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Encouraging Young Nevadans to Choose and Complete STEM Degrees: A Choice and Retention Perspective on Science, Technology, Engineering, and Mathematics Workforce Development

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In an economy increasingly characterized by and intertwined with technology, Nevada currently possesses an inadequate supply of employees trained in the areas of science, technology, engineering and mathematics (STEM). Projects such as the Tesla gigafactory and the telecommunications hub for Switch demonstrate the potential economic benefits associated with cultivating a population with these skills. The Nevada Legislature has taken important first steps in creating a foundation for effective STEM education and towards diversifying the Nevada workforce to build health and technology sectors. However, several challenges to broader STEM adoption remain. First, the number of students who choose STEM-related careers is relatively small. Second, because STEM curricula are particularly rigorous, late stage dropout is common. Programs that encourage and reward educational perseverance and support retention are critical.

Nevada Facts & Comparisons to the Nation

- Southern Nevada is ranked 97th among 100 metropolitan areas evaluated in terms of employees in STEM-related fields, with 3.6 percent of the workforce compared with 8.7 percent nationally.
- Rural areas of the state are particularly underserved. Of Nevada's 16 counties and one independent city, only four have any STEM-specific school programs and, of those, only two counties (Clark, with 13, and Washoe, with 4) have more than one STEM program.
- However, all seven NSHE institutions provide at least some academic programs that can contribute workers to Nevada's STEM workforce.
- STEM-related fields represent only 7.1 percent of Nevada's Gross Domestic Product (National Average = 18 percent GDP).
- Nationally, completion rates for STEM-related bachelor level degrees are approximately 50 percent after as many as 6 years.

Recent Actions in Nevada to promote STEM Workforce Development

- SB 345 established an NSHE-based clearinghouse to provide Nevadans a comprehensive listing of STEM-related resources and opportunities, including the Nevada STEM Coalition and Nevada STEM Pipeline.
- This legislation also established programs to reward successful STEM students and educators, as well as expanding in-school STEM programming.
- A report commissioned by SB 345 (authored by Brookings West) provided recommendations for future actions, which afford actionable proposals that could be considered during the 2017 Legislative Session.

Considerations for Future Actions

Measures that could improve Nevada's STEM education pipeline and fuel workforce development include efforts to

1. promote choice to pursue STEM (preK-12); and
2. continue to pursue degrees during the final phases before joining the workforce

Potential solutions to be implemented:

Across Nevada
Invest in digitizing existing STEM Collections at NV institutions so informal STEM learning experiences can be made available to residents of rural counties and urban residents with limited access.
Promote public, private & non-profit partnerships that remove cost barriers by making STEM-related informal learning centers accessible to social service recipients (food assistance, Medicaid); Science centers provide reduced/free admission to card holders **Model Programs:** Pennsylvania CHIP (NV STEM Coalition can coordinate)

In Nevada K-12 schools
Supplement K-12 curricula with activities known to enhance STEM interest, efficacy, choice, outcome expectations, and engagement **Model Programs:** See Table 3 of full report
In NSHE Institutions
Invest in data analytics packages that help identify students at risk of STEM dropout and target support effort **Model Programs:** UT-Austin; UNLV LearningTAGs project

Statewide Benefits of Future Action

- Salaries in technologically advanced fields such as telecommunications and energy are higher than for jobs in the service sector; higher incomes are correlated with increased contributions to the local economy and decreased reliance on public assistance programs.
- The growth and diversification of Nevada's economy—which based upon national business trends are most likely to result from the importation of technology-related companies—are reliant upon a STEM-educated workforce.

Implications of Maintaining Status Quo

- With tourism providing 31 percent of the private workforce, Nevada is vulnerable to national events that impact tourism; diversifying our economy is critical, and building technology and health care sectors is particularly advantageous in terms of GDP.
- STEM-related industries generated approximately $6 billion in Gross Domestic Product during 2015, or 7.1 percent of the total output. This compares unfavorably with the national average 17.7 percent). Cultivating a qualified employee base is a prerequisite for recruiting lucrative business opportunities.

Introduction

An emerging leader in the science and technology sectors. In sectors of industry that require workers who possess scientific, technological, engineering and mathematical expertise and skills, business in Nevada is booming. Consider some recent victories for the Nevada STEM economy:

- The State's successful bid for the Tesla gigafactory demonstrated Nevada's appetite for and ability to grow the state's emerging technology sector;
- Switch – the world's largest data center company – continues to expand operations in Southern Nevada and break ground in the northern part of the state;
- robust growth in the number of tech start-ups in urban areas create an attractive climate that can invite even more entrepreneurs to incubate their ideas in the state; and
- an increasingly nuanced policy climate is now poised to leverage the Silver State's abundant sunshine and persistent winds to establish Nevada as a clean energy leader.

Robust growth in these sectors has the potential to expand the Nevada economy, as long as Nevada can provide the human capital needed to make these businesses operate effectively. With the growth of these industries, the demand for workers who possess expertise and technical skills in STEM fields also continues to grow. In Nevada and across the country, there are concerns that the number of students choosing educational programs that prepare them for STEM fields is too small to meet this growing demand (Kuenzi, 2008). Channeling young people into the "STEM Pipeline" and retaining them through its phases have required the focused investment of numerous federal programs, spanning the Department of Education, the National Science Foundation, and others. In the most recent legislative session, State leadership focused on the Nevada STEM pipeline and provided an initial framework for supporting STEM education through the passage of SB 345. This bill (1) establishes programs to recognize and reward successful STEM students and educators, (2) provides mechanisms for the development and expansion of STEM programming in schools, and (3) creates panels to gather knowledge and develop a strategic plan for the state. In the two years since its passage, the strategic plan has been published (Lee, Muro, Rothwell, Andes, & Kulkarni, 2014), while work toward other initiatives is ongoing.

The passage of SB 345 positioned Nevada to develop its STEM pipeline, and the developments it initiated supplement the efforts in K-12 districts and NSHE institutions to provide formal opportunities for students. Establishing the pipeline is a critical first phase. The next is to evaluate

the intake of young Nevadans into such a pipeline, and to shore up leaks to ensure students who enter with dreams of a STEM career exit with the skills necessary to contribute to their chosen field.

