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Bubbleworms and Rogue Planets: Using Science as a Creative Prompt in STEAM Education

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Abstract

The *Imagine Aliens* project invited participants to design alien planets, create extraterrestrial life forms, and develop artworks and stories to bring these worlds to life. By using science as a creative prompt, the study demonstrates that a balanced interplay of art and science can make STEM subjects more accessible and create deeper engagement with both disciplines. Conducted in Montreal schools, *Imagine Aliens* engaged students aged 6 to 13, using a custom website and playing cards to guide research and boost the creative process. This article highlights two findings: how the science-based prompts challenged and expanded upon students' perceptions of extraterrestrial life, and how the artworks became a site for research, imagination, and scientific curiosity. *Imagine Aliens* entangles academic disciplines, allowing each to influence the other equally, placing the learner's focus on research, curiosity, and imagination, unrestrained by disciplinary boundaries.

From the Moon to Alien Worlds

My very first academic article was published in *Canadian Art Teacher*. Titled *Moon Colony: Taking STEAM into Outer Space* (Forget, 2018), it was based on my Master's research in Art Education at Concordia University. In the article, I advocated for a meaningful integration of art and science in STEAM (Science, Technology, Engineering, Art, and Math) Education, one that integrated art from the beginning rather than reducing it to an aesthetic adornment. To illustrate this point, I described an astronomy-based art workshop that I had designed and presented to a group of adult artists and scientists. The one-day *Moon Colony* workshop invited the participants to imagine what role they may play on a fictional lunar outpost, and then to create an artwork that represented a snapshot of their life on the Moon. The article explored how creative prompts that sit on the intersection of art and science can act as catalysts for cross-curricular teaching and learning.

I am now completing my Ph.D. in Art Education at Concordia University, and my research continues to focus on the art-science intersection, and how creative prompts can foster teaching and learning in STEAM Education. However, in my quest to foreground the arts in transdisciplinary education, I have ventured further into space: alien worlds and the search for extraterrestrial life. My doctoral research project *Imagine Aliens* invites participants to design alien planets, populate them with extraterrestrial organisms, and then to create drawings, stop-motion animations, and science fiction short stories that bring to life the worlds they created. The Imagine Aliens study demonstrates how using science as a creative prompt can foster innovation and create an engaging learning environment for both art and science. This article highlights two findings: how the project's science-based prompts inspired innovative designs that challenged and expanded upon students' preconceived ideas about extraterrestrial life, and how the artworks became a site for research, imagination, and learning.

Are we alone in the universe?

The idea to focus my doctoral research on the subject of alien life was inspired by my work with the SETI (Search for Extraterrestrial Intelligence) Institute. The SETI Institute is a non-profit, multi-disciplinary research and education organization whose research areas encompass the physical and biological sciences. Its mission is to explore, understand, and explain the origin, nature, and prevalence of life in the universe (SETI Institute, n.d.). The Institute is best known for its Hat Creek Radio Observatory in Northern California, where scientists search for extraterrestrial signals hoping to answer the question, "Are we alone in the universe?". However, the

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SETI Institute is equally active in exoplanet research—the study of planets that orbit stars outside of our solar system, and astrobiology—the study of life beyond Earth. My initial interaction with the SETI Institute was during my MA studies, when I conducted a series of interviews with its scientists as part of my research. I have since become the Director of the Institute's Artist in Residence (AIR) program, which connects contemporary artists with SETI Institute researchers in order to catalyze new perspectives, insights, and modes of comprehension (SETI Institute, n.d.). Jill Tarter, one of the founders of the SETI Institute, explained why she supported the establishment of the SETI AIR program at the 2018 Life Beyond Earth event at the Montalvo Arts Center. She remarked "How can we conceive of something that we can't yet conceive? How can we think about what we don't know? Art makes that happen. It connects us through imagination." (J. Tarter, personal communication, April 27, 2018). Jill Tarter's statement emphasizes the relevance of art as a research methodology and the significant contribution it makes in the quest to discover alien life. Her standpoint parallels the SETI AIR program's mandate, which equally positions art and science as sites of knowledge production in a non-hierarchical structure. How could this balanced interplay of art and science serve as a model for STEAM Education? How could a curriculum that integrates art and science in equal measure make STEM subjects more accessible and create deeper engagement with both subjects? To investigate these questions, *Imagine Aliens* was designed to place art and science on equal footing so learners could seamlessly transition between the disciplines.

