# A Novel Approach to a K12 School Focused on Space Exploration

**By Mark Wagner, Ph.D.**

## Introduction

With the current explosion of progress in space exploration and industry, many questions related to the first legitimate long-term space settlements are being asked—and not just about technical or logistical issues. Space philosophers are beginning to look very seriously at questions of social significance, including legal precedence, methods of governance, and even how best to educate children being raised in space or on another planet. Elsey and Omarova, for instance, challenge their students to imagine what an education system might look like on Mars.[1] They acknowledge this as an imaginative enterprise at this point, but the question becomes much more concrete if we consider how best to educate those who will actually be the first settlers—and are likely in today's classrooms.[2]

This question is thus already relevant if not pressing: how should K12 schools be designed best to prepare students for humanity's multi-planet future? Today's schools are not only poorly prepared for this future, but also poorly prepared for the current reality. Schools should be ready to handle the truly challenging problems of today while also preparing students for the unpredictable problems of tomorrow. Humanity cannot explore and settle space with an industrial-age education system. Luckily, there are new mindsets and skill sets available to educators, drawn from the successes of Silicon Valley and the space industry itself—and already proven on the cutting edge of constructivist pedagogy and educational technology.

This paper summarizes the academic justification for the design of the Academy for the Relentless Exploration of Space (or ARES), a prototype secondary school created to put these practices into effect with a focus on preparing students to participate in the space industry (directly or indirectly). The school has a two-part mission:

> MISSION I—Prepare students to solve enormous challenges in any community on any planet.
>
> At ARES Learning, students build the knowledge, skills, and mindsets necessary to navigate the great challenges of the future—on this planet or any other. ARES students emerge from their experience prepared for jobs that do not yet exist, to use technology that has not been invented, and to

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[1] Barry Elsey and Amina Omarova, "Space Education for Human Communities Living on Mars," *Journal of Space Philosophy* 9, no. 1 (2020): 21-41.

[2] Rachael Mann and Stephen Sandford, *The Martians in Your Classroom* (Irvine, CA: EdTech Team, 2018).

> solve enormous problems we cannot foresee. ARES prepares young people to become the designers, builders, philosophers, and explorers of tomorrow.
>
> MISSION II—Fundamentally disrupt and transform the global education system.
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> The recent pandemic has shown that traditional schools are not only unprepared for the challenges of the future, but also unprepared for the challenges of today. ARES is the new model for global education that combines the explorer's mindset, moonshot thinking, and human-centered design … supported by bleeding-edge technology and inspiring learning spaces. ARES places students at the center of solving enormous problems facing their communities—on this planet or any other. By design, ARES is a laboratory school meant to influence the true transformation of global education systems.

In particular, this paper articulates the reasoning behind the chosen curriculum, mindsets, and routines that form the foundation of the learning experience at ARES. A flexible curriculum is delivered via blended (face-to-face and online) methods. In addition to core subjects, it includes a foundation in problem-solving frameworks such as the explorer's mindset, moonshot thinking, and design methodology. For maximum effectiveness, daily routines also focus on synthesis, collaboration, and reflection.

## A Flexible Multi-Disciplinary Curriculum

At ARES Learning, learning experience in traditional subjects is based on CK-12, an internationally recognized core curriculum for English, social studies, math, science, and more, including an introduction to philosophy. This system is an open educational resource offering interactive experiences rich with multi-media, adaptive practice, and simulations. The program is modular and customizable to individual students' needs, and all students have agency in cocreating their own learning paths. This approach provides a solid foundation for students' academic future, and for the project-based learning that is the true focus of the ARES Experience.

The CK-12 system is delivered via a blended learning approach, combining face-to-face and online learning experiences. A blended approach allows students and teachers to develop a face-to-face rapport while still having the opportunity to communicate often online, and it has been shown to increase student-to-teacher interactions.[3] Blended

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[3] Sandra Somera, "Educator Experiences: Transitioning to Blended Learning Environment in K-6 Public Schools" (PhD diss., Walden University, 2018).

learning is particularly effective at teaching STEM subjects, including scientific reasoning[4] and mathematics.[5] The blended experience also helps students to develop greater comfort writing across the curriculum.[6] These basic skills help to form the necessary foundation for more advanced learning and higher-order problem solving.

