EXECUTIVE SUMMARY

SPACE
One giant leap for education
SUMMARY

1. Interest in Science, Technology, Engineering, and Mathematics (STEM) has decreased in many countries, driving a need for innovative education methods.

2. Eureka! moments emerge when education encourages creativity. Art brings humanity to STEM and STEM to humanity by connecting the personal to the technical.

3. Humanity’s achievements in space are sources of inspiration and motivation for all. Space inspires humankind to dream, act, and achieve.

4. Space-related activities inspire students to engage in their studies and should be incorporated into global STEM education.

5. Mobile games, festivals, movies, workshops, textbooks, and all forms of new media using space can enhance STEM education worldwide.

6. Tomorrow’s STEM education should be continually updated to involve students around the world in ongoing space missions.

7. Space can make the STEM education of tomorrow more global, equitable, affordable, creative, and attractive. Space is One Giant Leap for Education!
PROJECT RATIONALE

The STEM fields are fundamental to modern society. Today, the declining interest in STEM education is a global issue that threatens future progress.

Space programs produce some of humanity’s greatest achievements, scientific discoveries, technological advancements, and international cooperation. Space-related content motivates students in their studies and encourages them to pursue careers in science, technology, engineering, and mathematics.

We urge teachers everywhere to exploit space for STEM education.

MISSION STATEMENT:
To use space as a foundation for developing recommendations to improve the quality and accessibility of STEM education for all by embracing creativity, collaboration, and critical thinking.

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Cover design using images courtesy of NASA
Many students today feel that STEM subjects are boring and irrelevant. Student attitudes vary greatly depending on economic, social, and cultural background; however, all nations need a strong STEM workforce, and countries can benefit from reviewing and improving their STEM education system. In developed countries, there is a common perception of STEM education as hard and elitist. This attitude can create a critical lack of future STEM professionals as students pursue other fields such as business and social sciences. In rapidly developing countries, STEM education is often highly valued but is only offered in certain school systems. By contrast, many developing countries lack a strong education system and only a fraction of the population has access to education.

STEM education worldwide is influenced by gender, cultural, and societal expectations. Women and minorities are often discouraged from pursuing STEM studies because of strong and long-held family, social, cultural, and religious prejudices and stereotypes. Women are better represented in fields such as the social sciences and education, but are significantly underrepresented in technical fields. Expanding the reach of STEM education depends in part upon reducing these social barriers.

Many current teaching and evaluation methods are based on those developed during the Industrial Revolution and need to be revised to be more relevant in the Knowledge Age. Present day curricula fail to motivate many students and may even inadvertently discourage students from the STEM fields. One of the reasons is that the curricula often provide few opportunities for guided inquiry-based teaching. Also, many teachers feel that the available STEM teaching resources are inadequate. Finally, despite many accessible extra-curricular resources, teachers find it difficult to incorporate those resources into the strict curricula. The evaluation methods used in most countries provide a very narrow view of skills that students have learned, and do not track how students retain information and use learning tools. A more comprehensive evaluation system that provides feedback based on an assessment of knowledge application and relevance to students could improve STEM education.

STEM education must move past outdated methods, overcome social boundaries, and retain its relevance. STEM education must move beyond outdated methods, overcome social boundaries, and retain its relevance and value to produce the next generation of highly trained and motivated STEM professionals. The time has come for change, and space is a critical element for that change.

A word cloud constructed from data gathered using a survey of ISU students showed that parents and schools were strong motivating factors in their decision to pursue a career in STEM.
The modern trend of incorporating art into STEM to create STEAM (Science, Technology, Engineering, Art, and Mathematics) has great potential. Art makes STEM subjects accessible and enjoyable, bringing humanity to STEM and STEM to humanity. Creativity brings science into a wider social realm by connecting the personal and the technical. An artistic experience can create a profound and lifelong connection with a subject, encouraging students to pursue an education and a career in a STEM field.

Eureka! moments emerge when education encourages creativity. STEAM provides interdisciplinary collaboration and a bold, fresh method of innovative thinking. Art is usually perceived of as an object or product such as a painting or musical composition; it also encompasses a design-driven creative process that produces different ideas and new paradigms. Art represents non-linear, abstract thinking, and can foster relationships between seemingly unrelated subjects. Eureka! moments emerge when education encourages creativity.

