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Enhancing Astronomy Education through an Interactive STEM Day Program

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Abstract

The Great Space Adventure was a dynamic STEM outreach event hosted at Eastern Kentucky University's Hummel Planetarium in collaboration with the Civil Air Patrol (CAP) Kentucky Wing. Designed to communicate the significance of the April 2024 total solar eclipse and introduce students to aerospace education, the event brought together university faculty, CAP cadets, students, and community members for a day of immersive, hands-on learning in space science, aerospace, and engineering. Participants rotated through a series of interactive stations, including physical eclipse modeling, indoor and outdoor rocketry, drone piloting, flight simulators, and 3D planetary modeling. These activities emphasized active engagement, scientific exploration, critical thinking, and problem-solving, with guidance from faculty, EKU student assistants, and CAP cadets. The event concluded with a live planetarium show that visually simulated the solar eclipse and deepened participants' understanding of celestial motion. By repurposing non-traditional learning spaces across the planetarium and engaging the public in informal science learning, The Great Space Adventure fostered community involvement, sparked curiosity, and made scientific concepts accessible and memorable. Whether launching rockets, flying drones, or exploring the cosmos virtually, attendees were encouraged to think like and act like scientists and engineers. This collaborative outreach effort not only supported space and aerospace education but also highlighted the versatility of the planetarium as a venue for STEM engagement. Feedback from students and community members affirmed the event's educational value and inspirational impact. Through fun, inquiry-based experiences, this program demonstrated how informal science outreach can motivate the next generation to explore STEM pathways and dream beyond the stars.

Keywords

Community Outreach, Informal Science Education, Space Science

1. Introduction

Eastern Kentucky University (EKU) is a regional institution that provides low socioeconomic and first-generation students an opportunity to pursue a quality education. Our university is deeply committed to engaging with our community and surrounding areas in a variety of ways. This science, technology, engineering, and mathematics (STEM) day was designed to build awareness and excitement about various aspects of STEM and advancements in technology. We designed a day of learning called *The Great Space Adventure*, where we were on a mission to create an immersive STEM outreach program with the support of the Civil Air Patrol (CAP) Kentucky Wing to promote scientific knowledge and engage with students and adults from the community. We were able to design an unforgettable day of communication and learning using the planetarium as a multi-functional venue for informal science learning.

The Great Space Adventure was a community outreach event held at the Hummel Planetarium on the campus of EKU. This thoughtfully planned event was extremely hands-on and it was created to communicate and educate valuable information about the April 2024 total solar eclipse and aerospace education. From discussions about eclipses to interactive, hands-on learning with rocketry, drones, and flight simulators, participants were engaged with outer space, aerospace, and engineering throughout the day. The event culminated in a live planetarium show where students, cadets, and community members observed the dynamic interactions between the sun, Earth, and moon. Through this innovative informal science outreach, we were able to communicate valuable science concepts, encourage exploration, demonstrate the dynamic capabilities of the planetarium, and create a fun and memorable experience for students and community members in an informal learning environment.

2. Support for Informal Science

Research supports student learning through hands-on, minds-on activities during informal learning experiences. Informal STEM learning environments, such as out-of-school programs, provide engaging opportunities for students to conduct investigations using everyday materials (Ramey-Gassert, 1997). These experiences can increase students' interest, self-efficacy, and awareness of STEM fields (Hussim et al., 2024). These informal experiences also support students who may struggle in traditional formal education (Hsi et al., 2012). Additionally, informal STEM learning can be crucial for promoting early STEM education, even before children reach school age (Hurst et al., 2019). In order to maximize the impact of informal STEM learning, Hurst and colleagues also recommended integrating cognitive and learning science-based practices, increasing accessibility and diversity of experiences, and creating connections between formal and informal learning opportunities.