The Imagine Aliens project

Following my interest in Constructivist teaching approaches, which position the learner as an active participant in the construction of knowledge (Fosnot & Perry, 2005), I wanted to avoid delivering the science content through a series of lectures. Instead, participants would conduct their own research as part of their creative process. For the adult participants of the *Moon Colony* workshop, I had provided resources produced by space agencies and science journals, but this jargon-filled material was not a good fit for the age range that I was targeting for my study. Since stereotypes associated with academic disciplines solidify in early teenage years (Forget, 2021), I was interested in a younger population. The *Imagine Aliens* study took place in two primary schools and one middle school in Montreal, Canada, with participants ranging from 6 to 13 years of age. I therefore designed the website www.imaginealiens.com, which provides research materials written in a more age-appropriate style. The website provides information about exoplanets, biology, and sci-fi writing, and hosts a library of nature and astronomy images.

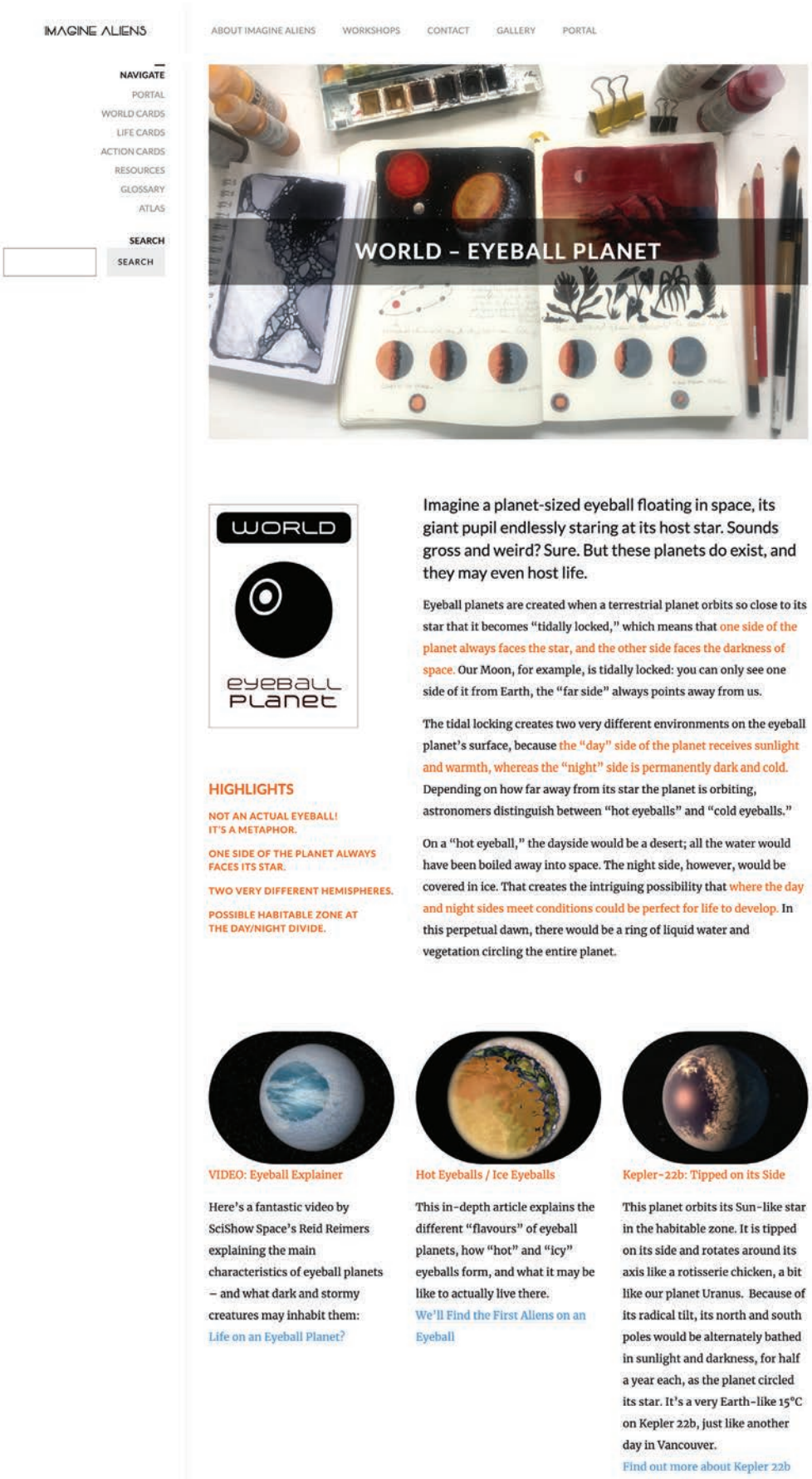

Figure 1. Example of a page on the www.imaginealiens.com website. This page accompanies the "Eyeball Planet" WORLD card.

Accompanying the website is a set of playing cards which direct the participant's research efforts and serve as catalysts for idea development. Together with the *Imagine Aliens* website, the cards act as a "constraint that enables" (Castro, 2007, p. 7) by providing a structural framework to guide creation while remaining sufficiently open for idea development.

