K12 Education for Space Settlement: An Ideas Unlimited Study

Mark Wagner, Brendan Brennan, Athena Brensberger, Joshua Dahn, Andrew Dobbie, Rosalyn Freeman, Janet Ivey, Bob Krone, Holly Melear, Rod Pyle, Steve Sherman, Rhonda Stevenson, Scott Thomas, Barbara Hopkinson Wagner, Artemis Westenberg, and Heather Wolpert-Gawron

Introduction

The purpose of this study is to explore how best to prepare current K12 students for humanity's multi-planet future. It begins with a review of literature in the field of space philosophy that demonstrates the benefits of space exploration, and thus the importance of educating students to be contributing participants in the coming settlement of the solar system and beyond. The study then includes the results of an original qualitative investigation of expert opinion using the Ideas Unlimited method and a grounded theory approach to generate actionable policy recommendations for educators and education leaders.

Literature Review

As Arthur has pointed out, the philosophy of space is a new and still developing discipline.[1] However, the space age is a historically significant period in human history that philosophers must confront.[2] Of primary importance to the practice of space philosophy is the question of why human beings should explore space, or whether we should. The purpose of this literature review is to answer that question based on a body of previous space philosophy, and to also consider the question through the lens of education; asking whether children should be educated for space exploration. In addition, some results of the review suggest how best to educate students for full participation in—and contribution to—the new space age of the next two decades, a time it seems will be characterized by an increase in activity from space agencies around the globe, expanding commercialization of space, and the return of crewed missions beyond low Earth orbit ... to the Moon, Mars, and beyond.[3]

Benefits of Space Exploration

For a generation, children have been taught that the benefits of the space program include Tang, freeze-dried ice cream, and Velcro. While these products obviously fall far short of capturing the most important benefits, this sort of pragmatic justification is often

[1] Gordon Arthur, "Why Go to Space? The Academic Philosophy of Space Travel," *Journal of Space Philosophy* 10, no. 1 (2021): 54–68.

[2] Florence Hetzler, "Man and Space," *Dialectics and Humanism* no. 2 (1982): 51–64.

[3] Rod Pyle, *Space 2.0: How Private Spaceflight, a Resurgent NASA, and International Partners Are Creating a New Space Age* [Kindle Paperwhite version] (Dallas: BenBella Books, 2019). https://amazon.com.

the first response of space philosophers when asked why investment in space exploration is worthwhile. Spin-off technologies now found in daily life are often cited as clear benefits, including medical advances;[4] improved agricultural practices;[5] the ability to monitor the environment, weather, and pollution from space;[6] the Global Positioning System used for navigation;[7] and the increasingly space-based infrastructure of many government agencies and the public internet.[8] It is becoming difficult to imagine industries that are *not* likely to be affected by space technologies (particularly satellites) in the next two decades. In addition, government—and now commercial—spending on space exploration has another practical benefit: it drives both economic growth and scientific training in the workforce.[9]

Perhaps one of the biggest benefits of the space program so far is less tangible, but rather a change in the way the general population perceives the planet Earth and the place of humanity in its biosphere. From Russia's first cosmonaut Yuri Gagarin, who wrote of the transformational beauty of the Earth and his desire to see it preserved, to Shuttle astronauts, like Saudi Arabian Prince Sultan bin Salman Al-Saud, those who have been to space have often reported a change in perspective that transcends national borders and ethnic divisions.[10] Dubbed the Overview Effect by White, this cognitive shift in awareness became available to a whole generation when the general populace first saw photographs and videos of the Earth from the moon, leading to an ongoing change in public opinion evident in the international environmental movements of today.[11]

This shift in consciousness is just one of the ways space exploration has already benefited efforts to protect humanity's threatened environment on Earth. Satellite data are already critical to monitoring and addressing climate change. In fact, it is a false dichotomy to think that we must choose between investing in space exploration and investing in the protection of the environment on Earth.[12] Munévar sees space exploration as a means to a cleaner future on Earth,[13] later arguing that resources from around the

[4] Hetzler, "Man and Space"; Pyle, *Space 2.0*.
[5] Pyle, *Space 2.0*.
[6] Hetzler, "Man and Space"; Pyle, *Space 2.0*.
[7] Pyle, *Space 2.0*.
[8] Frank White, "The Overview Effect and the Future of Humans in Space," in *Beyond Earth: The Future of Humans in Space*, ed. Bob Krone, Edgar Mitchell, Langdon Morris, and Kenneth Cox (Burlington, ON: Apogee Books, 2006), 38–40; Pyle, *Space 2.0*.
[9] Pyle, *Space 2.0*.
[10] Walter Peeters, "Space Science as a Cradle for Philosophers," *Astropolitics* 10 (2012): 27–38, doi.org/10.1080/14777622.2012.647393; Pyle, *Space 2.0*.
[11] White, *The Overview Effect*.
[12] Arthur, "Why Go to Space?"
[13] Gustavo Munévar, "A Philosopher Looks at Space Exploration," in *Evolution and The Naked Truth*, ed. Gustavo Munévar (Aldershot: Ashgate, 1998), 169–79.

solar system can be used to resupply the environment of "spaceship Earth."[14] Munévar also considered the development of such systems an obligation to the future.[15] Not surprisingly, K12 students have agreed, expressing both a desire to protect the Earth and a concern about the future of the planet.[16] Protecting and even extending Earth's biosphere into space is likely to be a priority among space explorers. Kirby and Kiker recognized the importance of plants in any long-term space-based human habitat,[17] and Sobodowski predicted that spacefaring humans will create entirely new habitats that may be even more important than the Earth for the ultimate development of life in the solar system.[18]

If the environment is an urgent concern of our time, so is the need for greater diversity, equity, and inclusion on Earth—and here again space exploration may be beneficial. Among his reasons why the United States should return to the moon, Rogers listed "the benefit of all mankind"[19] and called for representation of all the Earth's 200 countries. In part due to the Overview Effect, involvement with space exploration encourages acceptance and inclusion of people from a diversity of backgrounds,[20] and as Krone pointed out, space is something of a cultural blank slate, defined by six decades of international collaboration, and no open war or conflict yet.[21] We still have an opportunity to expand into the rest of the solar system in a historically peaceful and inclusive way.