3. Description of Outreach Event

3.1. Goals

From the outset, our goals for *The Great Space Adventure* were to craft an expe-

rience that would communicate and educate attendees on a special astronomical event, create hands-on, minds-on learning experiences in science and engineering, and engage and excite participants of all ages, with a particular focus on students between 12 and 17 years old.

Figure 1. Students collaborating.

While we could have easily collected content knowledge gains through pre- and post-surveys on eclipses (space science) and aerodynamics, or student attitudes toward science, this was not our goal during this event. Instead, we carefully selected a diverse range of activities, each designed to promote thought, collaboration (**Figure 1**), active participation, and interaction with scientific concepts in a dynamic and interactive environment.

3.2. Planning and Recruitment

The planning stages for *The Great Space Adventure* began approximately six weeks before the established date. Over the course of weeks, faculty discussed activities and logistics for the day. Once the general outline of planned activities was decided upon, faculty designed an agenda for timing, location, and transitions throughout the day.

We then created an informational flyer (**Figure 2**) and shared it amongst university departments via email. The event was posted through a university-wide announcement, the flyer was posted outside faculty offices, and it was disseminated through social media accounts on X, Facebook, and LinkedIn. This information was also shared with Civil Air Patrol (CAP) squadrons across the state to recruit students/cadets.

A QR code for event registration was included on the flyer for convenience and interested parties could contact EKU faculty, or CAP squadron leaders, with questions.

To maximize the registration window, but allow ourselves ample time for event

adjustments, we kept registration open for three weeks and closed it five days before the event. This allowed EKU faculty members and CAP Commanders to complete all final preparations based on participants' ages and grade levels, as well as finalize the agenda timing, activities, and lunch break during the day.

Figure 2. Outreach informational flyer.

3.3. Location

It was important to us that we highlight the versatility of the planetarium beyond the scope of the dome. While our planetarium does have a large classroom space, it was not large enough to accommodate the number of participants or planned interactive activities. Therefore, we maximized common non-educational spaces including the lobby, waiting room, and outside areas for this program.

Throughout the day, events were organized using a station format that rotated half-hourly. Participants were encouraged to visit all stations but had the option to choose stations based on individualized interests. If they were excited to do an activity again, we did not want to force them to move on because science and learning should be fun and stimulate interest.

The activities included solar eclipses using physical modeling—in the planetarium classroom, indoor rocketry—in the waiting room, outdoor rocketry—in the outdoor area, drones—in the planetarium classroom, flight simulators—in the simulator lab, and virtual three-dimensional modeling in the planetarium—in the theater.

3.4. Leadership

The various stations were led by university faculty based on our teaching experience and expertise. We recruited EKU student assistants based on their majors in education and aviation—they had a high degree of interest and knowledge to interact and educate the STEM-day participants. And CAP Kentucky Wing cadets who had leadership experience were tasked to lead certain sessions and provide logistical and instructional support throughout the day.

3.5. Description of Participants

In total, there was an amazing turnout of adults and students from the community and CAP in attendance (Table 1). Of the 10 community students, ages ranged from five to 12 years old, which required us to have some small group and more personalized dialogue to be age-appropriate. And of the 45 CAP cadets, approximately 40 fell between 12 and 14 years old, while the remainder were 15 to 17 years old. Due to a wide age range, all student participants had varying degrees of STEM knowledge and experience. However, this was not an issue as leaders were able to make adjustments in modeling, questioning, and activities to engage all students during the day. Overall, these demographics met our original expectations for the age of participants based on topics and activities selected.

Table 1. STEM outreach participants.

Participants	Number
University Faculty	5
University Student Assistants	5
KY Wing CAP Adult Members	15
KY Wing CAP Cadets	45
Community Students	10
Community Adults	10
Total	90

4. Description of Stations

With the day's focus on space science and aerospace education, we included a variety of activities for students to learn about aerodynamics, rocketry, eclipses, and the dynamic interactions of objects in space through hands-on, minds-on teaching. The combination of learning important introductory concepts and working through stages of the engineering design process, participants got to "act like" and "do science like" scientists/engineers as recommended by the Next Generation Science Standards (NGSS Lead States, 2013).