In addition to their core subjects, all students participate fully in the rich experience of a supplemental "launchpad curriculum," where they are exposed to new ways of thinking—and get to set the trajectory of their own advanced learning. All students are introduced to advanced domains of learning, like philosophy, anthropology, linguistics, psychology, and political science—as well as forward-looking pursuits like science fiction as literature, fictional languages, and data science for forecasting. With a grounding in the physical and life sciences, they then choose their own space science trajectory with options including astrophysics, orbital mechanics, spacecraft systems design, terraforming, and genetic engineering. This broad supplementary curriculum provides a deeper understanding of the world from which to launch their projects in the Moonshot Lab.

More importantly, a multidisciplinary philosophy-based approach like this can help students to develop the wide range of intellectual skills they will need for success in the future and help them to prepare for meaningful participatory citizenship.[7] In many schools, there is an overemphasis on repetition of science facts; teachers typically fail to characterize scientific knowledge as tentative and the scientific method as creative.[8] But when philosophy of science is emphasized rather than simply repeating facts provided by the teacher, "students construct their conceptual models and present them to others within the class."[9] Inclusion of science fiction as literature further prepares students to be creative in dealing with the unexpected, and it has been demonstrated as an effective

[4] Isalyn F. Camungol, Yves I Gonzales, and Lydia S Roleda, "Progression of Scientific Reasoning and Metacognitive Regulation of Secondary Students in the New K-12 Curriculum in Blended Learning Environment," in *IC4E 2020: Proceedings of the 2020 11th International Conference on E-Education, E-Business, E-Management, and E-Learning* (New York: ACM, 2020), 10-14.
[5] Lissa J. Raebel, "Introducing Blended Learning Environments for Mathematics Instruction: How Does it Affect Student Achievement and Attitudes?" (MS thesis, University of Wisconsin Whitewater, 2015).
[6] William Kist, *Getting Started with Blended Learning: How Do I Integrate Online and Face-to-Face Instruction?* (Alexandria, VA: ASCD, 2015).
[7] Sara Goering, Nicholas J. Shudak, and Thomas E. Wartenberg, eds., *Philosophy in Schools: An Introduction for Philosophers and Teachers* (New York: Routledge/Taylor & Francis Group, 2013).
[8] James J. Gallagher, "Prospective and Practicing Secondary School Science Teachers' Knowledge and Beliefs about the Philosophy of Science," *Science Education* 75, no. 1 (1991): 121-33.
[9] Susan L. Johnson and Jim Stewart, "Using Philosophy of Science in Curriculum Development: An Example from High School Genetics," *International Journal of Science Education* 12, no. 3 (1990): 297-307.

method for teaching climate change,[10] chemistry,[11] and analytical skills[12]—and for increasing interest in STEM-based pursuits in general.[13]

## Mindsets and Skill Sets

In the tradition of great explorers from the Polynesian islanders to American astronauts—and the inspirational explorers of science fiction, ARES Learning is infused with the explorer mindset. The school is a program for students with a deep love of exploration, discovery, and adventure. The learning experiences are designed to increase comfort with the unknown and with facing challenges in rapidly changing environments. Students are encouraged to see potential, opportunity, and abundance when they encounter problems as opposed to seeing threat and scarcity. They are taught to operate from the presumption that possibilities always exist.

National Geographic has provided a powerful model for exploratory learning by defining a framework for "the Mindset of an Explorer," including age-specific skills and knowledge—and attitudes such as curiosity, responsibility, and empowerment.[14] This framework has been extended by educators to include tools for helping students "see, observe, build curiosity, learn responsibility, feel empowered, and be stewards in our interconnected world."[15] The explorer's mindset is meant to develop a love of adventure, exploration, and discovery—and it is important for breakthrough thinking.[16] Importantly, the mindset can help students to be flexible,[17] adaptable, and ready to make critical decisions without complete information.[18] An explorer's mindset can also help leaders to shepherd a team through the process of innovation.[19]

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[10] Glenn Smith and Metin Besalti, "Learning Climate Change Science with Computer Games in a Science Fiction Novel," in *Proceedings of EdMedia: World Conference on Educational Media and Technology*, ed. T. Bastiaens et al. (Amsterdam: Association for the Advancement of Computing in Education, 2018), 1231-35, www.learntechlib.org/primary/p/184333.

[11] L. Gaby Avila-Bront, "An Experiential Learning Chemistry Course for Nonmajors Taught through the Lens of Science Fiction," *Journal of Chemical Education* 97, no. 10 (2020): 3588-94.