Munévar made a unique argument for the exploration of space on account of the unintended benefits of scientific serendipity.[22] For instance, nobody working on the Sputnik satellite could have predicted the daily use of Google Maps to navigate with a smartphone, which relies on GPS satellites; instead, our modern society has serendipitously benefited from the development of satellites. Arthur reasonably pointed out that there is no necessity involved in this argument; although serendipitous benefits

[14] Gustavo Munévar, "Space Colonies and Their Critics," in *The Ethics of Space Exploration*, ed. James S. J. Schwartz and Tony Milligan (Cham, Switzerland: Springer International, 2016), 34.
[15] Gustavo Munévar, "Space Exploration and Human Survival," *Space Policy* 30 (2014): 199.
[16] Lonnie J. Schorer, "Children's Visions of Our Future in Space," in *Beyond Earth: The Future of Humans in Space*, ed. Bob Krone, Edgar Mitchell, Langdon Morris, and Kenneth Cox (Burlington, ON: Apogee Books, 2006), 127–34.
[17] Richard Kirby and Ed Kiker, "Planning the Oasis in Space," in *Beyond Earth: The Future of Humans in Space*, ed. Bob Krone, Edgar Mitchell, Langdon Morris, and Kenneth Cox (Burlington, ON: Apogee Books, 2006), 251.
[18] Joe Sobodowski, "Space Education, Learning, and Leading," *Journal of Space Philosophy* 2, no. 1 (2013): 15–18.
[19] Thomas F. Rogers, "Creating the First City on the Moon," in *Beyond Earth: The Future of Humans in Space*, ed. Bob Krone, Edgar Mitchell, Langdon Morris, and Kenneth Cox (Burlington, ON: Apogee Books, 2006), 57.
[20] Madhu Thangavelu, "Human Space Activity: The Spiritual Imperative," *Journal of Space Philosophy* 3, no. 1 (2014): 110–15.
[21] Robert M. Krone, "Philosophy for Humans in Space," *Journal of Space Philosophy* 2, no. 2 (2013): 78–82.
[22] Munévar, "A Philosopher Looks at Space Exploration."

may arise, and often do, there is no guarantee that they will … and sometimes science is instead quite dangerous or destructive.[23] However, unintended benefits of scientific inquiry have been a significant driver in human history, and there is no reason to believe that this trend will not continue into the future.[24] Presently, we are experiencing an acceleration in the development of new space technologies and the commercialization of the benefits—often at a rate even faster than anticipated.[25] Consider the rapid implementation of StarLink satellites, for instance, or the timeline for landing on the Moon and Mars set by SpaceX, which is far more aggressive even than the NASA missions they have been hired to deliver. It is reasonable to expect that serendipitous benefits may also come more quickly to the general populace.

Perhaps the most meaningful of the reasons traditionally given in support of space exploration might be the inspiration it offers to people around the world. Investment in the Apollo program drove not just the development of the modern space program, but also the rise of Silicon Valley and innovations in many other fields.[26] There is even an element of spiritual inspiration, as can be evidenced in the religious testimonies of astronauts and others influenced by the Overview Effect who have never even been to space.[27]

Critiques and Counter Arguments

Despite these many benefits of investing in space exploration, there are of course common critiques and counterarguments. As Arthur pointed out, social critics argue that resources would be better spent addressing more important problems here on Earth, and ideological critics argue that continued space exploration may be dangerous or even immoral.[28] Both critiques are now easily answered by space philosophers.

If a critic of the space program is concerned about care for the environment of the Earth, it has already been demonstrated that an investment in space has clear benefits for climate science and increasingly efficient agriculture. In addition, Munévar showed that humans are not alone as a species that transforms the environment, and that the ethical requirement is now for us to do so with wisdom … which information from space can aid us to do.[29] Furthermore, he argued that many disruptions to the balanced ecosystems of the past then led to greater opportunities for new life forms. He suggested that humanity (and all land animals) are the beneficiaries of environmental changes that led to life venturing from the sea onto land—and he suggested that humanity taking life into space

[23] Arthur, "Why Go to Space?" This comment drew on Munévar, "A Philosopher Looks at Space Exploration."
[24] Krone, "Philosophy for Humans in Space"; Ord, *The Precipice*.
[25] Pyle, *Space 2.0*.
[26] Pyle, *Space 2.0*.
[27] Peeters, "Space Science as a Cradle for Philosophers"; White, *The Overview Effect*.
[28] Arthur, "Why Go to Space?"
[29] Munévar, "Space Colonies and Their Critics."

may have similarly long-term benefits for a variety of life forms. White would agree that we are the beneficiaries of the "explorer fish," and that we may play a similar role for future life forms.[30]

Similarly, Munévar recognized that we need to address problems on Earth by developing a better attitude toward equity and maturing beyond our historically colonial ethic of resource exploitation.[31] But not only can these changes be undertaken *in conjunction* with space exploration (there is nothing mutually exclusive about the two endeavors), but also they may actually be *enhanced* by the opportunity actually to put into practice something different as we expand into space. Humanity can explore the solar ecosystem through collaborating internationally, selecting more diverse crews, and focusing on making sure the benefits are realized by a more inclusive population … and the clean slate in space may be our best opportunity to do this.