This report takes the view that a Nevada STEM pipeline must not be built exclusively to provide education and training. Research has shown that it is equally critical to design experiences in formal and informal settings that encourage young Nevadans to choose to pursue STEM careers, and to persevere through the rigorous educational experiences that prepare them for the challenging careers they have chosen. In this volume, other papers focus explicitly on STEM Education in Early Childhood (Buchter, Kucskar, Oh-Young, Weglarz-Ward & Gelfer) and K-12 contexts (Vallett & Schrader), and on the training programs that produce STEM educators. This paper applies what is known about strategies that promote and maintain engagement in STEM to develop recommendations that (1) increase the number of students who will choose STEM careers and (2) decrease the number of students who give up on their STEM careers in the final years before they join the workforce.

The present report on the Nevada-specific STEM workforce development context draws focus on the scarce and uneven quality of and access to STEM opportunities outside of K-12 schools in Nevada (Note: we recommend only some activities that could be integrated into existing curricula of K-12 schools; STEM in schools is the focus of a separate policy paper; Vallett & Schrader). The report also highlights efforts by community colleges and four-year institutions that can increase retention of students, as well as ensure and accelerate their progression through to completion of STEM degrees and entry into the workforce. The final table provides recommendations for STEM workforce development strategies, and highlights both model implementation programs and potential pitfalls that are critical to avoid when implementing programs.

Part 1: The demands of the Nevada STEM sector and prospective supply of STEM workers

The demand for workers with the skills necessary to contribute in science, technology, engineering, and mathematically-heavy sectors continues to increase as Nevada gains prominence as a friendly place to conduct such business. Historically, however, these sectors have contributed a paltry amount to Nevada's overall economic output, which is fueled primarily by mining and service workforces that require less training and fewer specialized skills. Even by recent accounts, when growth has increased, the workforce aligned to advanced industries in a metropolitan area such as Las Vegas lags well behind the national average (by 5 percent of the workforce; Table 1). This leaves Nevada's urban areas languishing behind the nation, where a lower percentage of the workforce comprises the STEM-sector's skilled workers, who often earn higher salaries and can make a larger impact on economic output. Building a STEM workforce has a substantially larger impact on economic growth than building the overall workforce as a result of their higher earnings. This makes development of such a workforce a priority, and one that can be realized as the number of employees needed continues to increase. Questions remain, however, about whether Nevada's educational output can keep up with this demand, and whether those Nevada learners who will become the Nevada STEM workforce are prepared adequately.

Table 1. *Economic Growth in Southern Nevada compared to Major Metropolitan Area National Average*

	Las Vegas Metropolitan Area	**National Average (Across 100 Metro Areas)**
Total Jobs in Advanced Industries	30,810	
Share of Jobs	3.6% Rank: 97/100	8.7%
Change in Jobs (2010-13)	+3.0% Rank: 39/100	+2.7%
Total Output (GDP) in Billions	$6.0	
Share of Total Output	7.1% Rank: 97/100	17.7%
% Change in Output (Growth 2010-13)	+2.5% Rank: 62/100	+3.8%

Source: *Brookings [Muro, Rothwell, Andes, Fikri, & Kulkarni, 2015]*

K-12 Education in Nevada

Other policy papers will focus fully on the K-12 portion of the STEM pipeline and the educators who contribute to it. These papers demand attention, but a brief treatment of the state of K-12 education is warranted to understand potential implications for developing tomorrow's STEM workforce.

The 2016 Quality Counts report (Education Week, 2016), an annual publication that provides metrics on education infrastructure and quality for all 50 states and the District of Columbia, ranked Nevada last in terms of its ability to provide a "Chance for Success" to Nevada learners (a D). School finance (46th; a D) and K-12 achievement (38th; a D) round out a bleak report card, which draws on achievement and funding data to show meager gains in the achievement of Nevada's K-12 learners, and a poor outlook for learners as they reach adulthood. Most pivotal to the STEM workforce, which requires members to possess both a high school diploma and additional technical training or advanced degree, adult Nevadans' educational attainment in the state lingers at 48th out of 51 entities evaluated. Only 31 percent possess a two- or four-year degree, a percentage which must be improved if the Nevada-grown STEM workforce is to be expanded.

Opportunities to engage with STEM during early and K-12 years

Activity calendars such as those found on the Nevada STEM coalition website tend to be littered with one-time events that provide brief exposure to STEM disciplines. Carnivals and festivals sponsored by recreation centers, 4-H clubs, and other community and corporate organizations provide students with a momentary exposure to STEM topics. However, sustained exposure and expert guidance are far more effective means of increasing learners' interest and engagement. Historically, Nevada has dedicated insufficient resources to sustain exposure (Table 2).

Table 2. *K-12 STEM Programming in Nevada by County*

Nevada Counties	Carson City	Churchill	Clark	Douglas	Elko	Esmeralda	Eureka	Humboldt	Lander	Lincoln	Lyon	Mineral	Nye	Pershing	Storey	Washoe	White Pine
Extracurricular programs	3	1	15	1	1	1	1	1	1	1	1	1	1	1	1	12	1
Camps			4													10	
Science museums/centers			3													1	
STEM-specific schools			10														
STEM-specific school programs	1		13		1											4	

Source: *K-12 portal on http://www.nvstempipeline.org/*

As in most states, opportunities to substantially engage with STEM cluster in Nevada's metropolitan areas. Compared to young people in the more sparsely populated regions of the state, those in Clark and Washoe counties have far more opportunity to repeatedly engage with STEM. With a denser distribution of students, Clark and Washoe counties are able to offer STEM-specific magnet school options. Schools in counties with urban centers are also more likely to have school-based programming during and outside of the school day, and have easier access to resources such as museums and science centers, which further enrich the STEM learning experience. When school is not in session, students in metropolitan areas continue to have greater opportunity through the provision of STEM-specific summer camps offered by schools and community centers. This extensive network of

opportunities provides the possibility of sustained exposure to STEM outside the classroom for those who are able to enroll in STEM-schools and school programming, and for those whose families can afford to enroll and transport young learners to afterschool and summer programming. Even in Clark and Washoe Counties, families with working parents or who face transportation challenges may have less access to these supplemental programs. For those who live outside Clark and Washoe County, opportunities are few. Carson and Elko provide supplementary STEM-specific school programming; otherwise, the only persistent resource available to young Nevadans interested in STEM is the FIRST Nevada Robotics program. This program might provide an ongoing opportunity for engagement with STEM, as long as students are drawn to robotics and can coordinate with others to create and fund a team (projected cost $5,000-$6,000 annually).

