Nevada K-12 STEM Pipeline

David Vallett, Ph.D.
P.G. Schrader, Ph.D.

During the past several years, Nevada's elected leaders have placed considerable focus on diversifying the state's employment base to protect its citizens from economic instability. One key to achieving this goal is participating in the STEM-related economy, which nationally is growing significantly faster than the nation's economy as a whole. To some extent, early efforts have been successful. Tesla's gigafactory, the proposed Faraday Future, DroneAmerica's unmanned aerial systems, and the Switch telecommunications hub all represent significant progress in this area. The state is, however, constrained to a large degree by its relative lack of employees educated in science, technology, engineering and mathematics (STEM) curriculum. This is important because much of Nevada's growth potential is linked directly to those fields. To address a significant projected shortage of STEM-educated employees, Nevada must construct a "pipeline" that recruits and cultivates students interested in STEM disciplines.

Nevada Facts & Statistics

- While Nevada encompasses more than 110,000 square miles, approximately 85 percent of its residents live in one of two major metropolitan areas. Thus, STEM-related programs outside the urban areas of the state range from sparse to non-existent.
- Within Nevada's elementary schools, an average of only 15 percent of classroom time is dedicated to science instruction.
- Mathematics, on the other hand, is a focus item due to the adoption of the Nevada Academic Content Standards for Mathematics.

U.S. Facts & Statistics

- The President's Council of Advisors on Science and Technology predicts a need for a million more STEM graduates nationally during the next decade to offset a decline in domestic workers.
- The National Science Foundation has made significant investments in STEM-related grants intended to improve students' educational experiences and impact their decisions to pursue STEM-related careers.
- As a nation, failing to produce domestic workers fluent in STEM disciplines poses a threat to our economy as these industries will migrate to the workforce.
- Employment in STEM-related fields has increased at three times the rate of other jobs.

Recent Actions in Nevada

- GEAR UP, Gathering Genius, Math Science Partnership grants and NSHE-funded EPSCoR grants all include components that promote a stable STEM pipeline; however, all of these programs are externally funded.
- The Clark County School District has developed highly successful and sought-after robotics programs at its Cimarron-Memorial and Sunrise Mountain high schools.
- Full Options Science System materials have been adopted statewide, although not uniformly, as the primary resource for elementary science instruction in Nevada. However, the cost of kits is cost-prohibitive for some school districts and the product and associated curriculum could be more robust.
- Both Clark and Washoe counties have begun utilizing a nationally respected curriculum called Engineering is Elementary, developed by the Boston Museum of Science.

Considerations for Future Actions

Developing a stable STEM pipeline requires intervention early in the educational process, which must continue through postsecondary education to optimize graduation rates and application to the STEM workforce. Recommendations to expand and bolster this pipeline include:

- Expand professional development for K-5 teachers beyond mathematics, which are already adequately represented, to include science, technology (including computer science), and engineering curricula.
- Develop a more cohesive approach to education that more effectively balances emphasis on all four STEM disciplines and contextualizes learning in authentic

experiences.
- Expand availability of STEM-related programs to encompass rural areas of Nevada.
- Initiate STEM instruction earlier, introducing and encouraging students to pursue areas of interest in order to recruit them into more advanced programs in high school.

Statewide Benefits of Future Action
- With job growth among STEM-related fields far outpacing overall expansion of the workforce, Nevada stands to reap considerable rewards from an investment in technologically literate employees.
- An attractive tax and regulatory climate make Nevada a legitimate contender in drawing new industries, as demonstrated by the Tesla gigafactory. Addressing the state's real and perceived educational shortcomings would give it an increased competitive advantage.
- Diversifying the workforce with STEM jobs adds a more recession-resistant facet to the state economy.

Implications of Maintaining Status Quo
- While Nevada's elected leaders have been embracing technology as a pathway to economic vitality and diversity since the late 1990s, the state still lags significantly behind the nation in terms of STEM-related employment and STEM literacy among students. Failure to effectively address the STEM workforce deficit will result in persistent under-achievement within this sector of the economy.