The cost of space exploration is also a frequent concern of critics, particularly given the perception that these investments take away from investment in solving other problems. While it is clear that the Space Shuttle program was far too expensive, this concern is mitigated by the significantly reduced cost of newer spacecraft.[32] The rapid development cycles of SpaceX, for instance, are focused on minimizing costs, and they can deliver payloads and passengers to space for a fraction of the cost of past efforts or current competitors. Also, Pyle pointed out that most Americans actually have no idea what NASA's costs are, that its federal budget is currently about 90 percent lower than it was in the Apollo era, or that NASA is doing far more with comparatively fewer resources today.[33]

Whatever the costs, the dangers of space exploration are also commonly cited as reasons for avoiding investing in it, especially for crewed missions or human settlements. Even space philosophers agree that the integrity of a space station is fragile and that living in a space habitation would be considerably more dangerous than inhabiting an aircraft carrier.[34] Pyle captured this humorously in his anthropomorphized phrase, "space hates people."[35] Even K12 students understand the dangers, expressing a variety of fears about space exploration, especially in the wake of the *Challenger* and *Columbia* tragedies; however, many students still recognize that space settlement is risky but necessary.[36] Ord also acknowledged that humanity must not let the impossibility of knowing future dangers stand in the way of space exploration and the potential benefits,[37] and White

[30] White, *The Overview Effect*.
[31] Munévar, "Space Colonies and Their Critics."
[32] Arthur, "Why Go to Space?"
[33] Pyle, *Space 2.0*.
[34] Kirby and Kiker, "Planning the Oasis in Space."
[35] Pyle, *Space 2.0*, 15.
[36] Schorer, "Children's Visions of Our Future in Space."
[37] Ord, *The Precipice*.

went so far as to question whether humanity could continue to evolve and improve if it remains supposedly safe on Earth alone.[38] This brings us to the most important reasons for pursuing the exploration of space.

Critical Reasons for Space Exploration

Even recognizing the validity of these critiques, the most important reasons for space exploration are considerably more compelling. Nothing less than the survival of the human race, our greatest aspirations, and future stages of our evolution are at stake.

According to Krone,[39] space exploration is critical to the survival of humanity as a species, and he is far from alone in this belief. Munévar also advocated for colonization of other planets (and the galaxy) to ensure human survival in the long run.[40] This is articulated most completely in Ord's *The Precipice*, in which he demonstrates that a human expansion to other planets would protect the species against many natural catastrophes (including asteroid strikes, for instance) and against many human-made existential threats as well. Even politicians and diplomats recognized the threat in 1997 with the UNESCO *Declaration on the Responsibilities of the Present Generations Towards Future Generations*, which recognized that human survival may be at risk, and that acting on this knowledge falls within the mission of the United Nations.[41] More recently, Downing noted that strong global leadership is needed to avoid the probability of extinction.[42] Arthur brought home the importance of this reason when he cited Munévar's statement that "survival is of value to us because without it, our other aspirations are moot."[43]

It is our greatest aspirations that may be our most compelling reason for committing to space exploration. As explorers, we tap into our higher human nature to push boundaries and overcome obstacles.[44] And the coming decades will mean not just *explorers* in space, but the *pioneers* who will follow and create civilization there.[45] There may even be a positive feedback loop as we expand; ideally, we should be able to use space exploration (such as settlement of the Moon) to improve our culture,[46] our quality

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[38] White, *The Overview Effect*.

[39] Robert M. Krone, "Philosophy for Space: Learning from the Past—Visions for the Future," *Journal of Space Philosophy* 1, no. 1 (2012): 17–26.

[40] Gustavo Munévar, "Humankind in Outer Space," *International Journal of Technology, Knowledge, & Society* 4, no. 5 (2008): 17–25.

[41] Ord, *The Precipice*.

[42] Lawrence G. Downing, "Ethics, Values, and Moral Leadership for Space Settlements," *Journal of Space Philosophy* 8, no. 2 (2019): 56–60.

[43] Gonzalo Munévar, "The Morality of Rational Ants," in *Evolution and the Naked Truth*, 131–47. Munévar draws on the work of Peter Singer, E. O. Wilson, and Charles Darwin. Quoted in Arthur, "Why Go to Space?" 61.

[44] Pyle, *Space 2.0*.

[45] White, *The Overview Effect*.

[46] Rogers, "Creating the First City on the Moon."

of life,[47] and the models available for those left on Earth to emulate,[48] thus ensuring benefits for future generations both on and off the Earth.[49] White considered planning for space exploration and settlement to be synonymous with planning the evolution of human civilization (and perhaps the evolution of the universe itself).[50] In this way, expanding human civilization beyond Earth helps us to preserve our potential, avoiding biological or cultural lock-in that might limit it forever.[51] If Earth is alone in supporting life, humanity might be its best or only chance not only to avoid eventual extinction, but also to expand and flourish.[52] After all, "the Earth is the cradle of mankind, but one cannot remain in the cradle forever."[53]