Inspiration for the *Imagine Aliens* cards came from Yoko Ono's *Grapefruit* (1964/2010), her iconic book of poetic instructions; Brian Eno and Peter Schmidt's Oblique Strategies, a card-based method for promoting creativity (Frere-Jones, 2014); and the card set *The Thing from the Future*, developed by Stuart Candy and Jeff Watson (Candy, 2018), which prompts players to prototype artifacts from the future. All three are examples of what Candy calls "generative ideation engines" (Candy, 2018, p. 239) that provide simple, playful, open-ended instructions, calibrated to boost the creative process. The design of the *Imagine Aliens* cards was inspired by the minimalist icons and labels of the *The Thing from the Future* card deck. Designed in simple black and white, the cards are organized into three suits of twelve cards each: WORLD, LIFE, and ACTION.

Figure 2. The first iteration of the Imagine Aliens cards. The STORY cards were changed to ACTION cards in the third iteration.

The WORLD cards feature different exoplanet types, such as "Ocean World," "Lava Planet," or "Nearly Earth." The twelve exoplanet categories were developed following a review of literature on exoplanets including Elisabeth Tasker's *Planet Factory* (2017) and in consultation with Franck Marchis, Senior Planetary Astronomer at the SETI Institute. Conversations with astrobiologist Nathalie Cabrol, Director of the SETI Institute's Carl Sagan Center, and astrobiology textbooks such as Bennett and Shostak's *Life in the Universe* (2012) informed the design of the LIFE cards. The cards depict biological attributes and body parts, for example "luminous," "camouflaged," or "bubbles." The ACTION cards feature inciting incidents designed to spark story development. These include prompts such as "technical malfunction," "getting lost," and "time machine." This suit of cards was inspired by literature on science fiction studies, such as *Reading Science Fiction* by Gunn et al. (2008).

