An Astro-Animation Class
Optimizing Artistic, Educational, and Outreach Outcomes
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The authors investigate how teaching art and astronomy together has the potential to inspire new art forms, enhance scientific public outreach, and promote art and science education. The authors teach an astro-animation class at the Maryland Institute College of Art in partnership with NASA scientists. The animations explore science in creative ways. Astrophysicists, educators, students, and the general public were surveyed to evaluate the experiences and benefits from this project. The responses were very positive—the program is an effective way to stimulate art students to learn science, share an artist’s viewpoint beyond the classroom, and engage with the public.

TEACHING ASTRONOMY AND ART TOGETHER
Stunning imagery helps make astronomy one of the most popular sciences with both the general public and as a subject to study [1]. For example, the NASA “Astronomy Picture of the Day” Twitter account [2] has 1.29 million followers. But astrophysics is also about fundamental physical principles and measurements that are more difficult concepts to grasp, which can be an intimidating factor for some people [3]. Incorporating the arts with science in education is a great way to facilitate learning [4–6]. Including artists in the equation opens new possibilities and can generate motivation to explore science from a different angle and connect with a wider audience. “Science is too important to leave to the scientists. We need voices from the arts and sociocultural disciplines to provoke important debates” [7].

We teach an astro-animation class at the Maryland Institute College of Art (MICA). This undergraduate-level course began in 2014 in the Animation Department and now includes both introductory astrophysics, taught by a scientist, and studio components. NASA-affiliated scientists present their research to the class on topics such as black holes, supernovae, dark matter and gravitational waves. Students pick a topic and work in small groups with a scientist as a mentor. At the end of the semester, the animations are screened at NASA Goddard Space Flight Center’s Visitor Center. The animations are freely available at astroanimation.org and have been broadly used [8]. The animations have to be accurate to the science but can be whimsical, abstract, poetic, and inspirational rather than directly explanatory (Fig. 1).

Since the class has now been running for several years, we wanted to quantify its effectiveness. We therefore conducted a study examining how animation and astronomy can inspire art-making, enhance scientific public outreach, and promote both art and science education. We interviewed astrophysicists, educators, and animation students to document the expectations, experiences, and benefits of our program. We also made a comparison with an art/science class that is offered at the School of the Art Institute of Chicago (SAIC) and conducted interviews with the faculty members and students involved with this class. Based on the results of our research, we offer a set of recommendations and examples for other educational institutions wishing to initiate such programs and collaborations.

RESEARCH PROGRAM
Methods—Surveys and Interviews
We administered surveys to scientists, educators, students, and the general public. Surveys were available on paper and online, using scaled answers measuring both the direction and the intensity of opinions. Most people chose to answer the online version. For details see supplemental material.

One survey was administered at the Maryland Science Center (MSC) in Baltimore. We projected our animations on MSC’s “Science on a Sphere” system [9], which many visitors pass by (Fig. 2a). We also screened several of the animations on the same day at the MSC to an audience of middle-school teachers (Fig. 2b). The teachers were not provided with any additional scientific information.
We also carried out surveys at the GSFC Visitor Center and at a public outreach event at MICA associated with an astronomy conference (Fig. 3). The audiences at these events included mentor and non-mentor scientists as well as the general public. Short scientific presentations accompanied both events.

We interviewed MICA students and mentor scientists and used the interviews to explore more open-ended questions and to develop a better understanding of the overall responses. We also visited SAIC and conducted interviews with the students and instructors. We analyzed these interviews in the same ways. We transcribed the interviews and then coded the responses into a set of categories. This was done both manually and by using natural language computer processing as described in the supplemental material.

Analysis Results

**Highlights of Survey Responses**

In Figs 4 and 5 we show the details of the survey responses. From the scaled answers and the survey comments we identified the following major conclusions.

- **Students gained a lot from the class.** \((N = 10)\)
  
  “This experience has been very exciting and different, and taught me so much about incorporating science and astronomy into my animations.”