It is the future of life beyond the human that perhaps *should* be our highest concern. Many space philosophers are already considering a post-human (or posthumanist) future where the biological or inorganic descendants of humanity, such as designer life forms or artificial intelligences, are better suited to flourishing beyond the cradle of Earth. This is why White suggested not just a human space program, but a post-human space program broad enough to include humans, non-humans, post-humans, extraterrestrials, and any non-organic intelligence; and he imagined post-humans swimming through space like dolphins, a hypothetical species he dubbed *Homo spaciens.*[54] Similarly, Todd wondered what type of posthuman we will decide to become,[55] and Ord argued for a future in which people explore a diverse variety of post-human forms.[56] White also noted that humans may not need to understand their role in the evolution of intelligence in the universe to fulfill it, and he postulated that the purpose of human evolution may be to make a contribution to the universe rather than exploit it.[57] Realization of such a future will require

[47] Kenneth J. Cox, Robert M. Krone, and Langdon Morris, "Theory and Action for the Future of Humans in Space," in *Beyond Earth: The Future of Humans in Space*, ed. Bob Krone, Edgar Mitchell, Langdon Morris, and Kenneth Cox (Burlington, ON: Apogee Books, 2006), 271–75.

[48] K. T. Connor, Lawrence G. Downing, and Robert M. Krone, "A Code of Ethics for Humans in Space," in *Beyond Earth: The Future of Humans in Space*, ed. Bob Krone, Edgar Mitchell, Langdon Morris, and Kenneth Cox (Burlington, ON: Apogee Books, 2006), 119–26.

[49] Pyle, *Space 2.0*.

[50] White, *The Overview Effect*.

[51] Ord, *The Precipice*.

[52] Ord, *The Precipice*.

[53] Tsiolkovsky, quoted in Peeters, "Space Science as a Cradle for Philosophers," 79.

[54] White, *The Overview Effect*.

[55] Joseph Todd, "A Utopian Mirror: Reflections from the Future of Childhood and Education in Aldous Huxley's *Brave New World* and *Island*," in *Childhood, Science Fiction, and Pedagogy: Children Ex Machina*, ed. David W. Kupferman and Andrew Gibbons (Singapore: Springer Nature, 2019), 135–54.

[56] Ord, *The Precipice*.

[57] White, *The Overview Effect*.

new global systems of governance,[58] greater participation of the general populace, and ultimately the transition of space exploration efforts from a government project to a civilization-wide undertaking.[59] Preparing a new generation of students for this impending transition is very much the mandate of existing school systems, though they may not be well prepared for the challenge.

Should Children be Educated for Space Exploration?

Given these compelling reasons for humanity to invest in space exploration, it follows that it may be wise to prepare children to participate in and contribute to the coming new Space Age. It may even be something of a moral imperative to provide them this preparation for the world they will likely live in … and help to shape. As White suggested, we can now make preparations such as this with clear intention.[60] If we must explore space to promote peace, as Cox suggested, then perhaps schools should be a part of that learning process as early as possible.[61] And if Dror advocated for a Global Leadership Academy, then perhaps that learning should start as early as possible too—and for a much wider set of students—so that they can then be well prepared for the sorts of careers and leadership roles Dror advocates in his steps for redesigning global society.[62] These can include Dror's new space settlement profession, Peeters's space ronin—the independent rogues who serve as change agents,[63] and Arthur's wide range of disciplines involved in space settlement.[64] Here again, K12 students would agree … they expect our species to advance through study and exploration.[65]

So, if schools should be redesigned so that they better prepare students for humanity's multi-planet future, what should be the foundational principles of those schools? Though an additional answer to this question is offered in the study results below, the literature of space philosophy does provide some initial guidance. It is clear that the school should be hands on,[66] following constructivist learning principles and focusing on empowering

[58] Yehezkel Dror, "Governance for a Human Future in Space," in *Beyond Earth: The Future of Humans in Space*, ed. Bob Krone, Edgar Mitchell, Langdon Morris, and Kenneth Cox (Burlington, ON: Apogee Books, 2006), 41–45.
[59] Cox et al., "Theory and Action."
[60] White, *The Overview Effect*.
[61] Cox et al., "Theory and Action."
[62] Dror, "Governance for a Human Future in Space."
[63] Peeters, "Space Science as a Cradle for Philosophers."
[64] Arthur, "Why Go to Space?"
[65] Schorer, "Children's Visions of Our Future in Space."
[66] Becky Cross, "Sowing Inspiration for Generations of Space Adventurers," in *Beyond Earth: The Future of Humans in Space*, ed. Bob Krone, Edgar Mitchell, Langdon Morris, and Kenneth Cox (Burlington, ON: Apogee Books, 2006), 135–37.

the learner.[67] Students should also be trained in the practice of philosophy themselves, from classical philosophy including stoicism,[68] to the philosophy of science.[69]

In a sense, science fiction is "philosophy of the future," and it should be explicitly included in the learning experiences of the new schools; Hetzler called for philosophers (and by extension educators) to be open to thinking about possible worlds,[70] and Krone considered science fiction a staple of literature.[71] Perhaps more importantly, Levinson and Jandrić recognized the role science fiction has played in driving scientific innovation forward,[72] and it follows that if inspiring more scientists is an important goal, then science fiction should be a focus in schools. Similarly, if educating more creative problem-solvers is important, then exposing students to science fiction may be helpful, as the genre encourages imagination, speculation, and … delight.[73] Kupferman and Gibbons also pointed out that "science fiction reveals to the child the nature of the system in which s/he is being educated" and introduces children to "different forms of educational future."[74]

Engaging students in this sort of reflection will also be critical in a school designed to prepare students for altruistic space exploration—and to avoid potentially dystopian alternative futures.[75] Ultimately, reflection is also a necessary ingredient of the sort of wisdom that will be required of future leaders and citizens as humanity expands into space; the need for wisdom is a common thread through much of space philosophy, particularly with respect to global leadership, policy, and governance.[76]

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[67] Phillip W. Simpson and Andrew Gibbons, "Filling the Mind: Cortical Knowledge Uploads, Didactic Downloads and the Problem of Learning in the Future," in *Childhood, Science Fiction, and Pedagogy: Children Ex Machina*, ed. David W. Kupferman and Andrew Gibbons (Singapore: Springer Nature, 2019), 155–69.