In summary, opportunities for STEM engagement outside the standard curriculum of K-12 schools are sparse and uneven across the state. Offerings are almost entirely limited to metropolitan centers and, within these communities, barriers to access include limited space within STEM-schools and challenges to access due to transportation and financial cost.

STEM-specific Higher Education in Nevada

All seven institutions in the Nevada System of Higher Education provide at least some academic programs that can contribute workers to Nevada's STEM workforce. Of these, the largest institutions in Las Vegas (UNLV) and Reno (UNR) offer a host of baccalaureate, graduate, and doctoral training programs to meet needs for entry-level and advanced workers in the science, health care, and technology sectors. Nevada colleges supplement these offerings with associate-level degrees and certificates for technical work and preparation for advanced degrees (Appendix A).

Part 2: Understanding factors that promote STEM career choice

Understanding the motivational processes underlying students' involvement in STEM education and careers is integral to developing a strategic and targeted approach to increase STEM participation. One framework useful in conceptualizing the motivational processes associated with students' STEM involvement is the social cognitive career theory (SCCT) (Lent, Brown, & Hackett, 1994). The SCCT is predicated on Bandura's (1986) social cognitive theory and several frameworks centered on career development, such as Krumbolt's social learning theory of career decision-making and Hackett and Betz's (1981) self-efficacy approach to career development, and motivation (Eccles, 1987; Locke & Latham, 1990). The SCCT comprises multiple conceptual models seeking to explain the motivational processes leading to the attainment of several socially-valued outcomes, including people's academic and career-related choices, work and life satisfaction, well-being, and performance. As the present work centers on involvement in STEM pathways, the SCCT model of career and academic choice provides the most conceptually relevant framework within which to conceptualize the processes leading to students' STEM-related academic and career choices.

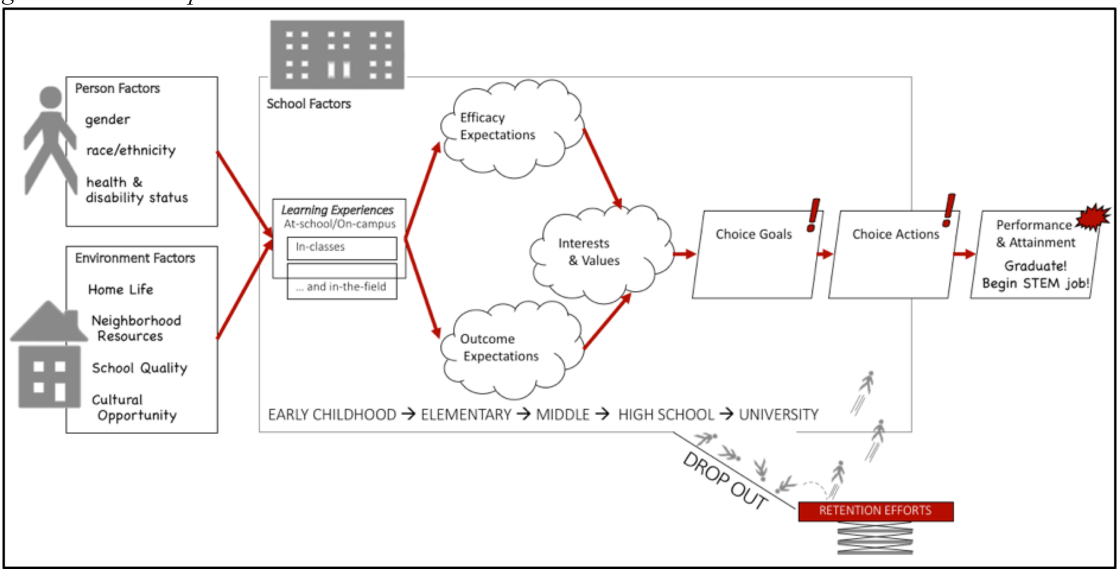
The SCCT model of academic and career choice integrates demographic, dispositional, social-cognitive, affective, behavioral, and contextual constructs toward understanding the process through which people choose academic and career pathways. From this perspective, STEM academic and career choices are predicted by seven classes of variables: (1) person inputs (core dispositions, gender, age, ethnicity/race), (2) contextual affordances (environmental factors), (3) past learning experiences, and a set of beliefs and motivations, including (4) domain-specific self-efficacy beliefs (about ability related to STEM), (5) outcome expectations, (6) values and interests, and (7) goals and intentions. All these inform the learner's decision to choose STEM (See Figure 1 on next page).

Proceeding further along the model, people are expected to choose STEM academic or career pathways when they set goals to pursue these pathways, which itself is influenced by the extent to which they are interested in STEM-related activities and tasks. Greater STEM interests, in turn, are expected of those who value and expect a favorable outcome from performing STEM-relevant tasks and who believe they are capable of performing these tasks. These efficacy beliefs, expectations, and values may themselves be informed by the STEM-relevant learning experiences that studentS engage in through formal and informal educational opportunities. In the temporal sequence of unfolding events, individuals' core dispositions,

such as their consciousness or generalized anxiety, and demographic characteristics, including gender and race/ethnicity, are expected to influence their STEM learning experiences and contextual affordances that precede the choice behavior.

Decades of research on learning confirm the critical role that students' motivations and beliefs play in their choices to pursue academic tasks like those that prepare them for STEM careers. Further, these factors also tend to predict students' achievement once enrolled. Additional research has identified productive methods for encouraging beliefs and enhancing motivations that promote STEM choice and achievement.