4.1. Eclipses

Many Kentuckians were able to view the previous total solar eclipse within the

path of totality in 2017 as that eclipse passed through the southwestern part of our state. Due to the crossing paths of totality in our state (Figure 3), and the fact that we could easily travel into Indiana or Ohio to view totality, one of the program highlights of our event was the exploration of eclipses. Any person who has not previously viewed a total solar eclipse will not have a chance to observe this phenomenon for many years unless they are willing to travel long distances in 2044 or 2045 (Gajanan, 2024).

By using interactive physical modeling and engaging discussions (Figure 4), participants gained a deeper understanding of these celestial phenomena, discovering the interactions between the Sun, Earth, and Moon.

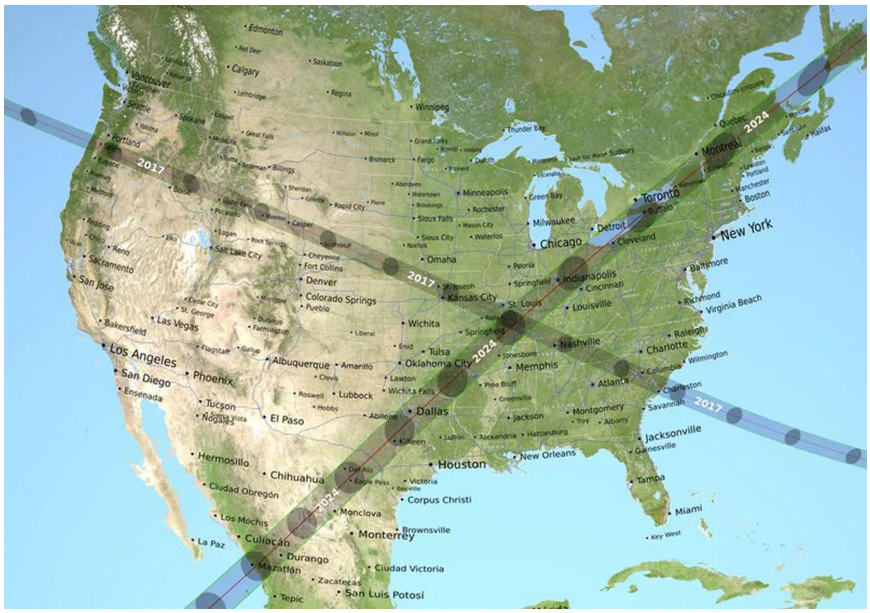

Figure 3. Paths of totality for 2017 and 2024 eclipses.

Figure 4. Physical modeling of eclipses.

Furthermore, students were presented with ideas to contribute to data collection methods as part of the NASA Globe Solar Eclipse Project (NASA, 2024; Civil Air Patrol, 2024a). This was an excellent example for anybody to engage in citizen science by getting community members to engage with the total solar eclipse. Research indicates that citizen science can enhance understanding of scientific practices while contributing data to ongoing studies (Schatz, 2018) and it can demonstrate the potential for meaningful scientific contributions by students (Brown & Liu, 2024). Additionally, Brown and Liu also report an increase in behavioral engagement following participation in citizen science projects.

While we did not track whether students who participated in our STEM-day collected and submitted eclipse data, we do know that many CAP members across the United States did participate in this large-scale citizen science project. It was reported that at least 4000 CAP members collected more than 250,000 data points from the eclipse, contributing data on air temperature, cloud cover and type, wind speed and direction, and precipitation (Civil Air Patrol, 2024b).

4.2. Rocketry

Another focal point of the program included an introduction to rocketry. There is a clear connection between space science and aerospace through engineering and design. Participants designed, constructed, and tested (indoors) or launched (outdoors) their model rockets. Guided by expert faculty, participants embraced the challenges with enthusiasm, learning valuable lessons in physics, aerodynamics, problem-solving, and the engineering design process throughout the day. This was an area where CAP cadets with rocketry experience through the CAP Aerospace Education curriculum were able to assist other station participants.