[68] Dror, "Governance for a Human Future in Space."

[69] Peeters, "Space Science as a Cradle for Philosophers."

[70] Hetzler, "Man and Space."

[71] Robert M. Krone, "Music and Arts for Humans in Space," in *Beyond Earth: The Future of Humans in Space*, ed. Bob Krone, Edgar Mitchell, Langdon Morris, and Kenneth Cox (Burlington, ON: Apogee Books, 2006), 114–18.

[72] Paul Levinson and Petar Jandrić, "Children and Pedagogy between Science and Fiction," in *Childhood, Science Fiction, and Pedagogy: Children Ex Machina*, ed. David W. Kupferman and Andrew Gibbons (Singapore: Springer Nature, 2019), 211–26.

[73] Walter S. Gershon and Reagan P. Mitchell, "Your Android Ain't Funky (Or Robots Can't Find the Good Foot): Race, Power, and Children in Otherworldly Imaginations," in *Childhood, Science Fiction, and Pedagogy: Children Ex Machina*, ed. David W. Kupferman and Andrew Gibbons (Singapore: Springer Nature, 2019), 93–110.

[74] David W. Kupferman and Andrew Gibbons, "Why Childhood Ex Machina?" in *Childhood, Science Fiction, and Pedagogy: Children Ex Machina*, ed. David W. Kupferman and Andrew Gibbons (Singapore: Springer Nature, 2019), 10.

[75] Todd, "A Utopian Mirror."

[76] Dror, "Governance for a Human Future in Space"; Robert M. Krone, "Utopia: Space Philosophy and Reality," *Journal of Space Philosophy* 2, no. 2 (2013): 44–48; Munévar, "Space Exploration and Human Survival"; Ord, *The Precipice*.

Summary of the Literature Review

It is clear that the benefits of space exploration are many, and that humanity cannot take advantage of them without proper planning and collaboration on a global scale. Spinoff technologies and serendipitous scientific discoveries that benefit the general populace are only the beginning. More significant benefits include the perspective-shifting Overview Effect; the technology to monitor and deal with climate change; the opportunity to practice diversity, equity, and inclusion on a global (and interplanetary) scale; and the inspiration of new generations of scientists, explorers, and pioneers. As the costs of space exploration come down and the understanding of the dangers improves, some critical benefits clearly outweigh the risks. Space exploration may help humanity to avoid existential threats, making it possible to achieve our highest aspirations as a species—and to move ethically into a post-human future of essentially unlimited potential.

Therefore, it is clear that it would be best to prepare the world's youth for this future in space, and that schools should be redesigned for this function. These new schools should provide opportunities for active learning while building students' foundations in philosophy, science fiction, and effective reflection so that they might one day serve as wise leaders and citizens.

Method

This qualitative study followed a grounded theory approach using the Ideas Unlimited method to engage a panel of experts and make their tacit knowledge explicit for real-world implementation, and for further research. The researcher operated from a social constructivist paradigm, a common foundation for education research resting on the belief that the human mind is constantly engaged in developing subjective meanings from the environment in which it lives, and that meaning making is a process of social negotiation via dialogs or conversations between individuals.[77]

School design is a complex long-term undertaking faced with many human elements that limit the effectiveness of quantitative analysis, making a qualitative approach more appropriate, especially with an emerging future context such as space settlement. Trochim defined qualitative research as a process involving any measures where the data are not recorded in numerical form, and he included short written responses on surveys among his examples of qualitative data.[78] These measures are especially appropriate in a social constructivist context because qualitative researchers are interested in the meaning that

[77] John W. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Method Approaches*, 2nd ed. (Thousand Oaks, CA: Sage, 2003); David H. Jonassen et al., *Learning to Solve Problems with Technology: A Constructivist Perspective* (Upper Saddle River, NJ: Merrill Prentice Hall, 2003).
[78] William M. K. Trochim, *The Research Methods Knowledge Database*, 2nd ed. (Cincinnati: Atomic Dog, 2001).

people construct and how they make sense of the world and their experiences in it.[79] The role of the researcher in qualitative research is thus to gather, analyze, and interpret data—a process that requires careful observation, tolerance for ambiguity, confidence in intuition, and clarity in communication.[80]

Because we do not know of any K12 schools that focus on preparing students for humanity's multi-planet future, a grounded theory approach is an effective choice for generating new ideas. According to Leedy and Ormrod, "the major purpose of a grounded theory approach is to begin with the data and use them to develop a theory."[81] In this case, the study works from the expert opinions of the participants to derive an abstract theory to guide policymakers.[82]

In particular, the Ideas Unlimited method is well proven for planning purposes, improving performance, and generating new ideas. According to Downing et al., "Ideas Unlimited collects and organizes ideas from people to solve strategy, policy, planning, program, process, task, or procedural problems."[83] Traditionally, ideas are collected on small slips of paper, thus the original name of C. C. Crawford's "Crawford Slip Method" before Bob Krone coined the name "Ideas Unlimited."[84] For this 2020 study, an online *Google Form* was used to collect submissions asynchronously from geographically dispersed participants into a collaborative web-based *Google Spreadsheet* shared between the researcher and his academic advisors. Participants responded to a single prompt, known as a "target" in the Ideas Unlimited method that was designed to focus their mind on their relevant experience.[85] Their responses were then copied from the spreadsheet into the *Zotero* qualitative research software for a process of tagging, keyword classification, and data reduction, with a focus on making recommendations for performance improvements.[86] An outline of the results was created using the online outliner *Workflowy*, and this analysis is the final outcome of the study. The researcher was personally responsible for all aspects of implementing the Ideas Unlimited process. He composed the target (and associated instructions, though these were adapted from a target sheet created by Bob Krone at Kepler Space Institute), recruited all participants, analyzed all data, and interpreted all findings.