The *Imagine Aliens* cards are drawn in a specific order: first a WORLD card, then a LIFE card, and finally an ACTION card. This sequence is significant because the evolution of a life form is dependent on the parameters of the world on which it lives, and the development of a story first requires world-building and the establishment of characters. Therefore, each suit builds on the previous suit. To support the creative process, each card has a corresponding page on the *Imagine Aliens* website, where students can discover scientific information connected to their card and browse through a collection of videos, images, and guiding questions.

The design of the cards and the website evolved throughout the study in response to the feedback of the participants. The *Imagine Aliens* study followed the Design Based Research methodology which tests educational interventions in iterative cycles, and with the participation of a diverse team of collaborators including the teachers and learners (Barab, 2014). After each iteration of the *Imagine Aliens* curriculum, a focus group of participants provided feedback and made suggestions about how the project could be improved. Based on the focus group discussions, observations during class activities, and intermittent analysis of the artworks, I made adjustments to the design of the cards, the website, and the curriculum.

Science as art catalyst: From Typical Alien to Bubbleworm

The *Imagine Aliens* curriculum consisted of six to twelve sessions spread over four to six weeks, depending on the iteration. Each session began with a conversation, such as the likelihood of the existence of aliens, various motivations for space exploration, or whether technology could be considered alien life. Our discussions frequently revealed the impact of popular culture on the students' scientific knowledge base. For example, during a video presentation about life on the International Space Station, some students were surprised to see the astronauts floating in the station's microgravity environment and suggested spinning the station on its axis to create artificial gravity. Similarly, during a presentation about the Mars rovers, a discussion emerged where students were absolutely convinced that humans had

already landed on Mars and had established a colony there. In both cases, our class discussions traced these ideas to science fiction movies and books, including Arthur C. Clarke's *2001: A Space Odyssey* and Andy Weir's *The Martian*. According to Janowska et al. (2019), these types of misconceptions are unsurprising. In the absence of direct experience with astronomy, children's mental representations of space are informed by popular media, a mixture of science illustrations, science-fiction imagery, and fairy tales. The authors note that creative practice requires a basic knowledge base, which in the case of astronomy is often lacking, especially in children. As a consequence, children default to popular culture tropes to fill in those gaps.

The *Imagine Aliens* project provided an astronomy knowledge base to facilitate the creation of complex, innovative planets and aliens that challenge the default stereotypes promoted by popular culture. In order to support the students' creative process, they were provided with personal notebooks and collaborative team sheets, where they could work on their planet and alien designs, take notes, brainstorm story ideas, and sketch out their storyboards. The notebooks, nicknamed "Explorer's Journals," provided students with a private, judgement-free space for idea development and visual research. Graphic notation and doodling during class discussions can help students to experiment and focus on their ideas rather than concentrating solely on their final artwork (Esselink, 2022). The notebooks and team sheets allowed the participants to experiment and provided me with fascinating insights into their idea development from the initial research phase to the final stories and animations.

During the three *Imagine Aliens* iterations I noticed that similar alien designs kept reappearing in the participants' images and narratives. This led me to conduct an in-depth content analysis of the artworks. I organized the alien designs into categories, an approach that was informed by Hayes' (2013) *Alien Ecosystem Project* and Giang et al.'s (2023) *Think of a Robot* study. Both studies organized student drawings into categories based on the alien's or robot's features, such as whether it was humanoid, an animal mash-up, or whether it directly referenced a fictional character. In my dataset, the pop-culture inspired designs included the humanoid "Little Green Man," the amorphous "Cute Blob," and the fanged "Monster (Humanoid)." By clustering the designs by category, I was able to identify the influence of popular culture tropes and trace the aliens' evolution from the initial sketches to more innovative forms. In fact, the largest cluster was the "New Invention" category, where students generated life forms that bear little resemblance to existing sci-fi or fantasy characters.