- **Mentor scientists also responded very positively.** \((N = 4)\)
  
  “Fantastic program. Students consistently deliver fascinating results. Communicating science to the general public is vital for both society and for scientists and this is one of the best ways to do so.”

- **Non-mentor scientists had valuable comments.** \((N = 27)\)
  
  “How effective the science part was (in terms of relaying scientific facts) varied from presentation to presentation of course. Sometimes this did not seem to be (and didn’t need to be?) the main focus but rather showing that these topics can be exciting, fun, relatable.”

  “One of the things I really like and is fairly unique is that most of the animations concentrate on artistic presentation and response to the science and not on being a science explainer or teaching tool. This is a really valuable and appealing approach

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**Fig. 1.** Examples of the animation styles produced by the students. [Compilation © MICA Animation dept.]

**Fig. 2.** (a) Survey with regular visitors at the MSC. (b) Teachers taking the survey at the MSC. [© L. Arcadias]
to science appreciation.” However, one scientist expressed concern about the potential for science to be misunderstood.

The school teachers were more reserved. (N = 37)

“It needs a little bit more detail. The animations were good, but many concepts are still vague.”

“The pirate ship looks cool. Quasars + Pulsars well done + beautiful. The concepts were probably a little too esoteric to really be illustrated in the short format for many of the concepts. An initial understanding of the factors at play was needed. The creative representation of the content was entertaining, humorous and artful, but concrete references to observable [phenomena] would help understanding.”

“Animations are a bit unclear to me, the topics were not clearly stated at all. Need more detailed descriptions.”

The general audience at the MSC expressed mixed feelings. (N = 25)

“These are cute and definitely spark interest! I still don’t understand the topic though so either people would need background knowledge to fully understand the videos or they could be used to spark interest to want to learn more.”

Audiences showed more enthusiasm when the animations were presented by both animators and scientists. (N = 15)

From the presentations at the GSFC visitor center and the outreach event, comments included: “I thought it was a great example of interdisciplinary collaboration, and a great way to energize creativity & spark interest in science by the general public.”

![Fig. 3. Surveys at a public scientific outreach event at MICA. (© L. Arcadias)](image)

![Fig. 4. Results from surveys of scientists and students. (a) Student survey. (b) Scientist survey. (c) Non-mentor survey. (© L. Arcadias)](image)
Fig. 5. Survey results and demographic information on survey participants. (a) Full audience survey results. (b) Sub-groups survey results and demographics. (© L. Arcadias)
We show a word frequency analysis of the open-ended survey responses in Fig. 6. The most frequent terms included suggestions for improvements (e.g. “more,” “but,” “not,” and “could”) and positive feedback (e.g. “understand,” “like,” “good,” “interest”).

Our primary conclusion from the surveys was that presenting astronomy via this type of animation is highly attractive to a range of audiences. We found that simply screening the animations on their own has a visual impact and may raise scientific awareness. However, for science learning and education it is essential to provide some additional context, which may be as little as a few explanatory sentences. When this is available, the overall responses are more positive.

**Highlights of interviews**

**Mentor Scientist Interviews.** Mentor scientists found the project to be an effective way to enhance science communication and outreach with the general public by offering a different perspective. They found that explaining the science concept to the students helped them to be more concise. Seeing the animation process and the range of techniques was revealing for them. Most wished to work with artists again and expressed their intention to use the animations for outreach and scientific presentations.

**Student Interviews.** Some students indicated that making an animation was a very effective way to learn about a science concept. While our goal for the class was for the students to have artistic freedom to pursue less-literal approaches, several students felt that their animations had to be strongly constrained to “stick to the science facts.” Recently, more animations have moved toward a freer interpretation.

Associating creativity with the research was inspiring to students, making them aware of their roles as artists connecting to science. Some students noted that scientists need artists to show their research in a more playful and effective way, and some saw an opportunity for further art and science collaboration.