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[79] Sharan B. Merriam, *Qualitative Research and Case Study Applications in Education* (San Francisco: Jossey-Bass, 1998).

[80] Creswell, *Research Design*; Merriam, *Qualitative Research*.

[81] Paul D. Leedy and Jeanne E. Ormrod, *Practical Research: Planning and Design*, 8th ed. (Upper Saddle River, NJ: Pearson, 2005), 140.

[82] Creswell, *Research Design*.

[83] Lawrence G. Downing, Robert M. Krone, and Ben A. Maguad, *Values Analysis for Moral Leadership* (London: Bookboon, 2016), 30. https://bookboon.com/premium/books/values-analysis-for-moral-leadership.

[84] Robert M. Krone and Selena Gregory-Krone, *Ideas Unlimited: Capturing Global Brainpower* (Wilmington, DE: Stratton Press, 2018).

[85] Krone and Gregory-Krone, *Ideas Unlimited*.

[86] Downing et al., *Values Analysis for Moral Leadership*.

Fifteen participants were included in the study, each an expert in space philosophy, education, or both. All participants are credited as co-authors of this paper. Their names, titles, and professional affiliations also appear in Appendix A. The following is the target to which each of them responded:

> Future space exploration and settlement: How might K12 schools best prepare students for success in humanity's multi-planet future?

Results

Several themes emerged from the analysis of participant responses to this target prompt. In general, there was consensus around what might be considered constructivist ideals: a focus on a learning experience that is engaging, context-embedded, inquiry-driven, collaborative, and supportive of metacognition. As such, mentorship (as opposed to teaching) was a focus of the responses, as was problem-solving (as opposed to rote learning and recall). Not surprisingly, the importance of technical skills came up often, but so did a variety of "softer" skills, including art, philosophy, and leadership. Finally, there was a consistency in participants' vision for a better future—a world inspired by utopian science fiction, characterized by equity, abundance, and humanist or post-humanist perspectives.

A constructivist learning environment can be said to be engaging, context-embedded, inquiry-driven, collaborative, and supportive of metacognition.[87] Participant responses tended to include many of these elements. For example, space educator Holly Melear argued that traditional approaches such as handouts, memorization, and testing would not be effective in preparing youth for success in off-world communities; instead, she advocated for students to be working in cross-curricular multi-age teams focused on solving real-world problems. Janet Ivey, host of *Janet's Planet*, suggested similarly authentic experiences, including activities such as planning Martian settlements, creating model robotic arms, or designing "astro socks" to protect astronauts' feet as they hook onto footholds in zero gravity. Rod Pyle, author of *Space 2.0,* also recommended *engaging* projects, field trips to space facilities, and connecting with scientists, engineers, and other space industry professionals. Additional participants suggested that students should complete *context-embedded* hands-on projects while learning about existing space policies, such as the Outer Space Treaty, and conducting interviews with professional astronauts. An *inquiry* process driven by student agency (including giving students "more practice in exercising power") was also a hallmark of many responses. A call for *collaborative* elements included cooperation, respect, and appreciation of unique contributions—and also included a more inclusive reduction in elitist attitudes. Rosalyn

[87] Mark D. Wagner, "Massively Multiplayer Online Role-Playing Games as Constructivist Learning Environments in K–12 Education: A Delphi Study" (PhD diss., Walden University, 2008), https://edtechlife.com/dissertation/.

Freeman, herself a student, also promoted the idea that students should rely on each other as they perform tasks similar to those of a multi-planet society. *Reflection and metacognition* appeared in several responses, with a focus on student analysis of learning outcomes, both in authentic research as a part of completing projects and in the context of more formal academic writing. In keeping with these constructivist methodologies, direct instruction was de-emphasized in favor of more meaningful mentorship from people who work in the space industry (such as experts at NASA, JPL, and elsewhere).

Realistic problem solving was a near universal recommendation of the participants. There were explicit calls for *project-based learning* (from Melear, Ivey, and others) including many suggestions of specific space-themed hands-on challenges. These projects were typically open ended with an expectation of multiple (and multi-disciplinary) paths to success. A *design thinking* approach was common, in which students would come to understand a problem (and the people it affects), ideate possible solutions, build prototypes, test their theories, and iterate on their creations to improve outcomes. For example, Assistant Principal Scott Thomas suggested teaching students engineering skills in the context of designing space habitats. Others embedded such challenges into a game or game-like format.

Activities involving technical skills were common recommendations, with a broad emphasis on science, technology, engineering, and math (*STEM*) skills, many of which were focused on the challenges of survival in outer space or in the hostile environments of other planets. Andrew Dobbie, a Grade 6 teacher, suggested that students be tasked with developing Arduino- or Raspberry Pi-controlled systems for meeting survival needs, such as lighting for plants, air filtration, or waste recycling. Other suggestions for STEM projects included environmental studies, resource stewardship, and challenges related to governance or interpersonal dynamics. Naturally, there were explicit calls for a wide range of *science education* as well, including other *coding* projects, such as games or *simulations*, and *maker* projects, such as 3D printing or model building from household materials (Ivey mentioned a papier mâché spacesuit helmet). Learning experiences were also expected to include cutting-edge technologies; some, including Freeman, wanted students to learn using augmented or virtual reality headsets and gloves.