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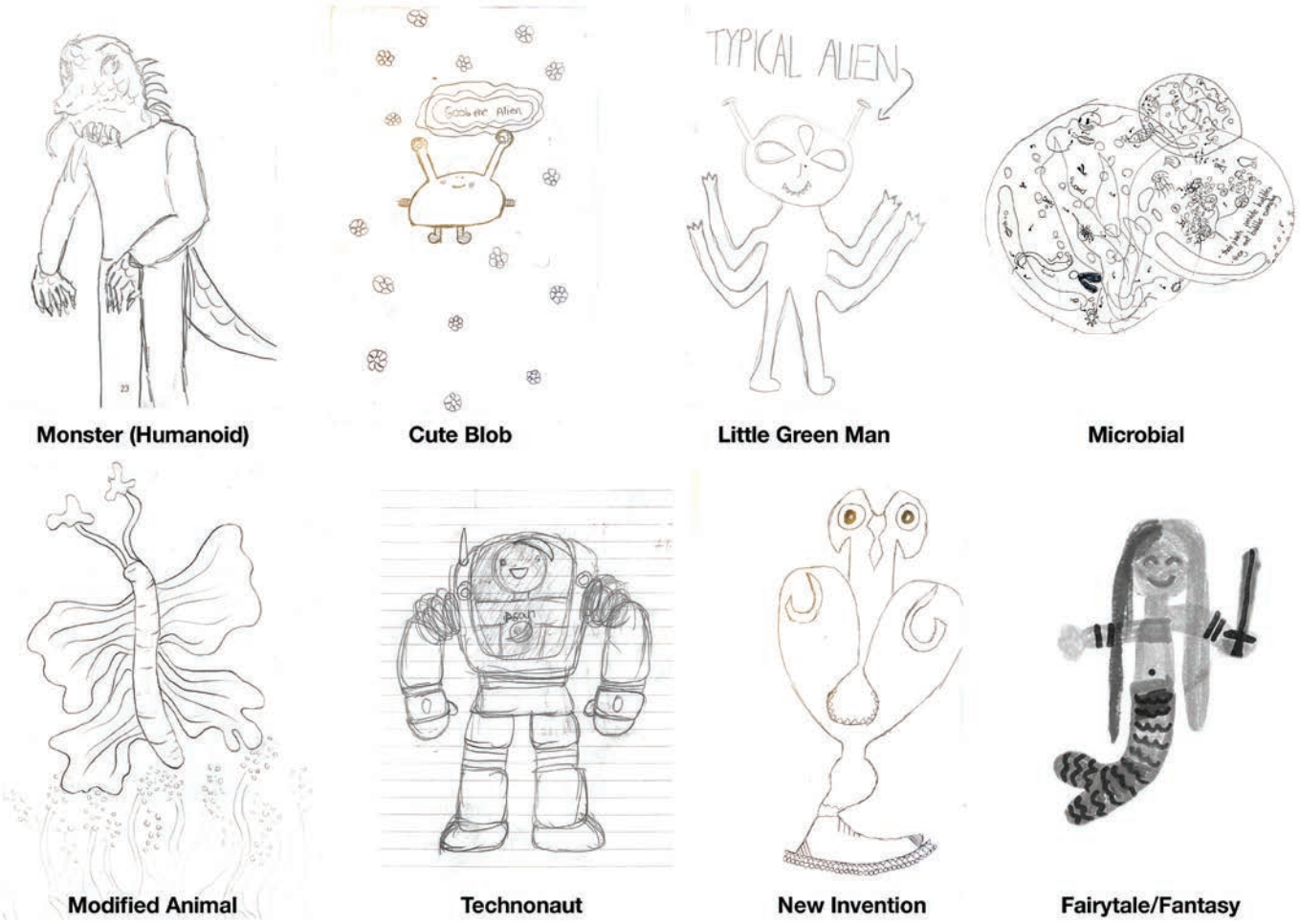

Figure 3. Organizing aliens into categories allowed me to trace popular culture influences and track the development of more innovative alien designs. Image printed with permission.