Figure 1. *Environments and Factors that Influence STEM Career Choice and Retention. The model is adapted to include elements of the Social Cognitive Career Theory of Lent, Brown, & Hackett (1994) and the STEM Pipeline, which spans informal settings, and formal settings spanning early childhood education through post-secondary education and training. Critical to STEM education and workforce development are issues of dropout from STEM programs and efforts to promote student retention, progression and completion.*



Strategies and Interventions Designed to Promote STEM Choices and Antecedents

Given the need to increase the number of students who choose to enter the STEM pipeline, educators and policy makers would do well to focus on intervention and enrichment efforts designed to promote self-efficacy, expectations, values, interests, and intentions related to STEM. Table 3 includes a selection of programs that have been shown to successfully promote one or more of the motivations or beliefs that positively influence people's decision to choose STEM educational and career pathways. Notably, many of the programs are centered on minority populations of considerable relevance to Nevada. All programs reviewed are supported by rigorous empirical bases and are largely predicated on a cohesive set of theories. More extensive overviews of programs are available in Rosenzweig and Wigfield (2016) and Valla and Williams (2012).

Importantly, many of these interventions tend to be designed in ways that they can be incorporated into a curriculum focused on content standards that guide instruction in STEM domains or extend STEM preparation in K-12 settings. By integrating activities like these into K-12 curricula, educators can continue to develop students' skills and conceptual understanding while also encouraging students to choose coursework and post-secondary degrees that prepare them for STEM careers.

Efforts to promote student retention, progression, & completion of STEM degree programs

Students who progress through their elementary and secondary education and intend to pursue a career in a science, technology, engineering or math-related field must next complete

technical training or a post-secondary degree. Two-year degrees from community colleges can prepare them for technician-level jobs. Bachelor degree-level training at four-year institutions can prepare them for entry-level positions as engineers or computer scientists, and in some health professions. More advanced positions will require graduate, doctoral or professional training. The Nevada System Higher Education (NSHE) system offers programs that allow students to complete their desired training, though many students fail to complete their degrees. Nationally, completion rates from bachelor-level STEM degrees hover under 50 percent after as many as six years of study (Eagan, Hurtado, Chang, Garcia, Herrera, & Garibay, 2013). For students from under-represented groups – who comprise the majority of students at NSHE institutions like UNLV and community colleges – completion rates hover closer to 25 percent.

Table 3. *Activities that can be integrated into K-12 and subsequent schooling to promote motivation to choose STEM fields*

Program **(Authors)**	**Program Aim**	**Population**	**Time Commitment**	**STEM Disciplines**	**Academic & Personal Enrichment Components**
Science Diaries **Bernacki et al. (2016)**	Increase motivation (i.e., goals and interest) for science classes	Middle school students	18 Weeks	Life sciences and physics	AC-Prep
Gateway to higher education **Campbell et al. (1998)**	Increase high school graduation rates, completion of gateway math and science courses, and college matriculation	High School minority students	One-month summer program + extended school day	Science and engineering	FT, PP, Ment., Tut, AC- & Test-Prep
Intervention to enhance interest, self-evaluations, & achievement **Häussler & Hoffman (2002)**	Increase physics-related interest, self-concept, and achievement	Middle-school females	One academic year; approx. 60 one-hour lessons.	Physics	AC-Prep; IBL
Upward Bound **Lam et al. (2000)**	Increase high school GPA, high school math and science achievement, retention, and intention to choose STEM pathway	Underserviced high school students	One academic year + 6-week residential summer school	Engineering, math, science, computer science	FT, PP, Tut, CC, Test-prep, IBL, TT.
STEM program for Middle Schools Students on Learning Disability-Related IEPs **Lam et al. (2008)**	Increase interest in STEM careers and development of self-confidence in technical skills	Middle school students, including those with learning disability related individualized education programs	7 one-day workshops (academic year) + one week of one-day Summer classes	Engineering, technology	IBL, PP, Ment.
Meyerhoff Scholars Program **Maton et al. (2000)**	Obtain advanced qualifications in STEM disciplines	Undergraduate college students (historically minority focused)	Undergraduate college years + initial six-week Summer residential program	Science, technology, engineering, math	CC, Tut, Ment, IBL, PP, PI
Stanford Medical Youth Science Program **Winkleby et al. (2009)**	Increase participation and success among underprivileged students in educational science pathways and professions	High school students (viz., under-privileged economically and ethnic minority students)	5-week summer residential biomedical program	Health/medical sciences	Ment., CC, IBL, Test-Prep, TT
High school bridge program **Zhe et al. (2010)**	Support intentions to choose engineering majors in college, explore STEM careers	High school students	10-week summer bridge program	Engineering	IBL, PI, Ment; TT

Note: **FT** = field trips; **PP** = complementary program for parents; **PI** = structured peer interaction; **Ment** = Mentoring; **Tut** = Tutoring (i.e., one-to-one remedial or non-remedial academic support; **AC-Prep** = academic preparation program (i.e., formal instructional activities that supplement typical coursework or curricula); **Test-Prep** = standardized and other test preparation (i.e., instructional practices and learning activities intended to enhance achievement on standardized tests); **TT** = Direct Technology Training; **IBL** = Inquiry-based learning; **CC** = college coursework.

To aid students' retention, progression and completion of undergraduate programs, higher education institutions have attempted a variety of solutions that employ financial, psychological, data-driven, and counseling mechanisms. What follows are brief summaries of successful programs and program components in place at large state-institutions, some of which enroll populations similar to Nevada students who are commonly the first in their families to pursue advanced degrees, and who come from underserved high schools and under-represented minority groups.

"Wise" Messaging and Instructional Design to Improve Retention and Achievement

When top high school students with aspirations of advanced degrees matriculate into universities, many of them struggle to adjust to more the rigorous academic climate. Those who fail to acclimate to the rigor and culture of higher education frequently drop out as a result of their perception that they don't really belong in their challenging major. In many cases, these students' feelings that they don't belong, or that they don't "have what it takes" to learn and complete their degrees can be offset by what are now called "wise" interventions. These interventions are usually brief or infrequent, cost little to deploy, and are often stealthy in the way they influence learners. A recent summary (Walton, 2014) describes these messaging approaches, which reframe students' perceptions of themselves, the university, and the learning process. Students typically complete brief writing activities that focus them on their strengths, principles they value, their past successes, and the idea that they too can learn through effort and perseverance. Researchers at multiple large, state-level academic institutions have pioneered different messaging approaches, and some universities have incorporated these activities into courses, to the benefit of their student achievement and retention rates. Effects of these programs include significant improvements in students' GPAs and require as little as an hour or less of investment in reading and writing activities.