Introduction

Although Nevada is geographically expansive, covering 110,567 square miles, roughly 85 percent of its nearly 2.9 million residents live in one of two large metropolitan areas: Las Vegas, and Reno-Sparks, with approximately 2 million and 420,000 residents, respectively. The remaining residents are distributed across 96,500 square miles of remote, rural land. Although fewer in number, the needs of those in rural areas are no less significant when compared to those in urban centers. As a state, Nevada's legislature is presented with the daunting challenge of defining policy and distributing resources in ways that benefit all citizens in the state and that prepare for the future of the state as a whole. To this end, Nevadans have made strides in diversifying the state's economy, in part through policy and funding associated with Science, Technology, Engineering, and Mathematics (STEM) education and careers.

In *Cracking the Code on STEM, A People Strategy for Nevada's Economy*, Lee, Muro, Rothwell, Andes, and Kulkarni (2014) observed that all "Nevadans deserve a healthy, diversified economy that offers them opportunities for prosperity and advancement. Bolstering STEM knowledge in the state—from kindergarten through postsecondary and beyond—will help ensure that Nevada can make good on its potential (p. 9)." This potential is embodied by recent opportunities in the high-tech STEM industry, including Tesla's Gigafactory, Faraday Future, Tony Hsieh's Innovation District, continued alternative energy electrical production, DroneAmerica's unmanned aerial systems, and an unparalleled cyber-infrastructure that paved the way for Switch.

Although incomplete, this list of high-tech STEM industry leaders underscores Nevada's need for a highly talented and skilled STEM workforce. A robust pipeline of STEM trained workers is imperative for Nevada, the Mountain-West region, and the United States' emerging industries in STEM fields. Research has shown, and statewide experience has confirmed, that there are three key aspects to a healthy K-12 STEM pipeline. Specifically, policies must provide opportunities for: (1) early experiences for students that are designed to promote affect in STEM fields, (2) authentic and integrated experiences for students in STEM, and (3) the necessary knowledge infrastructures to train teachers to successfully and meaningfully integrate STEM in their classrooms.

Currently, there are numerous projects that address one or more of these goals. Nevada's GEAR UP, Gathering Genius, Math Science Partnership grants, and NSHE-funded EPSCoR grants (among others) have some or all components that promote a stable pipeline to advanced STEM coursework and STEM careers. However, each program is funded by outside sources. Additional programs, such as the robotics experiences at Cimarron Memorial and Sunrise Mountain High Schools in Las Vegas, leverage high-interest topics during out-of-school time. Many of these focus on professional development for teachers in math and science, typically those supported with state funds; other programs focus on developing an understanding of engineering, or providing positive STEM experiences for underrepresented groups. This use of extramural funds to promote success in STEM creates an unstable environment, dependent upon the whims of funding agencies rather than local needs. Further, this approach is in opposition to research, which has shown that consistent and early exposure is instrumental and necessary for success in STEM. Finally, out-of-school projects tend to attract students, regardless of demographics, who already display an aptitude for and predilection to participate in STEM (Vallett, Lamb, & Annetta, 2016). Common issues among these programs include: sustainability, cogency, and breadth of impact.

As a result, this policy paper will outline key policy recommendations that are intended to maximize a stable and healthy STEM pipeline for Nevada students using permanent programs and sustainable approaches to funding. In situ, we will draw upon existing and successful, albeit soft-money, programs as models for STEM experiences in Nevada schools. Throughout, we will provide compelling evidence for policy changes in terms that are pertinent to key stakeholders throughout the state. Ultimately, we will highlight the need for such programs from a policy perspective in terms of economic success and diversity, as well as social responsibility to citizens of Nevada, particularly students who are typically at risk or underrepresented in STEM careers.

STEM in the United States

The sustainable preparation of STEM workers is complex. At each educational stage, students make decisions that benefit or limit their options when it comes to STEM majors and careers. Policy leaders and researchers have identified numerous variables and provided countless suggestions to increase the number, quality, and stability of workers in STEM careers. At a national level, for example, the National Science Foundation has made significant investment in STEM-related grants intended to improve students' educational experiences and impact their decisions to pursue STEM-related careers. At local levels, districts have implemented after-school programs and activities in STEM, intended to stimulate students' interest in the areas.

Ultimately, policy leaders, researchers, and educators have documented the need to transform STEM education to improve high school students' achievement and motivation for STEM career selection. The President's Council of Advisors on Science and Technology (PCAST, 2012) emphasized a need to produce a million more STEM graduates in the U.S. over the next decade to offset a decline in domestic workers. As a nation, a "new economy" based on technology and information has begun to replace our existing service economy. This shift adds value to products and processes and is the key to growing jobs and incomes (Aubert, 2004). However, workers must be technologically literate to compete in today's careers. As a nation, we lose considerable footing on an international scale if we continue to fail to provide domestic workers in STEM. Similarly, the next generation of workers must be scenario planners, not just problem solvers.