The evolution of seventh-grader Emily's [1] alien is an example of a transition from the "Little Green Man" to the "New Invention" category. Emily created her "Typical Alien" drawing during a "Draw and Alien" exercise during the first session of the curriculum.

This exercise was designed to create a baseline of the students' initial concepts of the "alien." In the following sessions, Emily drew the WORLD card "Nearly Earth" and the LIFE cards "Spikes" and "Floating." Based on the WORLD prompt, she created an Earth-like planet with a beach of blue water and pink sand that stretched into a vast desert. Inspired by her LIFE cards, she designed a flat, worm-like creature with long stalks on its back that were topped by translucent bubbles. In her short-story, she described the creature as "bubbleworm," a desert dweller that lures its prey by resembling a patch of water. She explained:

> "It's like a big worm, and it eats small desert animals. Once there is a small desert animal in sight, it goes into a small hole, covers itself in its weird bubble antenas, and the animal approaches what seems like water. As it's about to take a sip, the real bubbleworm comes out and eats it practically whole."

[1] The name of the participant has been changed.

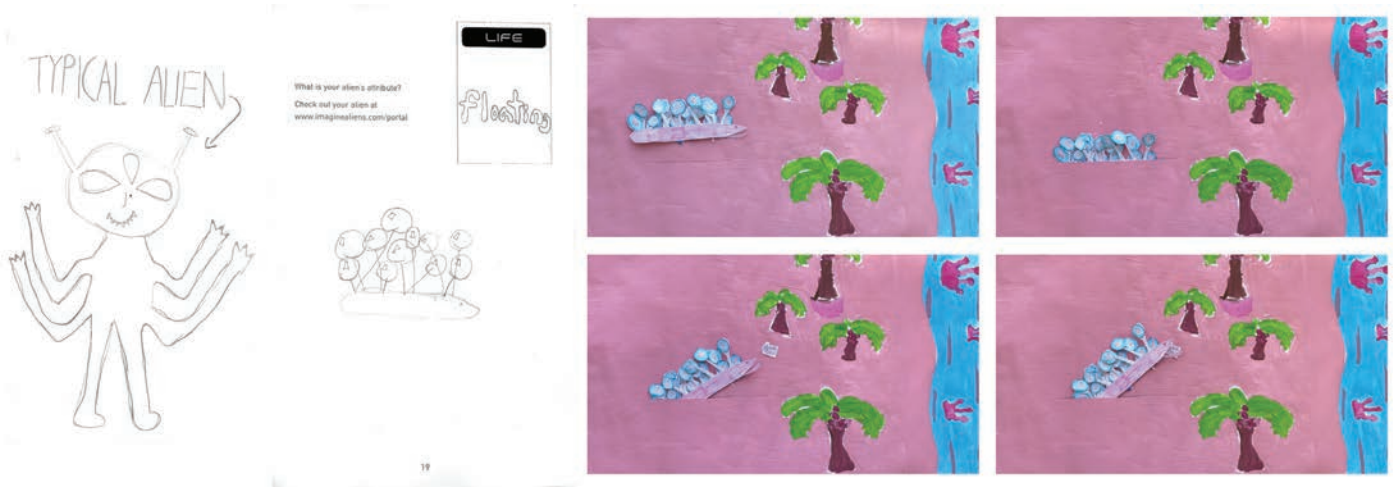

Figure 4. Emily's Explorer's Journal sketches and stills from her stop-motion animation, which shows the bubbleworm hiding in the sand and then suddenly leaping up to catch its prey. Image printed with permission.

It is possible to trace the inspiration for the bubbleworm's design elements to the WORLD and LIFE cards' web pages. For example, the "Bubbles" page mentions a creature using air sacks, and the "Spikes" page features two videos about cacti and deserts. In her search for inspiration, Emily browsed through science texts, images, and videos that informed her unique design choices. Her bubbleworm is far more innovative and complex than the "Typical Alien" she drew in the first class. Her animation and sci-fi story also demonstrate an understanding of evolution, as the alien's lure and predation strategy is perfectly adapted to its desert habitat. Science concepts were integrated in nearly all of the participant's artworks. Examining student artworks can provide a compelling approach to identifying science learning and become a site of conversation and problem solving when they reveal logic errors.