[12] Neil Selwyn, Luci Pangrazio, Selena Nemorin, and Carlo Perrotta, "What Might the School of 2030 Be Like? An Exercise in Social Science Fiction," *Learning Media and Technology* 45, no. 1 (2020): 90-106.

[13] Selwyn, Pangrazio, Nemorin, and Perrotta, "What Might the School of 2030 Be Like?"

[14] "The National Geographic Learning Framework" (National Geographic, 1996-2021) www.nationalgeographic.org/education/about/learning-framework.

[15] Explorer Mindset, "Students, Educators and the Explorer Mindset," 2021, explorermindset.org/about.

[16] Stephen Sweid, "Significance of the Explorer's Mindset for Breakthrough," Management & Leadership, 2015, flevy.com/blog/significance-of-the-explorers-mindset-for-breakthrough.

[17] Vani Kola, "The Explorer Mindset: Leadership Principles for Crisis," www.linkedin.com/pulse/explorer-mindset-leadership-principles-crisis-vani-kola.

[18] Sionade Robinson, "Introduction: An Explorer's Mindset matters…" An Explorer's Mindset, www.anexplorersmindset.com.

[19] Tenday Viki, "How Adopting an Explorer's Mindset Can Help You to Lead Innovation," *Forbes*, 2020, www.forbes.com/sites/tendayiviki/2020/06/07/how-adopting-an-explorers-mindset-can-help-you-to-lead-innovation.

Though it is a mindset that explorers have embraced for millennia, moonshot thinking was codified in President John F. Kennedy's commitment to putting a man on the moon even though the technology did not exist, and nobody knew how to do it yet. At Google's X Lab, this mindset was further formalized into a system for addressing huge challenges, applying radical solutions, and developing breakthrough technology. This mindset does not seek a 10% improvement … it seeks a solution ten times better than before, and it is known also as 10X thinking. It requires failing forward and failing fast. This is exemplified in the SpaceX approach to developing new spacecraft. The ARES Learning model supports students as they address meaningful challenges in their community, generate innovative solutions, and implement creative uses of technology.

The system developed at X is a method for pursuing wildly ambitious goals, including "processes and culture (that) make it easier to make radical breakthroughs—repeatedly."[20] This sort of thinking is particularly relevant and beneficial in preparing for the challenges of humanity's multi-planet future because "moonshots galvanise communities towards tackling a huge societal challenge and shap[ing a] desired future in the process."[21] It may also be particularly appropriate in the public sector (in public K12 schools for instance) as a way to address a social crisis.[22]

Within the context of moonshot style ambitions, the ARES Learning method of solving problems is heavily influenced by design methodology (or design thinking), of the sort used and promoted by the Stanford D School. This begins with understanding the people the problem affects, through a process of discovery, empathy, or ethnography. Then our students define a problem before ideating a variety of possible solutions (using one of many exercises they are trained in) and choosing one to prototype and test first. They build a prototype online, in virtual reality, or in a maker space with real-world tools, including 3D printers. Based on the results of their initial tests, they iterate on their solution, pivot to a new one, or begin the process again.

Design methodology (or design thinking) is "a human-centered problem-solving approach that may be used in the teaching/learning process to develop twenty-first century skills and enhance creativity and innovation."[23] The method has been effective in empowering teachers to facilitate constructivist learning and foster twenty-first century skills in students.[24] It also integrates well with the other methods in use at ARES, as design thinking helps to build student motivation for exploration, confidence in self-exploration,

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[20] "Moonshot Thinking," X Development, 2018, x.company/moonshot.

[21] Anne-Laure Mention, João José Pinto Ferreira, and Marko Torkkeli, "Moonshot Innovations: Wishful Thinking or Business-As-Usual?" *Journal of Information Management* 7, no. 1 (2019): 1-6.

[22] William D. Eggers and John O'Leary, *If We Can Put a Man on the Moon: Getting Big Things Done in Government* (Cambridge, MA: Harvard Business Review, 2009).

[23] Ineta Luka, "Design Thinking in Pedagogy," *Journal of Education, Culture, and Society*, 2 (2014): 63-74.

[24] Andrea Scheer, Christine Noweski, and Christoph Meinel, "Transforming Constructivist Learning into Action: Design Thinking in Education," *Design Thinking and Technology Education* 17, no. 3 (2012): 8-19.

and competence in teamwork (including expressing opinions and sharing knowledge), as well as building trust between student and teacher.[25] It leads to increases in students' creative confidence,[26] self-efficacy,[27] and ability to solve real-world problems practically.[28] Also, it prepares students well for management,[29] entrepreneurship,[30] and challenging fields such as medicine.[31]

The way the design methodology is implemented in conjunction with moonshot thinking at ARES, there is room for truly innovative approaches, always encouraging students to think bigger—and providing exercises to help them get out of their comfort zone and leave behind their preconceptions.