Responses that focused on technical skills were balanced by similarly numerous discussions of softer skills, including art, creativity, social emotional learning, personal growth, philosophical thinking, spirituality, and leadership development. The importance of *art* was a common concern, with Melear stressing the critical role of the arts for design, beauty, and stress relief, and Ivey advocating a wide variety of projects, including songwriting, dances, and travel brochures or various visual media as mock marketing materials. Others focused on the *creativity* in students finding their own paths to success. There were also explicit calls for the development of interpersonal skills and *social–emotional learning* for personal growth … even approaches like practicing mental health, compassion (and self-compassion), social restoration, collaborative meditation,

development of spiritual relationships, and intentional culture building. Some correlated this sort of personal growth to developing familiarity with classical *philosophy*—and with Stoic resilience in particular. Naturally, several participants also pointed out the importance of helping students to develop their *leadership skills*, which can be accomplished by allowing students opportunities to lead their peers while engaging in the sorts of projects and problem solving suggested above.

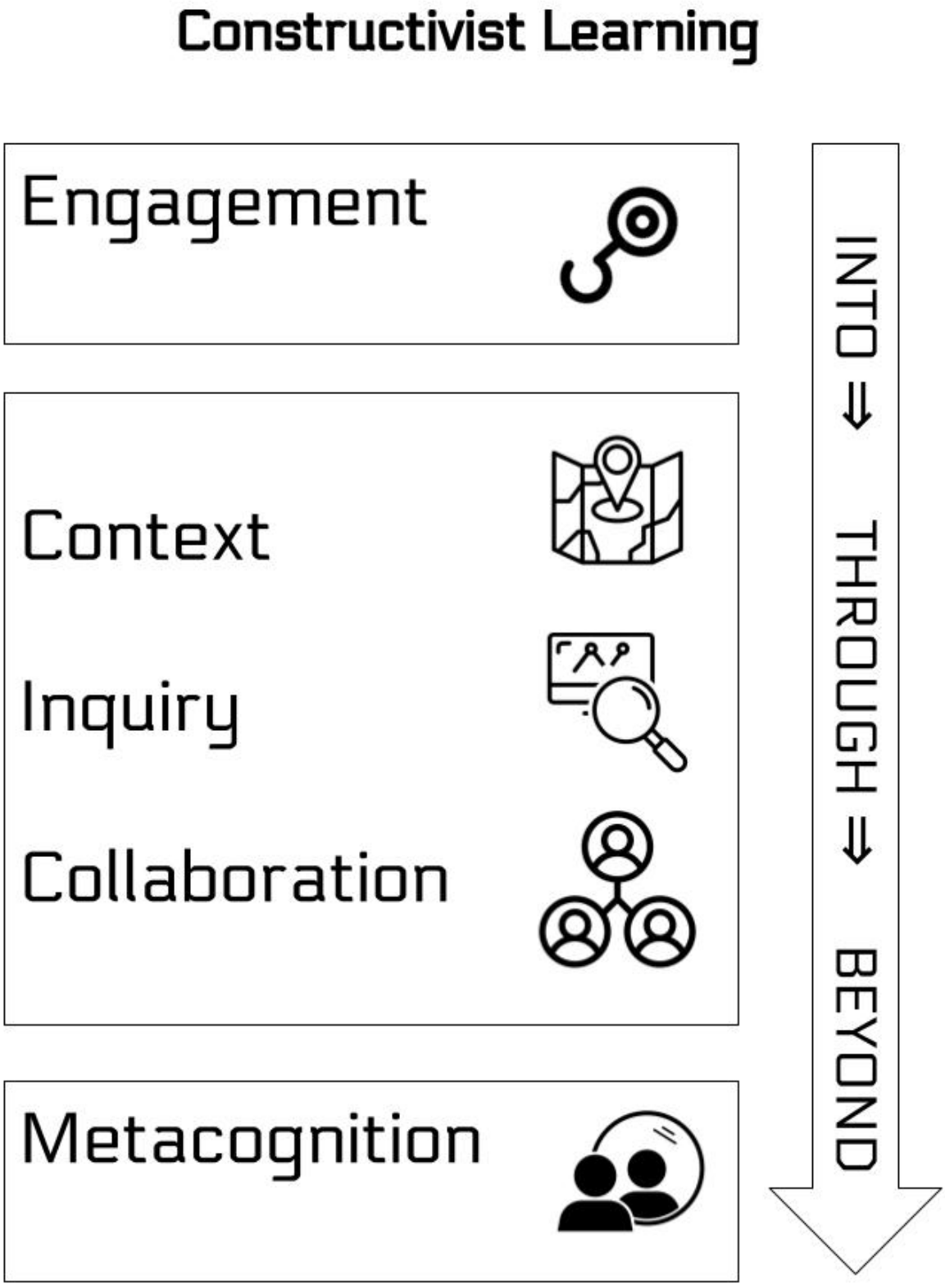
Participants tended to espouse an optimistic vision for the future, inspired in part by science fiction, but also their hopes for an inclusive global society with a sense of abundance for all, and with the commitment to duties, policies, and progressive administrations required to make that a reality. Some responses suggested establishing an environment of optimistic thinking for students, encouraging them to believe in themselves and pursue their dreams. Ivey included the practice of calling students by aspirational titles such as "Astronaut Aiden." These recommendations are explicitly meant to be inclusive and equitable for a diversity of students around the world, with an acknowledgment of the interpersonal, cultural, and ethical challenges involved in this "international investment." There were also concerns about overpopulation on Earth, but a generally optimistic belief in humanity's ability to settle other habitats throughout the solar system, and in the validity of both the Overview Effect and the Law of Space Abundance (which suggests that space has abundant resources to meet human needs). Respondents advocated helping students to develop a sense of duty and ownership over the solutions to such systemic problems. This included introducing students to issues of governance, including the policy sciences, and also working directly with current political administrations so that students can gain experience in dealing authentically with similar issues today. In keeping with these philosophies, several participants recommended that educators provide opportunities for students to study science fiction as inspiration; for example, Dahn expected instructors to select appropriate books and films for their students, and Pyle suggested a focus on the overlap between real science technology and science fiction. In addition, some explicitly recommended exposing students to the *Journal of Space Philosophy* published by Kepler Space Institute.