Unfortunately, trends within K-12 and higher education science and mathematics preparation programs, coupled with demographic and labor supply trends, point to a serious challenge: Our nation must increase the supply and quality of "knowledge workers" with specialized skills, enabling them to work productively within STEM industries and occupations. Targeting baccalaureate and advanced degree holders already within STEM fields is not sufficient. Our nation's economic future depends upon improving and increasing the labor pipeline into STEM fields. Targeted improvements focus on sub-baccalaureate students, as well as bachelor's and advanced degree holders, youth moving toward employment, adults already in the workforce, employed in STEM fields, and those who would like to change careers to secure better employment and earnings (U.S. Department of Labor, 2007). However, in order for the next generation of America's high school and college graduates to succeed, information and communications technology (ICT) must be the central medium through which current K-12 students learn, and learn how to learn. In addition, students must become familiar with the pivotal role that emerging digital technologies play in generating and applying new scientific knowledge to 21st century skills.

Rapid advances in information technology, educational informatics, and analytics are reshaping learning for students of the next generation. These students have grown up in a world where technology is seemingly innate and contextually integrated into their daily experiences. Emerging practices and learning styles include fluency in multiple media and simulation-based virtual settings, communal learning, balanced experiential learning, guided mentoring and collective reflection, non-linear representations, and co-designing learning experiences that personalize individual needs and preferences (Dede, 2005). Vallett and colleagues (2015), in studying the within group variation of the GRADUATE participants, noted increased participation in the design process was positively correlated with increased interest in school-based and informal STEM activities.

STEM in Nevada

In the United States, STEM jobs have grown three times faster than other jobs. In Nevada, this shift is made clear through examples and opportunities for qualified STEM workers. As early as the late 1990s, Nevada was eager to embrace new technologies as a pathway to economic vitality and diversity. At this time, millions of dollars in network infrastructure were installed to satisfy the nation's growing Internet and WWW needs. Switch purchased the network in 2000 and built the most advanced, efficient, and highest-rated data centers in the world: SUPERNAP. Currently, Switch operates its headquarters and four data centers in the Las Vegas area, with an additional three planned in the south, and seven planned near Reno.

There are numerous other examples beyond Switch. For example, Ormat Technologies in Steamboat, Nev., provides alternative geothermal energy. At the time of this writing, the company advertised positions for qualified engineers and plant managers. Another long-term STEM employer is IGT (International Gaming Technologies), which manufactures casino-related technologies, including slot machines. Although the company was acquired, the freshly merged company kept the IGT name and its ties to Nevada. In addition to gaming, Nevada competed for and secured Tesla's first Gigafactory, which completed the first phase early in 2016 in Storey County, near Clark, Nev. In addition to lithium ion batteries, Tesla announced that it would also manufacture drive units and motors for its electric vehicles. Beyond high-tech careers, energy, and gaming, it is important to remember that numerous traditional positions, like those in Nevada's hospitals, require advanced training in at least one branch of STEM. Ultimately, careers that require training in STEM translate to approximately 15 percent of all jobs in Nevada (Lee, et al., 2014).

STEM Preparation in Nevada

The notion of a STEM pipeline as a metaphor for students' preparation for STEM careers has been part of the national conversation for years. At its core, the analogy characterizes a steady flow of skilled workers, beginning in early childhood through elementary grades and culminating in successful STEM careers. At each phase of the pipeline, researchers have documented best practices, as well as barriers to success. From an educational perspective, research has established that early exposure, inquiry practices, meaningful connections to the real world, and faculty/student interactions are influential and determine whether or not students stay in STEM majors. Role models and experiences with scientists are instrumental in students' continued interest and success in STEM fields. Across Nevada, there are examples of these practices and others.