Working with astrophysicists helped the students realize that scientists have broader backgrounds than they had expected. Collaborating with the scientists was reported to feel relatively easy. Some students mentioned their fear or embarrassment at the beginning of the project that they might either not understand the scientists or disturb them in their work. However, these feelings changed over time, and students appreciated the accessibility and the excitement of the scientists when looking at the students’ work. One student regretted not having more time to work more closely with a scientist during the process. For most students, the experience reinforced their understanding of the scope of animation with its potential for telling different types of stories. Some students liked the fact that the class teaches them to apply animation to other fields. The amount of work seemed challenging for a few students, but most students felt that the overall experience was very positive for them.

**SIMILARITIES AND DIFFERENCES BETWEEN SAIC AND MICA PROGRAMS**

The SAIC offers a combined studio/science course that shares some similarities with the MICA astro-animation class. For example, both programs are guided by an astrophysicist and an artist and count for six credits. However, there are some clear differences. The SAIC faculty situated their program’s objective on the art side of the art-science intersection, exhorting students to examine what happens when their artwork meets physics. In contrast, the aim of the MICA class is to push art students to greater science awareness as a source of inspiration and collaboration.
The SAIC syllabus mentions exploring research-based art practice as well as embracing the possibility of art itself as a form of research. This may give the SAIC students a certain freedom to express their ideas with a primary focus on art. The SAIC program is open to any art form while the MICA class produces animation exclusively.

The SAIC artwork has been utilized to a significantly lesser extent for science outreach than we have utilized with our MICA class. However, the SAIC work has been successfully exhibited at the Sullivan Galleries in Chicago.

Overall, it appears that both programs have strong value for the students involved, even though one is focused on art practice and research and the other centered on art/science collaboration.

**DISCUSSION**

### Highlights of Results

Our investigation showed a very positive reception, from both specialist and nonspecialist audiences, for the animations produced in our astro-animation class. Scientists were generally very supportive, although a few expressed concerns that sometimes the science was lost. Some audience participants commented on a lack of clarity in the science message; however, the goal for these animations is not necessarily to explain science but to trigger an interest in the subject and make it more approachable. To communicate the underlying science more clearly, the animations would preferably be supported by additional material or presented by people with science knowledge. This program offers an effective way for art students not only to learn science but to have a glimpse of “science in action” and potentially become involved in the process as artists. This already has happened in the short term with several students becoming summer interns at NASA.

### Challenges

Undergraduate art education in the United States typically requires that students take a science class. By combining astronomy with animation in a single class, our course seems to be the perfect fit. Despite the popularity of such programs and the desire of our institution to move toward an integrated model it remains difficult to schedule such classes in academic settings. A project such as the astro-animation class requires a high level of passion and commitment to face the many challenges that may arise in bringing together such a collaboration [10].

We were initially concerned that after a few years the scientists might lose interest in our project. However, while we started our class with a small number of NASA scientists, it has been snowballing to other groups, which helped us develop new topics such as commemorating the 50th anniversary of the moon landings in 2019.

During the Covid confinement, we were still able to deliver our class online, although not being able to visit NASA physically may explain a small drop in the course registration. Student public presentations through video conferencing were very popular the first year, perhaps because of the novelty of the situation, but somewhat less well-attended in the second year, perhaps because of virtual fatigue.

### Lessons Learned and Recommendations

Learning goals and measurement must be defined clearly. In our case, the science learning part was achieved by lectures, hands-on experiments, research reading and discussion with scientists. The measurement happened through weekly quizzes and a final test. The animation learning was achieved through the artistic science response and production of the animation, and the measurement of the animation happens through a series of rubrics: creative voice, pertinence of response, production quality, collaboration efficiency.

Proximity to dedicated scientists was crucial for the class success. NASA being about 30 miles away from MICA was important to initiate our collaboration.

Working communication between students and scientists must be established as soon as the first day of class. In addition to the face-to-face meetings, we use Google Drive to store the work and Tumblr to show the work in progress. For direct communication, both parties use email for questions and feedback.

