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Trail blazing STEM education

No-one in the space community would deny the importance of Science, Technology, Engineering and Maths (STEM) education to the younger generation and the populace as a whole. But agreement does not always result in action. Bob Griesmer recognises the shortfalls and describes a US home-grown solution.

I remember the magic of that night sky in 1957. The grass soaked my back as I peered upward in search of that moving, beeping beacon. The sky was crystal clear, the Milky Way unpolluted by city lights. Sputnik would kick off a decade-long race to the Moon. Ten years; why so long? That was a lifetime for this ten year old.

The capsules that followed - the Mercury, Gemini and Apollo - were my generation's 'covered wagons of the new frontier' that John Kennedy held out as a promise. This was our manifest destiny. We who thought, even at a young age, that there were no mountains we could not climb, no alien planets we could not conquer, would come to consider science as a calling in our brave new world.

Life choices

So, why is it today that research indicates that by the time students reach the fourth grade, a third of boys and a higher proportion of girls have lost interest in science? By the eighth grade, almost 50 per cent have either lost interest or deemed it irrelevant to life choices as they move from being an adolescent to a young adult.

Both the Pew Research Center and PISA (Programme for International Student Assessment) demonstrate continued low academic rankings when the United States and other developed countries are compared to places like China, Hong Kong, South Korea and Vietnam. In 2015, America ranked 38th in maths and 24th in science in the PISA ranking. The Pew Research Center reported that the US ranks



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▼ Virginia Air and Space Center is dedicated to preserving US national achievements in air and space exploration.

behind many other industrialised countries based on maths and science assessments. The United Kingdom, with a 26th ranking in maths, is leading some of the developed countries on the European mainland, but, with few exceptions, countries in the European Union are absent from the top ranking.

Therefore, it is imperative that we ask the question: what is the correct combination of ingredients that sparks curiosity and engages students so that they connect their skill-sets with the careers of the 21st century? I asked this question over eight years ago when I began a journey to fund research to test different platforms, a test that would help us understand what types of intervention, and how many, are needed to make a significant statistical difference.

Formal and informal educators all need to pay attention to how we reignite wonder. How do we break the cycle of disconnect between the sciences and the exciting life and career choices that might await those who are fortunate enough to be presented with clarity of career options and the academic training needed to compete for those well-paid careers? There should be robust and sustained efforts to enable students to connect the dots between Science, Technology, Engineering and Maths (STEM) and actualise their life interests and potential.

So how, and with what tools, do we demonstrate that maths is necessary for those well-paying technical jobs? In Virginia alone, there are reportedly some 50,000 jobs unfilled due to lack of qualified candidates. We know not everyone will join the ranks of becoming an astronaut, or for that matter, an astrophysicist or an engineer. However, there will be continued demand for technicians in areas such as manufacturing, health care and transportation, to name just three. These are workforce supply

deficiencies that will continue to have serious social consequences if we do not make this a top priority.

Enter the Center

We are in a unique position at the Virginia Air & Space Center. The Center, in its capacity as the official visitor centre for NASA Langley Research Center, is dedicated to preserving US national achievements in air and space exploration, supporting NASA key messages and missions, and stimulating interest in the sciences.

As a NASA visitor centre, the Virginia Air & Space Center connects students and teachers with NASA content and brings cutting edge technology to the community, inspiring the next generation of scientists, technicians, engineers and mathematicians. Our 110,000 square foot facility is home to the Apollo 12 Command Module, the Orion test capsule, a collection of more than 30 aircraft spanning 100 years of flights and interactive exhibits that explore our world - past, present and future. It is logical, therefore, that the Center should act as a launch pad in optimising underutilised resources in the community and enabling successful programmes and projects.

There are, of course, many questions. What does this 'intervention' look like? How do formal education systems, such as schools, and informal educational institutions (such as science centres, zoos, aquariums, local industry and trade schools) work together for specific measurable outcomes? And what is the role of those free-choice learning institutions in communities around the world who have been limited to offering 'fringe contributions' in the form of a single spring school field trip?