Space is an inspirational springboard, a multi-disciplinary driver, and an engine of universal questions. New questions require new answers that, in turn, require new concepts. Art is integral to realizing the ideas, concepts, and dreams inspired by space. The universal appeal, creative learning tools, and hands-on practical immersion that art provides are the perfect complement to space-driven STEM learning.

The STEM-Art Relationship: The design process is an integral part of both art and the STEM fields. Incorporating art as an experience creates a feedback system through which improving one part of the system improves the whole.

Image Credit: E.O.Hoppé
Space to Inspire

Space provides humankind with broader perspective. We become more aware of the fragile nature and interdependence of our planet. When viewed from space, the continents are not divided by nations or borders; they are all part of a single world. Space can inspire a sense of global unity that transcends age, gender, nationality, and culture. Space motivates humankind to envision a better future, and STEM education is fundamental to that future.

This painting by Barry Munden of Ilan Ramon and holocaust victim Peter Ginz observing Earth from the Moon has inspired many young people to reach for the stars. Image Credit: Barry Munden

Space to Develop

Each country’s economic and social development depends greatly on its ability to cultivate its science and technology expertise. Space industries and activities can cultivate STEM skills and professionals. The technologies and skills established through national space industries also produce spin-off technologies and create opportunities for further innovation and development. Thus, STEM education through space industries and activities creates a positive feedback loop for national economic and social developments.

Image Credit: NASA
Space can enhance STEM education inside and outside the classroom. Many space agencies offer educational programs and provide supplementary teaching materials to teachers and educators, as well as directly to students. In the US, NASA is developing the next generation of STEM professionals by offering hundreds of programs every year, with materials for students from kindergarten through the post-graduate level. In Japan, JAXA has a more centralized structure allowing space content to be integrated with the Japanese school system. ISRO, in India, has many educational outreach programs including a successful and widespread tele-education program.

Many other extra-curricular activities exist beyond those hosted by national space agencies. Space camps in developed and developing countries challenge participants of all ages with an intensive introduction to space, and can complement school curriculum. Programming competitions (“App Hackathons”) aimed at space applications can help participants develop skills with computer hardware and software development. Groups such as The Planetary Society and amateur astronomical societies all over the world increase space awareness and engage people in active exploration. The commercialization of space by well-known companies, such as Google Lunar X PRIZE, provides a wide audience outreach.

The evaluation of STEM educational content and student learning is important and sometimes overlooked. Student assessment methods have evolved over time, and can now assess the student’s attitude towards the material as well as the specific skills they have learned. Space related synthesis questions, based on those developed for the Program for International Student Assessment, can be used to test if students can apply their academic skills to relevant real-world problems. New space related STEM content should include a comprehensive and on-going curriculum evaluation plan to ensure that it is meeting its goals and improves over time.

Despite the widespread availability of space-related content, accessibility and outreach remain limited. Most teachers experience difficulties using space effectively as part of their existing curriculum. Students acquire deep and applicable knowledge best when solving multidisciplinary problems, thinking creatively, and considering the big picture. Introducing space in primary and secondary school curricula will support a multidisciplinary approach to problem solving by incorporating the four STEM fields into other disciplines. Space presents a wide range of possibilities for future teaching and learning.
Several products and solutions are being proposed to use current space-related materials to improve STEM education:

**SPACE CYCLE GAME:**
The Space Cycle video game teaches the life cycle of space-based assets through the stages of design, construction, de-orbiting, and space debris removal. The game provides fun STEM education and inspiration through the electronic gaming medium. By using this virtual platform, students would be able to apply their classroom knowledge to a real design project, challenging them in new ways and promoting critical thinking throughout gameplay.

**VIDEO:**
“The Universe is Just Awesome,” a new creative video developed in parallel with this report, uses social media and video networks to inspire worldwide excitement about space and the universe. The lines of the song in the video are sung in 19 different languages with subtitles giving the translations of the lyrics. Using social media dissemination and content available in multiple languages, videos of this kind can inspire children all over the world faster and easier than ever before.