## Synthesis and Reflection

Inspired by the work of the Ad Astra School at SpaceX, the ARES Learning program focuses on synthesis throughout. Students are not just repeating right answers … they experience the tension of making difficult choices, and of risk taking in their explorations and experiments. The faculty ensures that their challenges include ethical dimensions to allow for more meaningful experiences, and deeper learning. Sufficient time is allowed for analysis, debate, strategy, iteration … and the changing of minds. The school has adopted the daily practice of sharing ideas during a "midnight lunch" (at noon) inspired by Thomas Edison, and the Japanese tradition of Hansei, or relentless self-reflection, with the aim of helping students to accept faults and failures with the high degree of emotion they will need to drive changes in the future.

Synthesis requires students to add to existing information by contributing "their own thoughts, experiences, opinions, interpretations, and connections to generate … new and

[25] Scheer, Noweski, and Meinel, "Design Thinking in Education."

[26] Ingo Rauth, Eva Köppen, Birgit Jobst, and Christoph Meinel, "Design Thinking: An Educational Model towards Creative Confidence," paper presented at the First International Conference on Design Creativity, ed. Toshiharu Tauri and Yukari Nagai (ICDC, 2010), Kobe, Japan, November 29-December 1, 2010.

[27] Birgit Jobst, Eva Köppen, Tilmann Lindberg, Josephine Moritz, Holger Rhinow, and Christoph Meinel, "The Faith-Factor in Design Thinking: Creative Confidence Through Education at the Design Thinking Schools Potsdam and Stanford?" in *Design Thinking Research: Measuring Performance in Context*, ed. Hasso Plattner, Christoph Meinel, and Larry Leifer (Berlin: Springer, 2012), 35-46

[28] Joyce Hwee Ling Koh, Ching Sing Chai, Benjamin Wong, and Huang-Yao Hong, *Design Thinking for Education: Conceptions and Applications in Teaching and Learning* (Singapore: Springer Science + Business Media, 2015).

[29] Judy Matthews and Cara Wrigley, "Design and Design Thinking in Business and Management Higher Education," *Journal of Learning and Design* 10, no. 1 (2017): 41-54.

[30] Suna Løwe Nielsen and Pia Stovang, "DesUni: University Entrepreneurship Education Through Design Thinking," *Education + Training* 57, no. 8/9 (2015): 997-91.

[31] Basil Badwan, Roshit Bothara, Mieke Latijnhouwers, Alisdair Smithies, and John Sandars, "The Importance of Design Thinking in Medical Education," *Medical Teacher* 40, no. 4 (2018): 425-26.

bigger [ideas]."[32] For example, at Ad Astra, students engage in synthesis through complex scenarios—working as a team through "case studies, simulations, and game-based challenges."[33] Students practicing synthesis also hone their analytical skills as they break concepts down into key points that allow them to draw useful conclusions and make decisions to solve meaningful problems.[34] Ethical dimensions can be included in the process of problem-solving through synthesis; "some best practices include making consequences and feedback on choices clear, [and] allowing more time for [students] to form relationships … using authentic scenarios and contexts.[35]

It was common for the scientists hired by Thomas Edison for his innovation factory in Menlo Park, NJ, to toil into the late evening or early morning hours, their boss alongside them. He often ordered a midnight lunch of meat, bread, cheese, and beverages for the entire crew to fuel their overnight discussions and theorizing. At a midnight lunch, Edison encouraged people from different project teams to "share their experiments, trade notebooks, and engage in spirited dialogue."[36] This arrangement allowed individuals from diverse disciplines to offer multiple perspectives when solving problems rapidly, thus avoiding both groupthink and a reliance on a culture of superstars.[37] ARES Learning embraces this collaborative and innovative approach to what traditional school lunch time should be. Similarly, at the end of the day, students come back together for a period of reflecting on their learning.

Hansei, or relentless self reflection, is an important part of Japanese culture—a continuous practice of subtle meditation undertaken to look at past mistakes, outline the lessons learned, and pledge to act on those lessons. "Han" means to change, turn over, or turn upside down. "Sei" means to look back upon, review, and examine oneself. In the workplace, Hansei typically involves taking individual responsibility for a problem and developing a (frequently written) plan for avoiding the issue in the future.[38] Studies show

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[32] Classroom Nook, "Reading Comprehension Strategy Series: How to Teach Students to Synthesize While Reading," www.classroomnook.com/blog/synthesizing-a-text.