The STEM 360 Research Project is the Virginia Air & Space Center's attempt to answer these questions.

STEM 360

The STEM 360 Project, which began in July 2016, explored whether three different levels of STEM learning enrichment could positively and significantly improve four key STEM learning outcomes: (1) STEM Career Awareness; (2) STEM Academic Achievement; (3) STEM Engagement; and (4) Attitudes toward STEM.

Four strategies were used to enhance the existing STEM learning environment: in-school classroom educational outreaches provided by the Virginia Air & Space Center; field experiences at the Virginia Air & Space Center and other local informal STEM institutions; family and out-of-school time engagement through STEM ambassadorships; and STEM-coach engagement and support.

This project is not just about the Virginia Air & Space Center. Our sister community informal



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learning centres, such as the Virginia Zoo, Virginia Aquarium and Marine Science Center, and Norfolk Botanical Garden have become key partners in this endeavour. Although one might not ordinarily think that formal trade schools and private industry would have something to contribute to this kind of research, they have been effectively incorporated into the foundation of STEM 360.

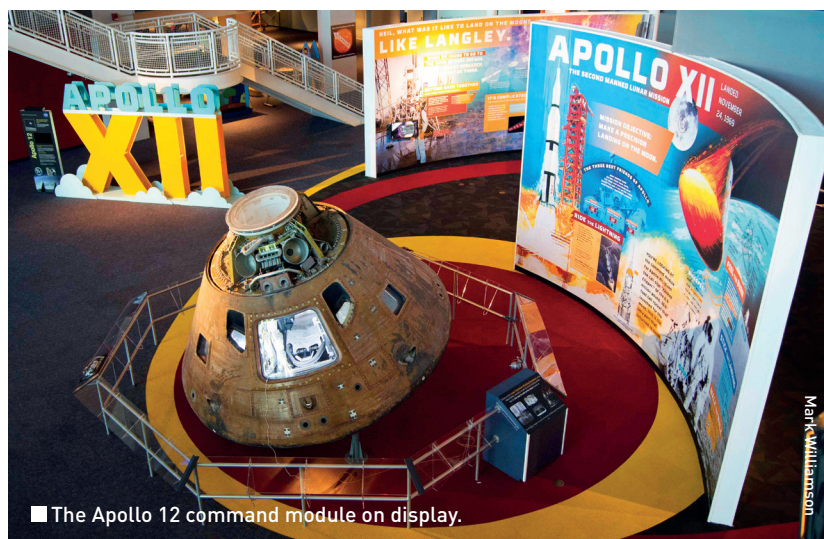
As for levels of intervention, an equal number of schools from three school districts were assigned to one of three such levels. Level 1 provided the maximum amount of engagement with each of the four interventions, Level 2 provided a moderate level of engagement and Level 3 provided minimal or 'typical' level of STEM engagement (and was considered the control group).

Over 1800 students participated in some part of the project, but overall it was the students in the Level 1 treatment group – the group with the greatest quantity and quality of STEM 360 Project intervention – that showed the greatest benefits. Specifically, Level 1 students significantly improved their awareness of STEM careers and interest in pursuing STEM careers, science academic achievement, STEM engagement through participation in group visits to free-choice learning venues, and STEM attitudes and interests in a range of specific STEM topic areas. The results provide strong evidence that when key 'levers' of educational influence are activated, student progress in all four areas can be significantly enhanced.

In the words of Dr John Falk, the leader of the Institute for Learning Innovation, who put the structure and controls in place to ensure the integrity of the data and conclusions, a process of transformation commenced to ensure that the "Virginia Air & Space Center would not be just a nice place, but an essential place, not just a provider of STEM programmes, but a leader".