The indoor rocketry activity was set up accordingly—two chairs directly across from each other, separated by a distance of 25 feet, and connected by a string. The challenge was to propel a satellite as far as possible along a string (**Figure 5**) using their knowledge of propulsion, weight balance, and friction. This activity included components of the engineering design process from Engineering is Elementary (Museum of Science, 2020) and Model Rocketry curriculum (Civil Air Patrol, 2024c). Participants were guided through stations on brainstorming ideas, designing and constructing satellites, and testing whether their satellite could be successfully launched from one side to the other. Each satellite had a similar design (**Figure 6**), and students were tasked with redesigning and retesting their creation to improve results after initial testing, a key feature of the engineering design process.

The outdoor rocketry activity involved participants using various materials to construct a rocket body tube, nose cone, and fins. Once their design was completed, students were able to test the success of their design by using a stomp rocket launcher (**Figure 7**). Based on the results, and after observing others' designs, our young rocket engineers were encouraged to improve their design by revising and relaunching their rockets. It was very fulfilling to hear their questions, observe their rocket designs, watch the participants build and test the rockets, as well

Figure 5. Indoor rocketry.

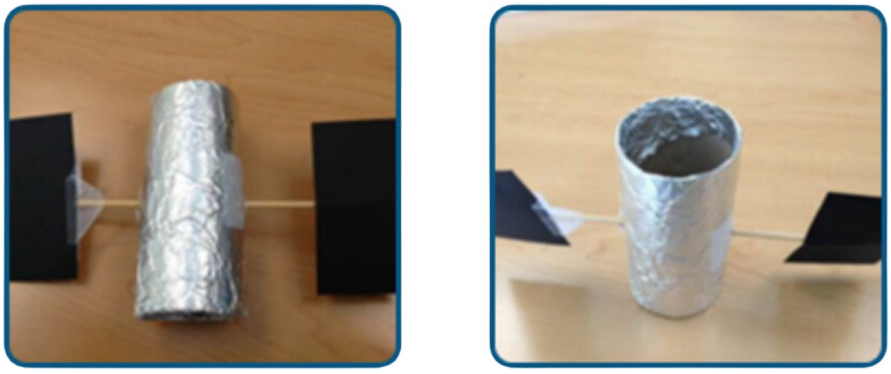

Figure 6. Multiple views of satellite.

Figure 7. Launching rockets outdoors.

as see their expressions as their creations soared into the sky. One of our younger students launched her rocket and exclaimed, "That was amazing!" (Torrellas, 2024).

4.3. Drones and Flight

Incorporating emerging technologies, such as drones, into our program provided students with a glimpse into the future of aerospace engineering. Although drone technology is not new, advancements continue and better drones have become affordable for the general public. This activity was unique in that it was student-led by CAP cadets who have experience using drones.

During this station, participants explored dynamics and forces of flight using indoor quadcopter drones (**Figure 8**) provided through the CAP Aerospace Connections in Education (ACE) program, as well as exploring concepts such as navigation, control, and autonomy. After this valuable content was presented and leaders modeled flight, the controls were handed over to other participants to practice flying.

Figure 8. Hands-on with drones.

In addition to learning about flight through drones, CAP Kentucky Wing cadets were also able to visit our university flight simulator laboratory. In this setting, cadets received instruction from EKU aviation students about basic airplane controls and the capabilities of planes during flight. Afterward, students were able to select a simulator (**Figure 9**) and fly freely in different types of aircraft (e.g., commercial planes and fighter jets) using their recently gained knowledge. "The experience was extremely valuable, and it increased my interest in pursuing a career in aviation", as this student has decided to attend EKU and major in aviation. It also had a positive effect on learning, as one student commented, "The simulator was very realistic, and it was cool. I literally knew nothing before, and after this expe-

rience, I feel that I know a lot". Furthermore, cadets received a tour of the Central Kentucky Regional Airport where they learned about aerodynamics and gained hands-on experience working alongside EKU Aviation faculty and students while exploring light aircraft.