**WORKSHOPS:**
Four workshops have been designed to spread knowledge and excitement about space. They are designed to integrate different grade-levels of students. Senior students act as mentors to junior students to promote learning through teaching.

The four workshops are:
1. Looking Up and Down (kite-launched photographic platform)
2. Nature and Us (environmental monitoring)
3. Touching the Clouds (rocket launch)
4. Beyond Earth (using astronomy in education)

Using hands on projects like these while including a mentorship component enables younger students to benefit from the experience of their older peers and allows the older students to learn by teaching. The older children may even learn from or be inspired by the enthusiasm of their younger counterparts.

**Khan Academy Extension:**
Khan Academy is a free website containing hundreds of educational videos on a variety of topics. Incorporating space-related content into the Khan Academy STEM lectures could increase student engagement, provide exciting examples, and introduce students to the field of space studies.
New and innovative space products can make the STEM education of tomorrow totally different from today. The following products and activities can bring space to future classrooms:

**SPACE APPLICATION TEXTBOOKS:**
The real-life examples in current textbooks could be replaced with space-related examples. Changing distance calculations in math textbooks to refer to rockets flying through space instead of cars traveling along a road is a simple but useful change that will introduce students to the subject of space and tackle their imagination without any drastic changes to STEM curricula. These changes are rather small steps that can make lasting impressions on students. Times are changing and technology is changing. The books used by students must also change if they are to remain interesting and engaging for today’s modern student.

**WORLD SPACE WEEK:**
The United Nations declared October 4-10 to be an annual World Space Week to celebrate each year at the international level, the contributions of space science and technology. An international event, such as World Space Week, can provide publicity to increase awareness and dissemination of space-related teaching materials. Ideally, departments of education all over the world can encourage teachers to use World Space Week as a springboard to bring space into the classroom. International children’s television entertainment networks can provide tie-in programming to bring the excitement into the home.

**ON-ORBIT STUDENT COMPETITIONS:**
The International Space Station (ISS) and future space stations provide an on-orbit platform for tomorrow’s STEM education. Space stations can host a series of student experiment competitions covering subjects such as microgravity, plant growth, and biology. Participating in student competitions can improve student perceptions of STEM subjects. The possibility of making a scientific discovery in the space environment can inspire a student to pursue a STEM-related career.

Current plant growing experiments on the ISS can be developed into worldwide student competitions.

Image Credit: NASA
Space can be used as a medium and driver for STEM education. Many developed and developing countries are experiencing declines in STEM education rates. Some least developed countries view STEM education as important, but are still struggling to provide basic local education. Space-related content can improve STEM education systems and change the common perception of STEM as elitist, hard, and boring.

International and multidisciplinary research has identified social and methodological challenges to STEM education. A major identified problem is that most 21st Century education systems are essentially the same as those developed during the Industrial Revolution. These old teaching methods are no longer appropriate for modern students who were born into the Knowledge Age.

Art can be used to connect space and STEM in a more attractive way and to improve and extend the skills of STEM students. The process and experience of art are important for design, creative thinking, and bringing humanity to STEM and STEM to humanity. Space can promote STEM education to increase the motivation of school-aged children and expand the current STEM audience. New teaching and evaluation methods can meet the needs of the modern education system by measuring students’ knowledge and attitudes toward the material. Mobile games, festivals, movies, workshops, textbooks, and all forms of new media using space can enhance STEM education worldwide.

Imagination, innovation, aspiration for exploration, and the potential to answer the most fundamental questions of humanity, attract people of all ages to space. Space provides a new perspective and collaborative environment that can help challenge stereotypes, and lead to national, cultural, and gender equality. Using space to promote STEM education helps develop open-minded and creative future leaders.

This project sought to answer the question: “What can space contribute to global STEM education?” The Team has shown that the inherent power of space to provide a wide appeal, and to inspire and motivate students, can be leveraged to improve STEM education. Incorporating space will encourage students to engage with their studies and pursue higher education in STEM fields. Space-related content can provide a Giant Leap for Education!
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