Artworks as sites of learning: Rainbows in the dark

A Rogue Planet painting by a team of sixth-graders demonstrated several scientifically incongruous elements. A rogue planet is an exoplanet that does not orbit a star but floats through space in complete darkness. The team spent a considerable amount of time debating how to depict this type of planet. Half of the team was unwilling to paint a "boring," dark planet and insisted on using fun, bright colours. Some team members felt strongly that the painting absolutely needed a star, a nebula, and constellations to make the space scene look realistic. After much debate, the team compromised on accompanying the rogue planet with a dark, brown star but maintained the planet's rainbow-colour palette. When I sat down with the team for a check-in, we began by talking about the brown star. I explained that it was an astronomical object that actually existed.

Named brown dwarfs, these objects are "failed stars" that do not contain sufficient mass to launch the thermonuclear reaction necessary to ignite them into a star (Tasker, 2017). Therefore, the team had accidentally stumbled upon a scientifically correct solution: brown dwarfs are not stars, so the *Rogue Planet* was still a rogue. The planet's multicoloured surface, however, posed a conundrum. "If there is little or no light," I asked, "how can you see the planet's bright colours? After all, you need light to see colour." In a traditional science class, this logic error may have counted as a failure. The team looked a bit crestfallen. However, following the adage "There are no mistakes in art, only unexpected results," I shifted our conversation into the space of possibilities. "How can the painting still be 'right'?" I asked the team, "Can you imagine a scenario where we could still see the colours?" Soon, one of the students had an idea. What if this space scene had been painted by an alien? The alien may have different kinds of eyes that allow it to see in the dark. We briefly discussed animals on Earth whose visual perception extends beyond human vision, such as bees who can see in the ultraviolet. We were off to a good start. I then reminded the team of a science fact from the Rogue Planet's webpage. "What happens in dark caves, or very deep in the ocean?" That sparked the second idea: bioluminescence. The planet could glow in the dark due to chemical processes, just like jellyfish and zooplankton that live in the deep sea. Our conversation of possibilities transformed a logic error into a more compelling story and a deepened engagement with science. As Long (2022) noted, failure should be reframed as "productive and positive signposts of learning" (p. 20), and be understood as an integral part of the creative process. By using science, imagination, and problem solving, we increased science learning as well as creative innovation, using the artwork as a visual cue for our exploration of ideas.

Figure 5. A rogue planet as seen through the eyes of an alien. Or, it may just glow in the dark. Image printed with permission.

Transdisciplinary entanglements

The *Moon Colony* workshop investigated how the integration of creative prompts in a STEAM Education project acted as a launch pad for idea development and fostered transdisciplinary learning. The *Imagine Aliens* project took this concept a step further, tracing learning and innovation against a background of existing information - and misinformation - that shaped learners' ideas about our world, and worlds beyond our own. The participant's engagement with science sparked more innovative artworks, and the artworks themselves became sites for learning and discussion. Teaching and learning became process-oriented rather than goal-oriented, positioning both art and science as methods of discovery. *Imagine Aliens* entangles academic disciplines, allowing each to influence the other equally, placing the learner's focus on research, curiosity, and imagination, unrestrained by disciplinary boundaries.

I hope that cross-curricular projects that position art and science as equal sites of knowledge production will gain in popularity. As veteran art educator Lorrie Blair noted in her conversation with Amy Atkinson (2023), art education has evolved little in the last 50 years, and the field requires a radical re-think. Blair proposed that educators should teach students the skills to imagine their future. Process-oriented teaching across disciplinary boundaries may be a promising way forward.

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