[33] Matthew S. Williams, "Learning Through Play: How Synthesis Plans to Bring the Ad Astra/Astra Nova Model to the Entire World," Interesting Engineering, 2021, interestingengineering.com/learning-through-play-how-synthesis-plans-to-bring-the-ad-astra-astra-nova-model-to-the-entire-world.

[34] Cosette Taylor, "What is 'synthesis'?" University of Manitoba, umanitoba.ca/faculties/nursing/students/What_is_synthesis.pdf.

[35] Karen Schrier, "Designing and Using Games to Teach Ethics and Ethical Thinking," in *Learning Education and Games Volume One: Curricular and Design Considerations*, ed. Karen Schrier (Pittsburgh: ETC Press, 2014): 141-58.

[36] Sarah Miller Caldicott, "Teamwork, Edison Style," *Mechanical Engineering Magazine* 137, no. 2 (2015): 46-49.

[37] Sarah Miller Caldicott, *Midnight Lunch: The 4 Phases of Team Collaboration Success from Thomas Edison's Lab* (Hoboken, NJ: Wiley, 2012).

[38] Jeffrey K. Liker and James M. Morgan, "The Toyota Way in Services: The Case of Lean Product Development," *Academy of Management Perspectives* 20, no. 2: 5–20. doi.org/10.5465/AMP.2006.20591002.

that Hansei enhances self-evaluation, improvement, and morality[39] (thus also addressing the need for ethics education), and that this process is effective even for very young children.[40] At ARES Learning, students engage in Hansei at the end of each day to chart a course forward academically, socially, and emotionally.

## Conclusion

ARES Learning is a prototype secondary school designed to prepare students for humanity's multi-planet future. To that end, it incorporates several mindsets and skill sets more suited to open-ended problem solving than traditional schooling. A flexible multidisciplinary curriculum (including subjects like philosophy, anthropology, and data science) is delivered via blended learning methods to lay an academic foundation for students. From there, the program helps students to develop experience with problem-solving strategies such as the explorer's mindset, moonshot thinking, and design methodology. The school schedule also includes routines to encourage synthesis, collaboration, and reflection, thus amplifying what students can accomplish together in a short period. This paper provides a summary of the academic justification for including these design elements.

It is the author's hope that this brief literature review might offer inspiration for educators in other contexts to implement some of these changes with their students, and that it might also inspire other researchers to explore some of these elements in more detail. Some questions suggesting further research include: What subjects should space explorers have a basic grasp of for the purpose of settlement on other planets? How might the explorer's mindset (or moonshot thinking, or design thinking) be employed by secondary students to help them to understand the sorts of problems they might need to solve in space better? How might learning experiences be crafted to provide students with opportunities for synthesis, collaboration, and reflection over a distance in online or virtual environments? And what if that distance included a twenty-minute delay in communications back to experts, peers, and online resources on Earth if students are in fact settlers on a planet like Mars?



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[39] Satomi Izumi Taylor, L. Weiping Wang, and Tetsu Ogawa, "I Think, Therefore, I Improve: A Qualitative Study of Concepts of Hansei (Introspection) Among Japanese Adults," *Journal of Early Childhood Teacher Education* 26, no. 1 (2005): 79-89.

[40] Satomi Izumi-Taylor, "Hansei: Japanese Preschoolers Learn Introspection with Teachers' Help," *Young Children* 64, no. 4 (2009): 86-90.

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**Editors' Notes:** This paper was accepted for publication before Mark Wagner took on his new role as Associate Editor of this *Journal of Space Philosophy*. It is the academic articulation of a vision he and his co-founder, Brendan Brennan, share for an innovative high school they call the Academy for Relentless Exploration of Space, or *ARES Learning*. Inspired by the idea of making *Star Trek*'s Starfleet Academy real, the school would prepare students to be well-rounded scientifically literate citizens prepared to face complex ethical challenges. Their hope is that ARES might also inspire change on a much broader scale in public schools around the world, fundamentally improving workforce development for the entire space economy, and preparing a generation of decision makers who will lead humanity into a peaceful, prosperous, and equitable multi-planet future. Clearly this vision is in alignment with the visions of KSI and this journal. ***Gordon Arthur*.**