Resetting the Academic Culture of the University and Off-setting the Graduation Gap

Messaging approaches like this one are often combined with instructional design changes that aim to improve learning, achievement, and retention at universities. For instance, the University of Texas at Austin has employed both messaging approaches that reaffirm students' beliefs that they belong in college, and instructional designs that adjust the undergraduate learning experience to promote academic community. The "Texas Interdisciplinary Plan" (TIP) provides students with smaller classes, peer mentoring, extra tutoring help, engaged faculty advisers, and community-building exercises (Tough, 2014). The combination of individual services – each of which themselves are known to benefit student achievement and retention, but also to come at financial cost – erased the gap between students who came to the university with very different likelihoods of success. TIP students – most of whom entered the university with lower SAT scores and correspondingly lower likelihoods of success – scored on par with their peers who excelled in high school and whose college outlooks were much stronger. Tough and other experts on higher education achievement underscore the importance of taking a multi-pronged approach to supporting students. These comprehensive programs tend to be the most effective for those most at risk of failing to complete their degree. What follows are examples of additional components of two additional large, state-level academic institutions that have been successful in promoting retention of students from under-represented populations.

Adjustments to the Financing of College to Bridge Trouble for Students At Risk of Dropout

Georgia State University (GSU) in downtown Atlanta enrolls 33,000 students, many of whom are first generation students (40 percent), from lower income backgrounds (51 percent receive Pell grants), and under-represented minority groups (60 percent non-white; Georgia State University, 2016). Though these demographic characteristics each diminish the likelihood of on-time degree completion, GSU achieves graduation rates that outpace national averages for typical undergraduates, and more intensely, rates for under-represented and economically disadvantaged groups. GSU's Promoting Access to Hope (PATH) program uses a combination of methods that overlap with the TIP program described above, including academic orientation, small learning communities for freshmen, and supplemental instruction, as well as novel components that bear closer inspection:

academically aligned on-campus jobs, modest financial support to bridge periods of challenge, and early alerts that indicate potential academic struggles.

Unique to GSU is a financial mechanism that employs a modest funding source to achieve a pronounced effect on graduation rates. GSU's Promoting Access to Hope (PATH) program provides small, temporary funding awards to help students who initially earned but subsequently lost their "Hope" scholarship of $8,000 per year towards their degree. These "Keep Hope Alive" micro-grants provide $500 each semester to these students, along with financial aid and academic workshops. Results of the Keep Hope Alive scholarship program indicate a 58 percent difference in the number of students who ultimately graduate, compared to similar students not in the program. Moreover, each component of the PATH program also contributes an additional 1-6 percent toward boosting graduation rates, for a 18 percent difference overall. Similar efforts to provide financial incentives (scholarships of as little as $4,000 improve retention by ensuring recipients agree to not work during the semester) have delivered improved retention (Marcus, 2014). The final component of GSU's PATH program involves an early alert system that leverages student ID card swipe data to track program and course attendance and identify students in need of support. This example highlights intensive academic support programs, such as that in place at Temple University in Philadelphia, Pennsylvania, and the emerging culture of data-driven decision making in higher education.

Intensive Academic Support

In order to improve the retention of students from lower-income households who are often at greatest risk of dropping out, Temple University employs what is self-described as "intrusive, or even aggressive advising." (Felton, 2016) University staff interact with students at risk of dropout to ensure these students are making use of the extensive resources that are generally provided at most universities but under-utilized by undergraduates. This intensive advising is at times quite successful, but it is also quite costly. To ensure resource-intensive support efforts are targeted at the students most apt to need them, Temple and many other universities are turning to data analytics to identify students at risk of dropping out of college.

Data-driven Tools to Focus Funding and Effort to Improve Retention and Achievement

UT-Austin, Georgia State, and Temple Universities are only a few examples of a trend in higher education to use data to predict student success and target university resources to improve student outcomes (Marcus, 2014). Predictive modeling efforts to address undergraduate retention are coordinated by the Gates Foundation, and involve for-profit institutions such as the University of Phoenix, as well as public and private universities (Fain, 2012). Universities employ different approaches to understanding and predicting their own students' achievement, including both the adoption of commercially available tools and the development of home-grown prediction models that emerge from the universities' own institutional research resources.

Companies such as Starfish and EAB solutions offer data modeling and prediction services to client institutions who provide access to data sources that can inform predictions of student outcomes like retention, progression, and completion. The alternative approach is to access local data and develop these models in house. A high-profile example of this approach is UT-Austin's Dashboard, an algorithm that uses 14 demographic (family income, parent education) and academic (SAT, class rank) predictors drawn from university data systems to predict the likelihood of a four-year graduation (Tough, 2014). While these models can predict student outcomes rather precisely, the challenge begins anew when a university must determine the best way to leverage available funding to provide a package of supports most likely to help a student graduate on time despite the odds.

Higher Education STEM Retention Efforts in Nevada

Much like Georgia State and Temple University, NSHE institutions heavily enroll students who are eligible for Pell Grants, are often first generation students, and often come from underrepresented groups. Many of these students also struggle to complete their degrees. Each NSHE institution has devoted some energy into supporting students to ensure they proceed to completion of their degrees. Below are samples of efforts at a four-year institution, UNLV, and a two-year institution, Nevada State College, that reflect the current state of STEM retention efforts in Nevada.

STEM Retention at UNLV

UNLV has adopted a similar, though far less extensive, approach to those employed at undergraduate retention innovators such as Temple University and Georgia State University. Specific to STEM retention, UNLV takes a multi-pronged approach by utilizing existing university-level resources, combining them with college-specific efforts tailored to their students' needs and data-driven methods to efficiently focus efforts on students most in need.

University-wide efforts. At the university-level, the Academic Success Center (ASC) serves as a resource where students can obtain academic advising related to their coursework that composes a STEM major. They can further seek out tutoring and writing support, as well as attend supplemental instruction, coordinated by ASC and faculty, outside their course. These services are offered to all students, and additional efforts are focused on first- and second-year students, student-athletes, and students who enter the university through special programs (e.g. Bridge programs that support those who need to develop study skills or accelerate their math coursework).