Elementary Grades (K-5) Focus on STEM

In elementary schools, the vast majority of time is spent on literacy and mathematics due to Common Core State Standards (CCSS) and high stakes testing. An average of 15 percent of class time is spent on science, with focus groups conducted with elementary teachers revealing that, in some cases, as little as 20 minutes per week is allotted for science. Elementary teachers who are dedicated to science instruction, or less anxious about their overall performance on standardized tests, anecdotally spend significantly more time teaching science or integrating it into their instruction, while newer teachers or those will little content background are likely to avoid teaching science entirely at the elementary level. Technology and engineering likewise suffer from a lack of dedicated class time, a lack of clear curriculum for teaching those disciplines, and the perceived need for them to be taught alongside science instruction. Mathematics, since the adoption of the Nevada Academic Content Standards for Science (NVACS) (and probably since the advent of the No Child Left Behind Act high-stakes testing), has received a great deal of time and attention from elementary teachers and administrators.

Existing K-5 Programs

Full Options Science System (FOSS). Delta Education's Full Options Science System (FOSS) serves as the primary resource for elementary science instruction statewide in Nevada. For example, CCSD allocated resources to fund FOSS kits and supplies in AY 2014-2015 on FOSS kits and supplies to replenish those kits. A total of 2,558 classrooms ordered those kits from the District.

FOSS, developed by Lawrence Hall of Science, combines hands-on investigations with the practice of science notebooks in an attempt to engage elementary aged students in meaningful scientific inquiry; the newest iteration being ostensibly aligned with the Next Generation Science Standards (NGSS). This aims to include science and engineering practices and crosscutting concepts, as well as the disciplinary core ideas, into integrated lessons and units that make explicit connections to the Common Core State Standards. Given the adoption of the Nevada Academic Content Standards (NVACS) that parallel these standards, FOSS kits would seem to be an important, if not the only, resource for many elementary educators teaching science. At first blush, this looks like an excellent program; expert review of materials by STEM educators in Nevada indicate that the FOSS lessons, however, need some adjustments in order to better foster student inquiry. Furthermore, while some districts are able to update their kits to match the NVACS, the cost (just under $1,000 per module for most) can be prohibitive for others.

Engineering is Elementary(EiE). EiE is a 20 unit curriculum for grades K-5 developed by the Boston Museum of Science, is intended to teach engineering aligned with the NGSS to elementary school students nationwide through a series of lessons built around a story that outlines the problem to be solved. EiE, featuring units for all science disciplines and topics, heavily leverages the engineering design process in an easy to implement format for teachers. Current use of EiE in Nevada is taking place in both Clark and Washoe Counties, and further supported through a $432,000 Great Teaching and Leading Fund (GTLF) grant awarded to the Southern Nevada Regional Professional Development Program (SNRPDP) to supply and train teachers in the use of EiE.

While some critical review of the materials is needed, EiE is popular nationwide, and the use of the design process and design thinking in students aligns with the research on building student interest and self-efficacy in STEM.

Funded Projects

The previously mentioned STEM education at all levels in Nevada is supported by grants obtained by both school districts and higher education, often in partnership. Federal dollars from the U.S. Department of Education flow through the Nevada Department of Education in the form of Math-Science Partnership grants. Recent grants partnering UNLV, SNRPDP, and CCSD (Project FOCCUS in 2014, and Project NEVADA-S in 2015) provided teachers statewide with professional development in the NGSS. The most recent iteration of that partnership also included NNRPDP, NWRPDP, and UNR (Project MANTA), aimed at creating a cadre of teacher leaders that are capable of carrying out professional development in their own schools in the K-3 and 6-8 grade bands. Other 2016 projects funded through MSP targeting elementary STEM include the intuitive thinking in K-3 Mathematics (UNLV/CCSD), Nevada Math Project-Phase III (UNR), Developing Mathematical Modeling: Numbers and Operations and K-12 Developing Mathematical Mindsets: Number & Algebraic Thinking (WCSD). This collection of grant projects should benefit the STEM pipeline in Nevada by building capacity in K-3 teachers to successfully develop and implement science and mathematics lessons consistent with the NVACS and research-based pedagogical techniques, which in turn should have some positive impacts on student understanding, affect, and achievement in STEM. The Great Teaching and Leading Fund has also provided a significant amount of funding to organizations, largely school districts, interested in providing quality professional development in science to their teachers.

A National Science Foundation funded project through UNLV, Developing Integrated Elementary Science, Engineering, and Language Arts Curricula Aligned with Next Generation Science Standards (NGSS), seeks to address the 'E' in STEM as well as literacy standards and science education in elementary classrooms, again through improving teacher capacity to plan for and teach these topics.