Figure 9. Student on simulator.

4.4. Planetarium

In connection with the primary focus on eclipse outreach, attendees ended the day with a live planetarium show guided by an expert astronomer and planetarium educator. We are very proud of the Hummel Planetarium, as its 67-foot diameter and 194 seats make it the largest planetarium in the state. It truly is a magnificent space for informal science to take place.

The digital capability of the planetarium took students on a journey through the cosmos (flight) where they observed the night sky, learned about the dynamics of planetary motion (manipulation of time and dynamic modeling), and encountered awe-inspiring visuals that only a planetarium can provide (Thornburgh, 2017). Participants observed the interactions between the Sun, Earth, and Moon and they were able to witness the virtual modeling of the April 8, 2024 eclipse (**Figure 10**). This experience fully complemented the earlier classroom material and physical modeling of eclipses and sparked an increased interest in why eclipses occur. It helped everyone understand why the 2024 total solar eclipse could be a once-in-a-lifetime experience for those who have never seen one before.

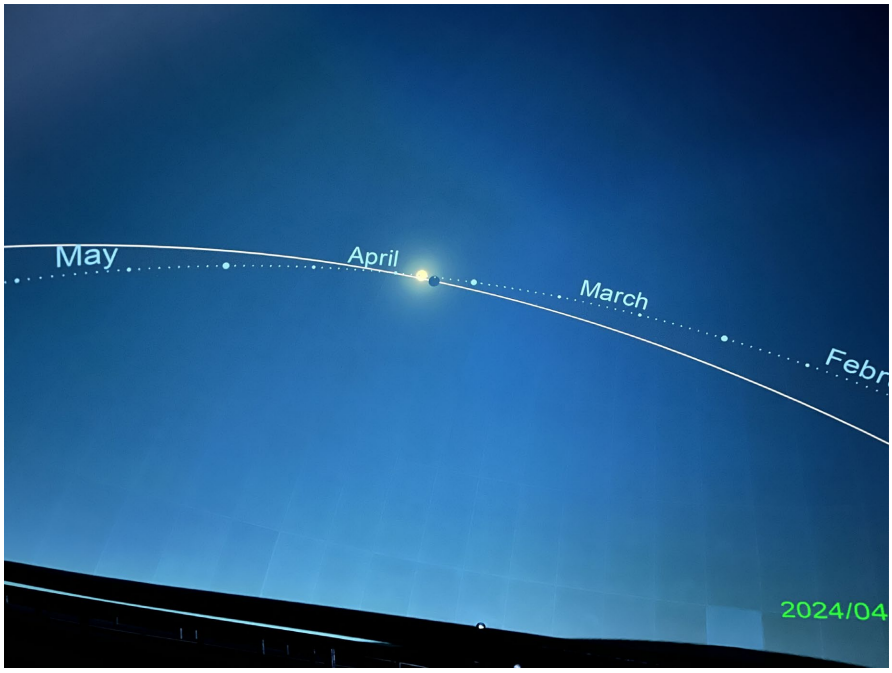

Figure 10. Virtual modeling of the April 8, 2024 eclipse.

5. NGSS Connections

The NGSS encourages student-centered and hands-on learning where students are "doing science" and "acting like scientists (and engineers)". To align with their goals, we purposefully included activities that aligned with the standards and where students could do both.

There are eight Science and Engineering Practices (SEPs) that represent skills and knowledge that scientists and engineers use to investigate the world and design solutions. During this STEM event, the SEPs present throughout the day included:

- Asking questions—in all stations,
- Developing and using models—during rocketry and eclipses,
- Planning and carrying out investigations—during rocketry and drones,
- Analyzing and interpreting data—in rocketry, flight, and in the planetarium,
- Constructing explanations—during eclipses, rocketry, drones, flight, and in the planetarium, and
- Engaging in argument from evidence—in eclipses, rocketry, and the planetarium.