This is the fundamental strategy that will drive the Virginia Air & Space Center to a new place, thereby ensuring not only its relevance, but its sustainability. Dr Falk, Sea Grant Professor Emeritus of Free-Choice Learning at Oregon State University, is an outstanding social scientist whose reputation and experience made him the logical choice to participate in and guide this important research project.

Now, having completed the two-year Phase I original research, as well as the replication Phase II, our sights are set on geographic expansion and pilot testing. The four years of research indicate, not surprisingly, that the highest level of student experiences (Level 1) demonstrate statistically significant



improvement as compared with the lowest (Level 3) control group.

The STEM 360 Research Project continues to be funded through the Commonwealth of Virginia. We believe that new leadership opportunities exist for science centres which are able to successfully bundle the components considered in this research. We are achieving a more in-depth relationship with school divisions and our sister institutions due to the partnerships developed and the outcomes being achieved. How this rolls out into a larger context is yet to be tested with our next pilot project, Phase III, currently under design.

Trailblazers

We see the STEM 360 Project as a small component of a much larger and intricate supply chain of future trailblazers who have the training and determination to break barriers, like those who came from the generation that looked to the night sky and dared to

How do we break the cycle of disconnect between the sciences and the exciting life and career choices that might await?



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chart their individual paths to explore new worlds. Katherine Johnson, who passed away in February 2020 at the age of 101 here in Hampton, Virginia, was breaking barriers with her mind at the dawn of the Space Age. She was a female African-American mathematician working at NASA Langley Research Center in a segregated group of 'human computers', but her mathematical talents propelled her into the world of white male engineers.

Margot Lee Shetterly, the author of the book *Hidden Figures: The Story of the African-American Women Who Helped Win the Space Race*, said of the 'human computers' such as Johnson, "We are living in a present that they willed into existence with their pencils, their slide rules, their mechanical calculating machines - and, of course, their brilliant minds".

What must we do to ensure that we create equal opportunities for a new crop of trailblazers capable of meeting the challenges of the 21st century? We believe that the STEM 360 research platform is a viable programme that provides some answers to this question while, at the same time, addressing essential community needs and positioning the Virginia Air & Space Center as not just a provider, but a leader in STEM education and research. We are proud of the successes this research project has achieved and we look forward to the next phase of expansion that will share and build on what we have learned.

From the perspective of the Virginia Air & Space Center, "Failure is not an option". These were the words that rang out in mission control in Houston when it committed to bringing back alive those

three brave men of the Apollo 13 mission. Among them was astronaut Fred Haise, who I hope will not object to my revealing what he told our small dinner gathering at Stennis Rocket Center: despite what was portrayed in the Hollywood film *Apollo 13*. "There was no hugging going on upon the capsule's re-entry", he said. So, while Hollywood can inspire us, we must stay true to the facts, do the research and deploy effective measures in order to provide the tools to the next generation as they explore their new frontier.

John Dewey was an American 19th century philosopher, psychologist and educational reformer who many consider the father of American progressive education. He believed strongly that an educated critical-thinking population was essential to preserving democracy. In this global economy, with competing national interests and government systems, Dewey seems more relevant than ever. Our nations and our children's futures are at risk if we do not, once again, capture and hold the high ground in science, technology, engineering and maths. ■

About the author

Robert R Griesmer (www.RobertGriesmer.com) is Executive Director & CEO of the Virginia Air and Space Center (www.vasc.org). He has more than 30 years' experience in leadership roles in free-choice learning institutions, having previously served as President & CEO of the Children's Museum in West Hartford, Connecticut, and Chief Operating Officer at The Maritime Aquarium at Norwalk, Connecticut. Before joining the non-profit world, Mr Griesmer held positions in New York City, Alexandria, Egypt, and Abu Dhabi, UAE, in banking, economic development and large scale infrastructure construction, respectively.

Editor's note: this article uses the European form of abbreviating mathematics to 'maths' rather than 'math' as in American English.