Evaluation of Programs

As previously noted, the largest hurdle for elementary STEM is the focus on mathematics alone of the four disciplines, due in part to the emphasis on the subject for high stakes testing, but also due to a lack of content knowledge in elementary teachers. As a result, there is a great deal of professional development being carried out in Nevada to improve content knowledge and pedagogy in STEM amongst K-5 teachers, particularly in science, but also in mathematics and engineering. The effectiveness of these programs in providing quality professional development is readily available in the evaluation reports submitted to funding agencies at the end of the funding period, particularly in the case of MSP and GTLF grants, which have largely shown a significant impact on teacher content knowledge and teaching self-efficacy. What remains to be seen is how that translates directly to student achievement in areas other than math, and interest and attitudes towards STEM as a whole, due to the difficulties in obtaining meaningful assessment data from students and shifts in the state assessments.

Perhaps more importantly, teacher ability to teach STEM doesn't necessarily translate into more time to teach or more time spent teaching STEM. One reasonable solution is to integrate STEM with literacy, or other STEM subject with mathematics, as suggested in the NSF grant mentioned above. In part, pre-service teachers are encouraged to do so through recently revised elementary science teaching methods courses at UNR and UNLV, although that leaves the vast majority of current Nevada teachers out of that process.

There are, however, elementary schools in Nevada that are focused on an integrated STEM experience for students, contextualizing traditionally taught mathematics and literacy in science, engineering, and social studies. The following account was obtained from the principal of an elementary school in Washoe County:

> "Students at Agnes Risley have been busy scientists and engineers. Our kindergarten students are learning about weather patterns during each seasons and have planted a tree that they will be studying as it changes throughout the seasons. Our first-grade students are trying to help a young explorer communicate over a distance by modifying a device that she could use to communicate from her boat to the shore of a foreign country. Our second-grade students are embarking on a study of Earth's landforms in order to help the people of a village in Nepal cross a flooded river during monsoon season. Third grade students are gearing up for their project to research climate and how their families can prepare for severe weather conditions. The fourth graders at Risley are studying energy transfer, have built alarm circuits, solar ovens, and are beginning to learn about the how sound and light travel through waves. Fifth grade students are investigating the energy flow of ecosystems. They will be taking a field trip to Oxbow at the end of the month to collect evidence of matter cycling through a habitat. Risley sixth graders are studying the cycling of Earth's water and how weather impacts the environment and life on Earth."

STEM in Washoe County School District (WCSD)

A further exemplar account was provided by WCSD's new Assistant Superintendent, gathered from school principals:

> "In the WCSD we support STEM education with Project Based Learning. Our students are working on solving real world problems using critical thinking, collaboration, and technology. Here are a few examples of what our schools are doing:
>
> **Alice Maxwell Elementary School**
>
> At Maxwell Elementary School, we are making sure that we have a STEM focus at our school. Each grade level has developed a yearlong plan that has integrated science and social studies units. All grade levels are engaging in developing, implementing and refining STEM/PBL units. These units have an authentic audience and a real-world problem or project. Our teachers meet monthly to work with the STEM Implementation Specialist to build their capacity for integrated lessons. Maxwell also supports STEM at our school through designing and maintaining a STEM lab where teachers and students have access to materials and a dedicated place to work on activities with students.
>
> **Lincoln Park Elementary School**
>
> At Lincoln Park, I am supporting teachers to create integrated units of instruction. They are

teaching reading, math, and engineering through inquiry science and social studies. Students are exposed to more authentic situations to which they can apply their skills and knowledge when they learn through STEM units. The units also allow for practicing 21st Century Competencies, skills all students need in order to be successful both in and out of school. To successfully guide students through inquiry, however, teachers should have a strong understanding of STEM components. To build teacher capacity, I lead professional development around STEM content and pedagogy. I also refer the teachers at my site to conferences and classes that would inspire them to bring even more STEM into their classrooms. Further, I coach teachers one-on-one in teaching science, technology, engineering, and math for understanding and in using data-driven instruction. I also support teachers in finding and implementing new technologies. We are moving towards paperless classrooms where appropriate. Each of our classrooms has a set of iPads and an additional cache of laptops. Students and teachers are using iPad mirroring, share documents, Dropbox, online texts and research databases in the classrooms. All of the work we do at Lincoln Park around STEM is done with the goal of student achievement. We use formative and summative data to plan, implement, and reflect on our teachers' and students' work. We have found that teaching STEM components has made this work more exciting, effective, and powerful!