Sharing the “how it’s made” component of the students’ animation work with audiences and the scientists is a great way to engage with people. It brings to light the art component in addition to the science.

Making the science class hands on with in-class physical demonstrations helped improve the students’ engagement and attention. This is a great way of understanding the physics concepts as well as encouraging students to conduct their own experiments. Having a playful attitude toward science has a direct connection with artistic exploration.

NASA online educational resources, in particular the Afterschool Universe [11], were found to be very valuable in augmenting the classroom learning experience. NASA’s extensive open-source material, such as its free sound images and video library, offers great opportunities for students to explore.

The outputs of such a class have a broad popular appeal. For example, the students presented their animations at events such as the Balticon and Escape Velocity science fiction conferences. This shows the students the power of using art to communicate important messages for public awareness.

### CONCLUSION

The results of the surveys and interviews on the astro-animation project show very positive perceptions and much enthusiasm from the scientists, the animation students, and the general public. The combination of animation together with astronomy produces very rich outcomes. Both the process of creating the animations and the resulting films have a wide variety of benefits. They facilitate the science education of the student artists, produce animations that are powerful in themselves, and encourage scientists to become more involved in communication with the general public. Moreover,
the increasing number of animations available is a resource that can continue to be used for outreach. The program has the potential to grow in multiple directions, such as STEM learning, or by expanding the artistic outcomes, supporting artistic visions, and raising worldview questions. With a stronger understanding of science, students are empowered to become activists in the cause of science- and evidence-based policies.

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References

1. National Research Council, "The Role of Astronomy Education," in Astronomy and Astrophysics in the New Millennium (Washington, DC: The National Academies Press, 2001): doi.org/10.17226/9839.
2. Astronomy Picture Of The Day: twitter.com/apod (accessed 1 April 2022).
3. Bob Fosbury, "Difficult Concepts," in IAU Commission 55: Communicating Astronomy with the Public (2005) pp. 130–134 (accessed 1 April 2022).
4. John Ceschini, "STEM + Art: A Brilliant Combination," Education Week 34, No. 13, 22–23 (2011): www.edweek.org/ew/articles/2014/12/03/13ceschini.html (accessed 1 April 2022).
5. Ruth Catchen, "Reflections – How STEM becomes STEAM," The STEAM Journal 1, No. 1, Article 22: 10.5642/steam.201301.22 (2013) (accessed 1 April 2022).
6. Anne Jolly, "STEM vs. STEAM: Do the Arts Belong?," Education Week Teacher (18 November 2014) www.edweek.org/tm/articles/2014/11/18/ctq-jolly-stem-vs-steam.html (2014) (accessed 1 April 2022).
7. Mike Stubbs, quoted in Gisela Williams, “Are Artists the New Interpreters of Scientific Innovation?,” The New York Times Style Magazine (12 September 2017) pp. 12, 134 (accessed 1 April 2022).
8. For further details see L. Arcadias and R. Corbet, “Animating Fermi—A Collaboration Between Art Students and Astronomers,” Leonardo 48, No. 5, 484–485 (2015) (accessed 1 April 2022); L. Arcadias et al., “Astro-animation—A Case Study of Art and Science Education,” Animation Practice, Process & Production, in press (2022): arxiv.org/abs/2104.06215 (accessed 1 April 2022).
9. NOAA, “What Is SOS?”: sos.noaa.gov/sos/. A.A. Simon-Miller et al., “Planetary Education and Outreach Using the NOAA Science on a Sphere,” 42nd Lunar and Planetary Science Conference, 7–11 March 2011, at the Woodlands, TX, U.S.A. LPI Contribution No. 1608, (2011) p. 1052 (accessed 1 April 2022).
10. Arcadias et al. [8] (accessed 1 April 2022).
11. imagine.gsfc.nasa.gov/educators/programs/au/ (accessed 1 April 2022).

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