Conclusion

It is clear from the literature review that the benefits of space exploration are many, and that humanity cannot take advantage of them without proper planning and collaboration on a global scale. Spinoff technologies and serendipitous scientific discoveries that benefit the general populace are only the beginning. More significant benefits include the perspective-shifting Overview Effect; the technology to monitor and deal with climate change; the opportunity to practice diversity, equity, and inclusion on a global (and interplanetary) scale; and the inspiration of new generations of scientists, explorers, and pioneers. As the costs of space exploration come down and the understanding of the dangers improves, some critical benefits clearly outweigh the risks.

Space exploration may help humanity to avoid existential risks, making it possible to achieve our highest aspirations as a species—and to move ethically into a post-human future of essentially unlimited potential.

Given this evident moral mandate to prepare students for humanity's multi-planet future, the results of this new Ideas Unlimited study suggest a clear plan of action for educators and education policy makers. It is critical that a *constructivist* approach to active learning be adopted, with a focus on creating learning experiences that are engaging, context-embedded, inquiry driven, collaborative, and supportive of reflection and metacognition. Methods should focus on *mentorship* (as opposed to didactic teaching) and on authentic real-world *problem-solving* (as opposed to rote learning and recall). *Technical skills* should certainly be emphasised (including coding, making, and the practice of the scientific method), but so should a variety of *soft skills,* including creativity, social emotional learning, and leadership development. Finally, educators should uphold an optimistic worldview, inspired by the best of science fiction, and characterized by equity, abundance, and a post-humanist vision for humanity's future in the solar system and beyond.


Constructivist Learning
Engagement
Context
Inquiry
Collaboration
Metacognition
INTO ⇓ THROUGH ⇓ BEYOND

Appendix A: Participant Names, Titles, and Affiliations

Name	Title	Affiliation
Brendan Brennan	Co-Founder	ARES Learning
Joshua Dahn	Executive Director	Astra Nova School
Athena Brensberger	Science Communicator	Astroathens
Andrew Dobbie*	Grade 6 Teacher	SDG Global Ambassador
Rosalyn Freeman*	Student	MPH
Janet Ivey*	CEO	Janet's Planet, Inc.
Bob Krone	Former President	Kepler Space Institute
Holly Melear*	CEO & Founder	STEAMSPACE Education Outreach
Rod Pyle*	Writer and Editor	National Space Society
Steve Sherman	Chief Imagination Officer	Living Maths
Rhonda Stevenson	President/CEO	Tau Zero Foundation
Scott Thomas*	Assistant Principal	Stuyvesant High School
Barbara Hopkinson Wagner	Social Awareness Educator	Kids Are the Solution Project
Artemis Westenberg	CEO	Explore Mars Europe
Heather Wolpert-Gawron	21st Century Learning	San Gabriel Unified School District

* All participants in the study are credited as co-authors on this publication. Participants indicated with an asterisk requested credit in the body of the text for their specific contributions.

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About the Author: Mark Wagner serves as President of the Space Prize Foundation, a non-profit organization focused on promoting STEM education and increasing the representation of women in aerospace careers. He also teaches the Space Education graduate certificate program at Kepler Space Institute and is the Associate Editor of the *Journal of Space Philosophy*. In addition, he is the founder of ARES Learning, a vision for schools that prepare students with the skill sets and mindsets they will need to be successful in the growing space economy—and in humanity's rapidly approaching multi-planet future. Mark has a PhD in Educational Technology and a master's degree in Cross-Cultural Education. He also holds graduate certificates in Space Education and Space Philosophy. He is the author of *More Now: A Message from the Future for the Educators of Today* (2018) and a forthcoming book about space education, which explores both current opportunities on Earth, and the possibilities for teaching students on the Moon, on Mars, and in deep space habitats. Outside his work, Mark loves playing hockey, practicing martial arts, and obsessing over his '62 beetle, which now runs on an electric motor and Tesla batteries. He is a certified health coach and biohacking enthusiast, who also enjoys songwriting, spending time in nature, and exploring the world with his friends and family.

Editor's Notes: Contributing an article to the *JSP* for the fourth time, Dr. Mark Wagner (our associate editor) offers not only a look ahead at how we might prepare students for humanity's rapidly approaching multi-planet future, but also an academic justification of why that is important to everyone. Drawing on the space philosophy of the past decades, including several of the authors included in this issue, he argues that space education is a moral imperative and provides recommendations for how best to move forward. At this point of the issue, we have moved squarely into prospective material. ***Gordon Arthur.***