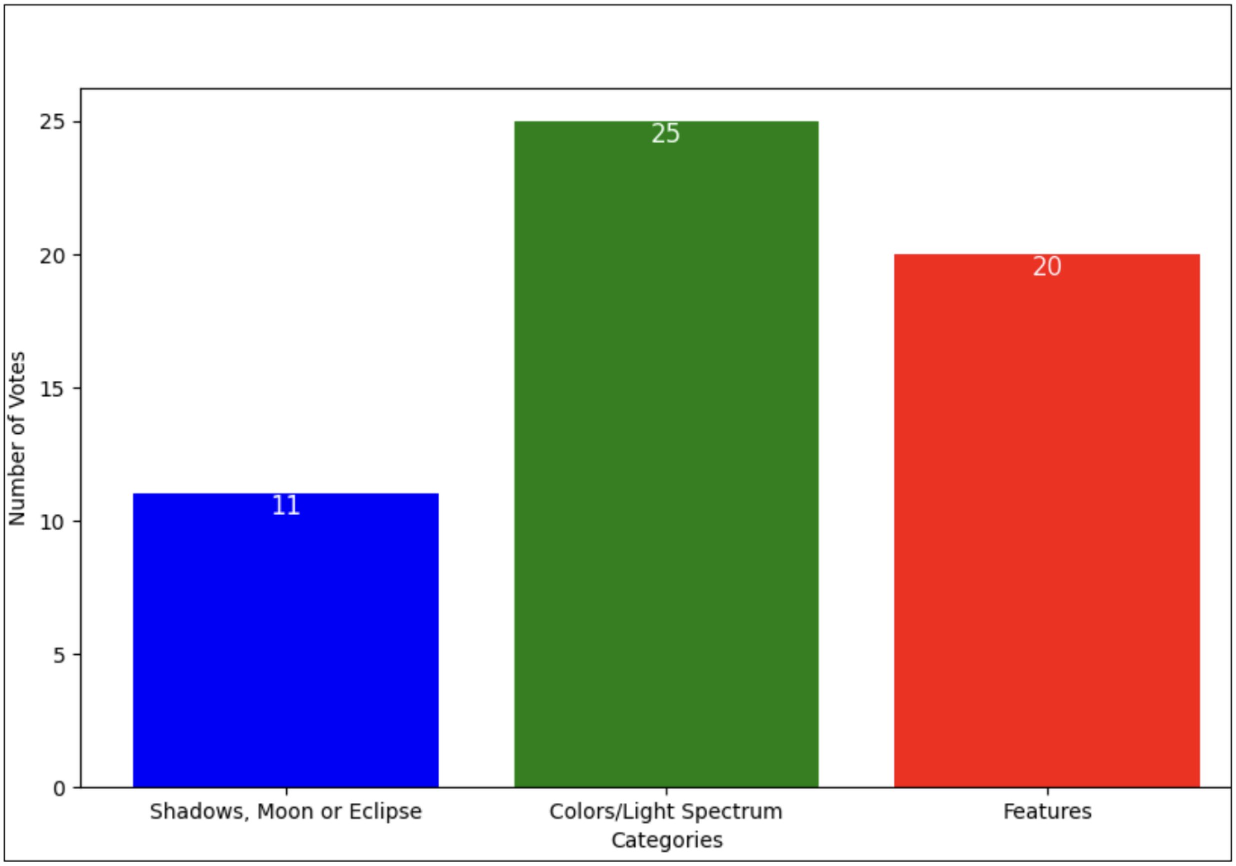

Figure 7
People voted for their choice of one educational takeaway from the sculpture.

Overall, the distribution of votes across all three categories indicates that participants appreciated different aspects of the sculpture, with a clear preference for the "Colors/Light Spectrum" component. This suggests that the use of vibrant colors and the visual representation of the light spectrum resonated well with the audience. The balanced interest across categories also highlights the sculpture's success in engaging viewers on multiple levels, whether through its scientific representation, artistic depiction, or detailed features. This insight can guide future artistic and scientific presentations, emphasizing the importance of colorful and visually dynamic elements in capturing and maintaining audience interest