Of the seven Crosscutting Concepts (CCCs), students were able to learn scientific concepts and make connections across science disciplines by:

- Observing and discussing patterns (eclipses, planetarium);
- Cause and effect (eclipses, planetarium, rocketry, drones, flight);
- Scale, proportion, and quantity (planetarium);
- Systems and system models (eclipses, planetarium, rocketry);
- Energy and matter (rocketry);

- Structure and function (rocketry, drones, flight), and;
- Stability and change (drones, flight).

While the CCCs tend to be overlooked in traditional classrooms and take a backseat to the SEPs and Disciplinary Core Ideas (DCIs), they are important in helping students see how they bridge various science disciplines and unite core ideas.

While the grade band is important to determine age-appropriateness, teachers have the ability to introduce topics at different times based on their students' abilities, and to determine the level of complexity in explanations and activities in regard to the DCIs. You have many options for chosen activities in a similar STEM event (formal or informal), but based on our student participants and STEM-day theme, here is a sample of DCIs and their alignment with the various stations:

- PS2.A: Forces and Motion—indoor and outdoor rocketry
- PS3.A: Definitions of Energy—rocketry, drones, and flight
- PS3.C: Relationship Between Energy and Forces—rocketry
- ETS1.A: Defining and Delimiting an Engineering Problem—rocketry
- ETS1.B: Developing Possible Solutions—rocketry
- ETS1.C: Optimizing the Design Solution—rocketry
- ESS1.A: The Universe and Its Stars—eclipse modeling and the planetarium
- ESS1.B: Earth and the Solar System—eclipse modeling and the planetarium
- ESS2.A: Earth Materials and Systems—eclipse modeling and the planetarium
- ESS3.C: Human Impacts on Earth Systems—drones

6. Limitations and Thoughts

The *Great Space Adventure* was a single-day event where students participated in a variety of activities over a six-hour period on a weekend day. We felt that a one-day event was most appropriate for our desired population and that six hours was a reasonable amount of time for engagement by students and service from our leaders and volunteers. The duration of the event—single versus multi-day, as well as the length of time each day—would impact the selection of different STEM activities, the scheduling of activities and how much time students get to spend at each, as well as the time (and possible financial) investment by parents, facilitators, and students. It is reasonable to think that more time would lead to increased engagement and learning; however, it could also contribute negatively to students' attitudes toward science based on fatigue, perceived fun/interest, and connections with others during the event.

While this was a valuable day of STEM learning and the focus of this article is practitioner-centered, there is ample opportunity for research and data collection. Beyond direct observation during the event and post-event follow-up with CAP Leaders, EKU faculty, and EKU student assistants, perceived success was based on anecdotal evidence and personal interpretation of those directly involved. And as a result of not having a comparison group of students, we cannot report on the effectiveness of informal teaching or measure differences in learning gains at the

conclusion of this STEM event.

7. Conclusion

One of our important roles as university faculty members is to communicate, educate, and engage with our community through outreach events. As we reflect on *The Great Space Adventure,* we were extremely pleased with the positive effect it had on students and adults in attendance. The success of the outreach was documented by faculty observations—student smiles, active engagement, and questions; CAP squadron commander communications—reporting post-event cadet comments; students' responses—onsite during activities; and local news station coverage (St. Claire, 2024; Torrellas, 2024).

We highly recommend that teachers and university professors consider offering similar STEM days, which could be centered around specific, unique occurrences (e.g., an upcoming eclipse) or could be general in nature (e.g., an engineering day). You can have a positive impact on improving content knowledge, building scientific skills, increasing interest in STEM and future STEM careers, and introducing the fun back into science education within an informal environment by conducting a similar event in your school/community.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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