Kate Smith Elementary School

At Kate Smith, our teachers have participated in professional development around each of the Disciplinary Core Ideas and how they align vertically between the grade levels. Teachers have also had training in 3-Dimensional teaching and learning, creating units of study that integrate all subject areas based on grade level standards, writing in science, 21st Century Dimensions and how they integrate with the NGSS, and Project Based Learning. These are all aspects of STEM teaching and learning. Teachers are also required to teach at least one Practice-Based Learning (PBL) based unit, and about one-third of our staff has participated in the STEM/PBL team, enhancing their learning about PBL and STEM teaching. We continue to use the support of Bucks Institute to support teachers in building units and conducting Learning Walks to assess the progress of our school towards our goals. We have also reorganized teaching supplies for teachers to access so that they are more aligned with science instruction, including arranging our leveled book sets into themes based on the science and social studies standards, so that our teachers have easy access to any supplies they might need for STEM instruction.

Our students at Kate Smith participate in their grade level PBL units (examples include designing coolers to preserve a state of matter in 2nd grade, building weather resistant structures in 3rd grade, designing a dream home in 4th grade, designing solutions to lessen the impact humans have on the earth in 5th grade, and designing solutions to help the impact of global warming on animals in 6th grade), and we are working towards more integration of subject and content standards. We also have some after school STEM activities in conjunction with our TEAM-UP program. This year we have seven teams of students participating in WCSD's Punkin Chunkin event where they built a catapult or trebuchet to launch pumpkins at the event. Students in all grade levels work through the engineering design process both in class and in the afterschool activities. We also take our 5th and 6th grade students to an outdoor science camp each year."

Overall, while more time and emphasis in elementary STEM education is needed. Regardless of discipline, the focus of current programs is largely on science and mathematics, with two projects targeting engineering and none, at the moment, specifically targeting technological literacy in elementary students.

Middle Grades (5-8)

In middle school, STEM subjects, particularly science and technology, benefit from having their own designated course time. Teaching mathematics as its own subject area from the time the students enter school continues to be a major focus of school achievement initiatives. Science in middle school is granted its own devoted class periods (and often teachers), along with the introduction of rudimentary computer skills classes. This shift in time devoted coincides with a developmental period when many students are lost to the STEM pipeline due to negative changes in interest and affect (STEM Connector, 2013). Despite this increased amount of time devoted to STEM, a theme recurs from elementary grades here: a lack of integration across STEM disciplines. With the exception of engineering, which is now taught in conjunction with science in schools fully implementing the NGSS or state equivalent, STEM is broken into its constituent components when courses are created and curricula designed, and as a discipline integration is often severely lacking.

Existing Programs

GEAR UP. In Nevada, the Gaining Early Awareness and Readiness for University Programs (GEAR UP) initiative has provided several decades of support for students from underrepresented populations and low socioeconomic status (SES) as they transition to college and university work. In southern Nevada, GEAR UP invested resources in UNLV to train teachers in methods to incorporate STEM into their classrooms. By contrast to other STEM professional development initiatives, UNLV's GEAR UP STEM programs provided teachers with hands-on, authentic experiences in a cohesive environment. Further, the entire professional development is provided to teachers as though they were students. The adopted inquiry perspective leverages argumentation while addressing Nevada's content standards in math and science. The program successfully trained 80 middle school teachers from all parts of Nevada over three years. By extension, the project has influenced thousands of students since its inception.

Math Science Partnership. The Math Science Partnership grant program through the Nevada Department of Education is currently funding three projects that impact middle school students and teachers, two in mathematics and one in science. Project MANTA, in science, extends the cadre of teacher leaders able to deliver professional development in the NVACSS/NGSS to teachers in the 6-8 grade band, with approximately 25 of the 76 participants being middle school teachers. In addition, MANTA provides all science teachers in Nevada with access to the Public Consulting Group's Pepper online coursework in NGSS awareness. The ReAlgebra PD Project (Edu2000 America, Inc.) and K-12 Developing Mathematical Mindsets: Number & Algebraic Thinking (WCSD) advance teacher, and ideally student, knowledge of more advanced mathematical concepts in algebra.