STEM-specific Efforts. Colleges such as the College of Engineering supplement university-level programming to meet the more specific needs of engineering students. These services include a local advising office that provides more precise advising on coursework and milestones that are critical for aspiring engineers. Additional services include supplemental instruction for engineering courses taught by experts in engineering domains and skill training embedded in introductory coursework designed to strengthen students' learning skills. This web-delivered training is part of a federally-sponsored research grant and provides students with domain-general training that builds upon decades of educational research (NSF DRL 1420491; National Science Foundation, 2016). Students devote only a few hours out of class to training, which teaches them how to apply skills to their current and future STEM courses, and which has been shown to improve exam scores and course grades (Bernacki, Vosicka, & Utz, 2016; 2017).

Additional campus centers such as the Math Learning Center are designed to help students overcome specific barriers to completing their STEM degrees. Extending the engineering example, math coursework is a gatekeeper to on-time completion of all engineering degrees. If students do not arrive ready to enroll in Calculus I, their time to degree is extended by a full year. Unfortunately, the majority of those who enroll at UNLV are unprepared for calculus after completing high school and must complete the pre-requisite Algebra, and sometimes more basic mathematics coursework that lays the foundation for calculus concepts that are critical for engineers. The Math Learning Center triages this bottleneck by providing intensive tutoring, online coursework, mid-semester and compressed course progressions, and other tools to help students gain critical knowledge and skills and to do so quickly so they can accelerate their time to STEM degrees.

Data-Driven Retention Efforts. Like many higher education institutions, UNLV is also developing its ability to make data-driven decisions about directing effort toward students as they enter particular contexts where retention issues are most severe. The university recently began implementing a service called Academic Performance Solutions offered by EAB (EAB, 2016). Academic Performance Solutions "[are] solution[s] designed to empower financial and academic leaders with the department-specific performance and cost data they need to make more effective decisions." When implemented at a university, the system identifies courses and progressions of studies that are critical predictors for specific majors. This allows universities to deploy their efforts in a more efficient targeted fashion to students at junctures where they are most likely to experience need.

In addition to university-level data solutions that try to pinpoint course progressions during which students will require additional support, UNLV is developing innovative course-level solutions for identifying and supporting students who will struggle to move forward in their STEM program. The same NSF-sponsored project that delivers learning training to students has supported the development of a data-driven "learning analytics" prediction model that can identify struggling students in real time – using their own learning behaviors – so support can be delivered (Dominguez, Bernacki, & Uesbeck, 2016; Kelly, 2016). Utilizing only university software and staff already in place, researchers and members of the Office of Information Technology are able to model students' learning behaviors, use them to identify struggling

students, and work with instructors to deliver alert messages to students before they begin to perform poorly on exams. In early work, students who receive these messages outscore students who don't receive messages by 5 percent on an exam they take just a week after receiving the message. One-third of messaged students identified as likely to earn a C or worse in a critical course where a B is needed ultimately achieved a B or better and were able to proceed on time toward their STEM degree (Kelly, 2016). This effort is in its infancy, but demonstrates a promising line of learning analytics innovation taking shape in Nevada that can improve the output of STEM degree-holders, if supported and leveraged appropriately.

STEM retention at Nevada State

While four-year institutions devote much of their effort to students once they arrive on campus, (primarily) two-year institutions often must help students bridge the transition from K-12 to higher education. Many students who enroll at NSHE institutions that primarily offer associate's and some bachelor's and graduate programs arrive in more of a transitional space where their STEM degree plan is less clear. These students require help navigating this middle space that family and community members have seldom explored. Nevada State College provides transitional support through their Nepantla Program Initiative (Ley, 2016; Nevada State College, 2016), which focuses efforts of high school educators, students, their family members, and college administrators to promote a culture where students see college as a pathway to economic success. These kinds of programs serve to broaden the pool of Nevada high school students who possess emerging skills and are willing to explore STEM careers, but lack information about how to proceed towards an appropriate STEM degree.

Part 3: Recent Policy Recommendations and Existing STEM Workforce Development Resources

To inform the discussion about policy initiatives to encourage STEM career choice, we begin with a set of recommendations made by Brookings West at the request of the NV STEM Advisory Council. Within their recommendations related to "Establish[ing] Proficiency," the report suggests that Nevada must (1) Encourage student excitement about STEM and the careers available to those with STEM knowledge, (2) Design and implement STEM outreach efforts that are accessible to all students, (3) Develop a high-impact web portal to raise student awareness of STEM career pathways, and (4) Implement proven approaches to postsecondary remediation that accelerate students' time to degree. These recommendations are sensible and, if implemented effectively, would likely increase the number of students choosing STEM careers and their pace of study to join these fields. However, each recommendation is sufficiently abstract that effective implementation is a significant challenge. Because scores of educational researchers devote their careers to determine the best ways to achieve these ends, this paper examines the "State of the State" pertaining to these goals, assesses the "State of the Science" on the ways these ends can be achieved, and suggests model approaches that have achieved these goals. Table 4 on the following page provides a summary, which is elaborated upon in the following pages. The final tables in Part 4 provide more specific and executable policy recommendations, which are organized into the contexts and in light of the leverage points known to promote student career choice.

Part 4: Strategies to Encourage Students to Choose and Maintain a STEM career goal

This report reviews programs that have positively influenced students' decision to choose STEM careers and maintain their pursuit of a STEM degree through to completion of an advanced degree. In light of the current state of Nevada's STEM workforce development efforts and what is known from educational research about successful methods of improving STEM choice and retention, a more specific set of recommendations that builds upon the recommendations produced by SB 345 appears in Table 5 in the appendix.