4. Conclusion

The importance of our artistic representation lies in its ability to visually and tangibly demonstrate complex scientific concepts related to the solar spectrum and the behavior of solar phenomena. By using art to show how the Sun’s light is composed of different colors, The sculpture is aimed towards making the concepts of solar physics accessible to a broader audience. It transforms nine abstract scientific data into a form that can be seen and appreciated, thereby enhancing public understanding. Our sculpture engages viewers, encouraging them to explore and understand how light and color reveal vital information about the Sun and other celestial bodies. This fusion of art and science can inspire curiosity and foster a deeper appreciation for both fields, demonstrating that scientific principles can be communicated effectively through creative and visual means. The use of reflective acrylic shapes not only enhances the aesthetic appeal of our sculpture but also serves an educational purpose. As viewers move around the sculpture, the changing reflections and colors mimic the dynamic nature of solar light emerging from an eclipse, where the light and shadow continuously shift. This interaction helps illustrate the transient nature of solar eclipses and the interplay between light, shadow, and movement. Furthermore, the sculpture provides a simplified view of complex solar phenomena. Each structure, from a CME to a solar flare, is thoughtfully represented to convey its scientific significance, helping viewers understand the intricate and powerful processes occurring on and around the Sun. Our sculpture integrates art and science to deepen public understanding of solar eclipses. It transforms complex scientific concepts into a tangible and engaging form, demonstrating how art can effectively communicate intricate phenomena. By experiencing the sculpture, viewers better appreciate the mechanics of solar eclipses, the nature of light, and the beauty of celestial events, thus bridging the gap between artistic expression and scientific exploration. The visitors love the colors and features of the sculpture. Our aim is to conduct this survey for the next six months before the sculpture is moved to another location. This extended duration allows us to collect a substantial amount of data from a diverse group of visitors, ensuring that we have a robust sample size for our analysis. By engaging with a wide range of participants, we can gather comprehensive feedback on the educational impact of the sculpture. This time frame also provides ample opportunity to observe any seasonal variations in visitor demographics and responses, which could influence the outcomes of our study. The collected data will be analyzed to identify trends and patterns in how visitors at the VC study the Sun. Furthermore, the results of this survey will provide critical insights into the strengths and weaknesses of the current exhibit. This feedback will inform any necessary adjustments or enhancements to the sculpture's design, interpretative materials, or associated educational programs. By understanding how the sculpture is perceived and interacted with over an extended period, we can make informed decisions to optimize its impact in its next location. Overall, this six-month survey period is a strategic component of our research, aimed at maximizing the educational and outreach potential of the sculpture while gathering detailed, actionable insights to guide its future use

Acknowledgments

The Sunspot Solar Observatory's Visitor Center, the New Mexico State University (NMSU) Astronomy Department. The project was funded by the National Science Foundation’s Faculty Development in geoSpace Science (FDSS) grant #1936336, and is part of the Nationwide Eclipse Ballooning Project. We would like to tank Sunspot Visitor Centre staff: Tia Schawe and Liz Fernande who helped us in gathering the survey. KB would like to thank Professor Carissa 10 Samaniego, Josh Blundell, Riah Preciado, and their immediate family and extended family members for their support.

Footnotes

1. Richard Parry offers a summary of some of this complexity in “Episteme and Techne” The Stanford Encyclopedia of Philosophy (Spring 2024), https://plato.stanford.edu/archives/spr2024/entries/ episteme-

techne/ (Accessed June 21 2024); see also Eric Schatzberg, Technology: A Critical History of a Concept (University of Chicago Press, 2018), especially ch. 2. ↩

References

1. Pasachoff, J. M. (2009). Solar eclipses as an astrophysical laboratory. *Nature*, *459*(7248), 789-795. https://doi.org/10.1038/nature07987 ↩
2. Zhentao, X., Yau, K. C., & Stephenson, F. R. (1989). Astronomical records on the Shang dynasty oracle bones. *Journal for the History of Astronomy, Archaeoastronomy Supplement (Chalfont St. Giles)*, *20*(14), 61-72. ↩
3. Stephenson, F. R. (1997). *Historical eclipses and Earth's rotation* (Vol. 64). Cambridge: Cambridge University Press. ↩
4. Bonnet-Bidaud, J. M., Praderie, F., & Whitfield, S. (2009). The Dunhuang Chinese sky: A comprehensive study of the oldest known star atlas. *Journal of Astronomical History and Heritage*, *12*, 39-59. https://doi.org/10.3724/SP.J.1440-2807.2009.01.04 ↩
5. Evans, J. (1998). *The history and practice of ancient astronomy*. Oxford University Press. ↩
6. Bricker, H. M., & Bricker, V. R. (2011). Astronomy in the Maya codices. *American Philosophical Society.* ↩
7. Ramírez-Weaver, E. M. (2017). *A Saving Science: Capturing the Heavens in Carolingian Manuscripts*. Penn State University Press. ↩
8. Kunitzsch, P. (2017). *The Arabs and the Stars: Texts and Traditions on the Fixed Stars and Their Influence in Medieval Europe*. Routledge. ↩
9. Curth, L. H. (2005). The medical content of English almanacs 1640–1700. *Journal of the History of Medicine and Allied Sciences*, *60*(3), 255-282. https://doi.org/10.1093/jhmas/jri041 ↩
10. Wee, J. Z. (2015). Discovery of the zodiac man in cuneiform. *Journal of Cuneiform Studies*, *67*(1), 217-233. https://doi.org/10.5615/jcunestud.67.2015.0217 ↩
11. Fletcher, L., Dennis, B. R., Hudson, H. S., Krucker, S., Phillips, K., Veronig, A., ... & Temmer, M. (2011). An observational overview of solar flares. *Space science reviews*, *159*, 19-106. https://doi.org/10.1007/s11214-010-9701-8 ↩
12. Chen, P. F. (2011). Coronal mass ejections: models and their observational basis. *Living Reviews in Solar Physics*, *8*(1), 1-92. https://doi.org/10.12942/lrsp-2011-1 ↩

13. Aschwanden, M. J. (2005). Coronal Heating. *Physics of the Solar Corona: An Introduction with Problems and Solutions*, 355-406. Springer Berlin, Heidelberg. https://doi.org/10.1007/3-540-30766-4 ↩

14. Reale, F. (2014). Coronal loops: observations and modeling of confined plasma. *Living Reviews in Solar Physics*, *11*(1), 4. https://doi.org/10.12942/lrsp-2014-4 ↩

15. Solanki, S. K. (2003). Sunspots: an overview. *The Astronomy and Astrophysics Review*, *11*, 153-286. https://doi.org/10.1007/s00159-003-0018-4 ↩