Great Teaching and Leading Fund projects granted to Nye, Washoe, Elko, and Douglas County School Districts, along with Doral Academy, Nevada Virtual School, and Carson City Schools, support NGSS implementation in their respective locations through teacher professional development.

Evaluation of Programs

Middle school level programs, though with slightly more focus on students than elementary as a result of GEAR UP, are still largely focused on developing teacher pedagogical competencies and content knowledge. The amount of funding available for middle school through some competitions is reduced from elementary, despite inclusion in MSP requests for proposals for the 2016-2017 grant cycle. From a professional development perspective, this makes sense, as middle school teachers are typically discipline specific, and more likely to have a background in a STEM discipline than elementary teachers. The programs themselves appear effective in improving teacher ability and content knowledge, but impacts on student achievement and interest in STEM have not been assessed. Like the elementary grades, STEM initiatives and programs for the middle grades, as well as coursework, tend to be isolated by STEM discipline rather than integrated, and the nature of middle school course schedules, as currently designed, is less conducive to integrated coursework than elementary grades.

High School (9-12)

Secondary STEM education, and the STEM pipeline, tends not to vary greatly from middle to high school in terms of structure. STEM coursework is focused mostly on math and science, with engineering now integrated into the science classes that are NGSS aligned, and typically a single or half-credit course required in computing of some sort. More importantly, students are allotted significant time to STEM courses; most states require three or four credits in mathematics for a diploma, although a significant number only require two credits in science. Elective courses, magnet schools, and after school programs add to a richer variety of STEM experiences for high school students than is available in lower grade levels.

Existing Programs

The Solar Energy-Water-Environment Nexus project, funded through the National Science Foundation's EPSCoR program, has a workforce development program that has two separate initiatives for high school students. The first, run in southern Nevada through UNLV, brought together a group of middle and high school teachers to design integrated units on alternative energy topics, resulting in two mini-units that include field trips for students if implemented according to plan. The second, SCIP (Science Career Investigation Program in the north, STEM Career Investigation Program in the south), brings together high school students with guest speakers who are currently in STEM careers. SCIP has introduced high school students to scientists working with UNR, UNLV, and DRI, as well as the president/founder (and former designer) of Petroglyph Games, engineers from the Department of Environmental Protection, engineers from NV Energy, and the Southern Nevada Water Authority. Speakers for this program typically present for about 45 minutes to the students, who then ask questions regarding the topics. SCIP is run slightly differently in Reno and Las Vegas: participants in Reno take part in six sessions, while participants in Las Vegas can attend as many of the six sessions as they wish depending on interest.

State Funded Programs

State funded initiatives, using flow-through federal dollars, exist for high school STEM programs as well. While the most recent request for proposals for MSP excluded high school grade levels, prior years have funded professional development for teachers across the state in the NGSS and CCSS math standards. The GTLF projects funded for the 2016-2017 cycle also include full K-12 professional development in science.

A key feature of the STEM pipeline at the high school level that does not occur in lower grades is the existence of Career and Technical Academies (CTAs) in Clark County. The CTAs, while not entirely devoted to STEM, feature programs in engineering, web design and development, information technology systems, mechanical technology, biotechnology, digital media, IT management, environmental management, and animation and digital game development. It is arguable that CTAs aren't necessarily appropriate, given the career focus, for grade bands lower then high school, but they provide the first real taste of the STEM pipeline beyond K-12 to school age learners, and the potential for authentic experiences in STEM, and they are the only programs that feature options dedicated to engineering and technology.

Evaluation of Programs

STEM initiatives for secondary students show promise in improving achievement, attitudes, and the likelihood that students will select STEM coursework and careers after high school. However, Vallett, Lamb, and Annetta (2016) determined that students who already show a strong interest and confidence in their ability to succeed in STEM are far more likely to engage in programs at the high school level. It is important, however, to note that more in-school and school sponsored opportunities exist for students at this level than earlier grades. Finally, as with other grade bands, STEM programs for high school students tend to focus on science and math, while excluding engineering and technology, and tend not to be integrated. Technology, in particular, suffers from a lack of emphasis, although the recent 'Computer Science for All' initiative from the White House, if funding is maintained, may help to ameliorate that deficit.