Conclusion: STEM Workforce Investment Strategies and Returns on Investment

Those with an appetite for investing in the Nevada STEM workforce must consider where in the pipeline their efforts should be directed, and how much patience will be required before their investment can demonstrate a return. Investing at the "intake" of the pipeline by targeting early childhood is critical, but legislators must bide their time during the many years that will elapse before

Table 4. *Recent Policy Recommendations, Current Nevada Programs Aligned to Recommendations, and Research Base that Can Inform Policy Decisions*

Cracking the Code Strategy to "Establish Proficiency"	State of the State	State of the Science
Encourage student excitement about STEM and the careers available to those with STEM knowledge	▪ Access to STEM experiences is uneven by county, income level outside of K-12 schools ▪ Some programs exist in higher education to encourage advancement to STEM degree programs	▪ Design practices can maximize the value of informal STEM experiences for learners. ▪ Brief, cost-effective interventions exist to promote students' efficacy and valuing of STEM fields as well as perceptions of belongingness and ability to complete degrees
Design and implement STEM outreach efforts that are accessible to all students	▪ Outreach is mostly episodic, especially in rural counties and low-SES areas of Clark/Washoe	▪ Exposure can be delivered in formal and informal settings, but needs to be ongoing
Develop a high-impact web portal to raise student awareness of STEM career pathways	▪ Portal is created, degree of impact on student awareness is unclear; offerings are sparse	▪ Models show that well designed materials targeting both student and parent can increase interest and engagement with STEM
Implement proven approaches to postsecondary remediation that speed students' time to degree	▪ Few "proven" methods exist; some person-driven and data-driven effort underway, but are not systematic or extensive	▪ Evidence is emerging that a portfolio of intensive academic & support & nimble financial mechanisms can improve retention ▪ data-driven models are increasingly effective at identifying students at risk so that resources can be focused efficiently

children who intend to choose STEM careers actually enter them and interim results (e.g., number of math/science units taken in high school, entrance into university STEM field of study) should be monitored to ensure that investment and corresponding policies are having their desired effect. For instance, in Table 5, we recommend a relatively inexpensive strategy of providing drastically reduced admission fees to museums for holders of public assistance cards for Medicaid or food assistance. This can increase exposure to STEM for children in low socioeconomic status (SES) households, broadening and diversifying the pool of talented children who might one day choose careers in energy, health care, or other STEM sectors. Indeed, early exposure to STEM environments has been shown to increase intent to choose STEM fields of study, which, in turn, influences entry into STEM (Wang, 2013). This ultimate output would take a decade or more to evaluate, but the number of children attending science museums can be compared to prior years' attendance, and an assessment of the initiative's effectiveness can be made with respect to outcomes, such as intentions to choose STEM pathways.

Investment in higher education also requires some patience as the first cohort of students impacted by a STEM workforce program would graduate 4 years—or two legislative cycles—after enactment and implementation. Compared to K-12 focused initiatives, these programs can produce more measureable and immediate impacts on the workforce. For instance, the type of data-driven support systems we advocate in Table 5 had an immediate impact on graduation rate (up 6 percent within three years) and time to degree (a half-semester lower) and level of achievement for both typical and underrepresented STEM majors at Georgia State (Kamenetz, 2016). A statewide investment in learning analytics tools (and professionals who can wield them) can provide similar opportunities for improving retention, progression, and completion rates across NSHE institutions.

Appendix
STEM degrees offerings across NSHE Institutions

Note: *A = Associate's degree, B = Baccalaureate G = Graduate, D/P = Doctoral or Professional. UNLV = University of Nevada Las Vegas, UNR = University of Nevada, Reno, NSC = Nevada State College, CSN = College of Southern Nevada, GBC = Great Basin College, WNC = Western Nevada College, TMCC = Truckee Meadows Community College.*

STEM Degree	A	B	G	D/P
Accounting and Information Systems		UNR		
Actuarial Science		UNLV		
Advanced Manufacturing Emphasis	TMCC			
Aerospace Engineering			UNLV	
Agricultural Science		UNR		
Architectural Design Technology	CSN TMCC			
Astronomy			UNLV	UNLV
Atmospheric Science		UNR	UNR	UNR
Automotive Certified Technician Emphasis	TMCC			
Automotive Technology	CSN WNC			
Aviation Technology	CSN			
Biochemistry		UNLV	UNLV UNR	UNR
Biochemistry and Molecular Biology		UNR		
Biology/Biological Sciences	CSN GBC TMCC	GBC NSC UNLV UNR	UNLV UNR	UNLV
Biomedical Engineering	CSN GBC TMCC*	UNR	UNLV UNR	UNR
Biotechnology		UNR	UNR	
Cardiorespiratory Sciences	CSN	CSN		
Cell and Molecular Biology			UNR	UNR
Cellular and Molecular Pharmacology & Physiology				UNR
Chemical Engineering	CSN GBC TMCC*	UNR	UNR	UNR

STEM Degree	A	B	G	D/P
Chemical Physics				UNR
Chemistry	TMCC	UNLV UNR	UNLV UNR	UNLV UNR
Civil, Environmental Engineering	CSN GBC TMCC*	UNLV UNR	UNLV UNR	UNLV UNR
Community Health Sciences	TMCC	UNR		
Comprehensive Medical Imaging		UNLV		
Computer Science and Engineering	CSN GBC TMCC*	NSC UNLV UNR	UNLV UNR	UNLV UNR
Computing & Information Technology	CSN GBC WNC			
Construction Management	CSN TMCC WNC	UNLV WNC	UNLV	
Curriculum & Instruction (Technology Integration, Leadership)			UNLV	
Diesel Heavy Equipment	CSN			
Diesel Technology	GBC TMCC			
Dietetic Technology	TMCC			
Digital Information Technology		GBC		
Drafting Emphasis	TMCC			
Ecohydrology		UNR		
Ecology, Evolution, Conservation Biology				UNR
Electrical Engineering	CSN GBC TMCC*	NSC UNLV UNR	UNLV UNR	UNLV UNR
Engineering Physics		UNR		
Entertainment Engineering and Design		UNLV		
Environmental Engineering		NSC UNR		
Earth, Environmental, & Resource Science	GBC TMCC	GBC NSC UNR UNLV	UNLV UNR	UNLV UNR
Exercise Physiology			UNLV	
Fire Technology	TMCC			