Full K-12 Programs

While few truly K-12 programs exist, there are two of interest that do take place within Nevada. The first is the existence of STEM magnet schools at all grade levels, fostering STEM pipeline interest and ability in students who apply for and attend those schools. The second, the Regional Professional Development Programs, are an invaluable resource in providing and supporting quality professional development in science and mathematics statewide and at all grade levels, particularly in smaller districts where the capacity of school and district employees to provide professional development may be limited by the number of employees in those roles. As with other STEM programs for students, magnet schools are limited in their effectiveness by the need for students to self-select into those sites by interest, and further complicated by the likelihood that members of under-represented populations, even when interested, are less likely to opt into magnet programs due to concerns regarding stereotype threat or a simple lack of the cultural capital on the part of parents seeking to gain their children's admission.

Recommendations

While there is no 'magic bullet' for improving participation in the STEM pipeline, some trends do emerge from successful programs, both in Nevada and elsewhere:

Teacher Professional Development. Perhaps the simplest means of improving the STEM pipeline in Nevada is through investment in high quality professional development for teachers at all levels. It is clear from successful programs and research that early exposure is one key component of a healthy pipeline. Elementary teachers, in particular, require greater levels of content knowledge and understanding of STEM pedagogy to meaningfully engage students in the types of inquiry activities that leverage learners' natural curiosity. Paired with improving teachers' understanding of STEM content and pedagogy is a need to develop administrators' understanding of what good STEM teaching looks like in the classroom. Regardless, policy makers may wish to consider training as a component of reimagined teacher training, part of continuing education initiatives in the districts, or both. Ultimately, leveraging existing systems like these and enhancing the state's knowledge infrastructures in a way that is focused and organized, will promote the health of Nevada's STEM workforce and economy overall.

Cohesive Approach to STEM. As evidenced by the reported amount of time spent on STEM subjects other than math, the emphasis on standardized test results over the past 17 years of education has greatly reduced the amount of attention given to STEM subjects. While one solution to this might be to suggest rigorously testing the remaining three disciplines, it is our recommendation that we instead focus on a cohesive approach to teaching and learning STEM. This, in turn, gives students practice applying STEM concepts, including mathematics, to real-world problem solving situations. Typically, problems in these situations depart from strict disciplinary boundaries. More importantly, a collective approach to STEM content also provides context for more abstract concepts in mathematics, while demonstrating conceptual links between subjects. This benefit of an authentic approach to problems in an integrated, cohesive way, is well documented in the literature. In short, teaching practices that evolve from a cohesive approach to STEM are an answer to the ever present "why do we need to know this?" question.

Increased Focus on Technology and Engineering. In addition to a more cohesive approach, student engagement in the STEM pipeline would benefit from a greater focus on technology and engineering at the K-12 level. Many of the successful projects discussed above feature one or both disciplines in improving student interest in STEM, and the burgeoning STEM careers in Nevada require an understanding of science and mathematics, but feature technology and engineering tasks. This increased focus can neatly dovetail with a more cohesive approach to STEM, or take the form of new educational requirements like the suggestions of the Nevada Computer Science Taskforce.

References

Aubert , J. & Reiflers J. (2004). *Keeping economies in the Middle East and North Africa: Toward new development strategies.* Washington, D.C.: World Bank.

Graham, M.J., Frederick, J., Byars-Winston, A., Hunter, A-B., & Handelsman, J. (2013). Increasing persistence of college students in STEM. Science 341(6153): 1455-6. DOI: 10.1126/science.1240487.

Kelly, T.R. & Knowles, J.G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education* 3(11). DOI: 10.1186/s40594-016-0046-z

Lee, J.A., Muro, M., Rothwell J., Andes, S., & Kulkarni, S. (2014). Cracking the code on STEM: A People's strategy for Nevada's economy. *Brookings Institute: Brookings Metropolitan Policy Program.*

Mervis, J. (2012). PCAST remedy for undergraduate science is a tall order. Science. Retrieved from http://www.sciencemag.org/news/2012/02/pcast-remedy-undergraduate-science-tall-order.

National Science Teacher's Assocation Board of Directors (2006). Position statement: Professional development in science education. Retrieved from: http://www.nsta.org/about/positions/profdev.aspx

President's Council of Advisors on Science and Technology (2012). [statement redacted from Whitehouse.gov by current administration].

Vallett, D.B., Lamb, R., & Annetta, L. (2017) Equity in after-school and informal STEM projects: The effect of participant self-selection. *Journal of Science Education and Technology (In Press).*