STEM Degree	A	B	G	D/P
Fire Technology Management	CSN			
Floral Design Technology	CSN			
Food Processing Technology Emphasis	TMCC			
Forest Management and Ecology		UNR		
Geography		UNR	UNR	UNR
Geological Engineering		UNR	UNR	UNR
Geology		UNLV UNR	UNR	UNR
Geophysics		UNR	UNR	UNR
Geoscience	GBC TMCC		UNLV	UNLV
Graphic Communications	CSN GBC WNC TMCC	GBC		
Graphic Design & Media		UNLV		
Health Information Technology	CSN			
Health Physics		UNLV	UNLV	
Heating, Ventilation, Air Conditioning/ Refrigeration (HVAC/R) Emphasis	CSN TMCC			
Hydrogeology & Hydrologic Science		UNR	UNR	UNR
Industrial Millwright Technology	GBC			
Information Management / Systems	WNC	UNLV UNR	UNR	
Instrumentation		GBC		
Interdisciplinary Health Sciences				UNLV
Kinesiological Sciences		UNLV	UNLV	UNLV
Land Surveying/Geomatics	GBC	GBC		
Learning & Technology				UNLV
Logistics Operations / Management	TMCC			
Machining	TMCC WNC			
Management in Technology		GBC		
Management Information Systems			UNLV	
Materials and Nuclear Engineering			UNLV	

STEM Degree	A	B	G	D/P
Materials Science and Engineering		UNR	UNR	UNR
Mathematical Sciences	TMCC	NSC UNLV UNR	UNLV UNR	UNLV UNR
Mechanical Engineering		UNLV UNR	UNLV UNR	UNLV UNR
Medical Laboratory Technician / Scientist	CSN	CSN		
Medical Physics				UNLV
Metallurgical Engineering		UNR	UNR	
Mining Engineering		UNR	UNR	
Molecular Microbiology and Immunology		UNR		
Networking and Server Technologies Emphasis	TMCC			
Neuroscience		UNR		UNR
Nuclear Medicine		UNLV		
Nutrition Sciences		UNLV		
Ophthalmic Technology	CSN			
Orthodontics and Dentofacial Orthopedics with Oral Biology			UNLV	
Physics	CSN	UNLV UNR	UNLV UNR	UNLV UNR
Preprofessional Biomedical Sciences		UNLV		
Production Systems Emphasis	TMCC			
Radiation Therapy Technology	CSN			
Radiochemistry				UNLV
Radiologic Technology	GBC TMCC			
Rangeland Ecology and Management		UNR		
Renewable Energy and Resources Emphasis	TMCC			
Social Science		GBC		

STEM Degree	A	B	G	D/P
Solar Energy Emphasis	TMCC			
STEM Education (or single subject)		UNLV UNR	UNLV UNR	UNLV UNR
Surgical Technology	CSN			
Technology (Automated Systems)	WNC			
Technology (General Industrial)	WNC			
Telecommunication Technology		NSC		
Transportation			UNLV	
Veterinary Science	CSN TMCC	UNR		
Water Resources Management	CSN	NSC	UNLV	
Web Development Emphasis	TMCC			
Welding Emphasis	TMCC			
Welding Technology	CSN GBC TMCC WNC			
Wildlife Ecology and Conservation		UNR		
Wind Energy Emphasis	TMCC			

Table 5. *Policy Recommendations for Promoting STEM Choice and Retention*

Opportunity for Action	Why It Can Work	Model Approaches	Threats to Implementation
In NV Environments			
Invest in digitizing existing STEM Collections at NV institutions so informal STEM learning experiences can be made available to residents of rural NV counties and Clark and Washoe residents with limited access.	Digital collections with appropriately designed, child-friendly interfaces can provide a resource that enhance learning and exposure opportunities inside and outside of classrooms.	• Museum of Anthropology, University of British Columbia • Smithsonian Natural History Museum's digitization project • National Science Foundation's \$10M/yr investment to fund digitization efforts by non-federal collections	Multimedia design must align to known best practices in order for the learning environment to achieve its ends. This effort should be overseen by qualified experts in instructional and multimedia design.
Remove cost barrier by making STEM-related informal learning centers by providing free admission to those who possess social services cards (i.e., food assistance, Medicaid).	Low-SES Nevadans are commonly members of underrepresented groups in STEM; most do not attend STEM-learning centers due to cost. Free and deeply discounted access (\$2) via a card they possess utilizes an existing service model with no new infrastructure.	Art-Reach.org using Pennsylvania Access Card (for Child Health Insurance Program & PA Food Assistance)	STEM-related informal learning centers in Nevada are mostly private and not-for-profit entities and may not wish to participate.
Evaluate the quality of existing STEM centers and museums to ensure they adhere to informal learning design practices & effectively engage youth	Public-private partnerships can enhance existing assets under the direction of experts on informal learning. Collaboration with researchers and designers have resulted in engaging public works projects as they are developed or redeveloped ,including stadiums, museums, and parks. Additional costs are minimal and can maximize return on costs already committed to existing resources	• LIFE Center (Stanford University & University of Washington) • UPCLOSE (University of Pittsburgh Center on Learning in Out of School Environments)	Expertise in design of informal learning is critical to ensure the potential of existing Nevada resources are realized. Experts must be sought out and connected with public, private, and non-profits, who may need to be convinced to participate
Develop public-private partnerships to connect students with private groups who encourage STEM learning, like maker-spaces.	Makerspaces are accessible in urban areas, and actively seek to build up their membership, including families and children. These organizations often host kid-friendly events to encourage students' interest in science/math/engineering/programming.	• makerfaire.com • family events at the SynShop (Henderson, NV)	Makerspaces are numerous and not often connected to one another. Outreach and coordination may need to be organized by an existing Nevada STEM organization (e.g., NV STEM Coalition)
In K-12 Schools			
Supplement K-12 curricula with activities known to enhance STEM interest, efficacy, choice, outcome expectations, and engagement	Activities can be incorporated into existing content-focused instruction to affect both learning and motivation. Practices are included in some STEM curricula (e.g. guided inquiry, simulation), but continuous exposure is needed to promote interest and engagement	See Table 3, which contains many potential activities	Curriculum aligns to content standards; instructional time & effort at a premium
In NSHE Institutions			
Continue to fund resources known to improve retention for students at risk of drop-out	Targeted deployment of human resources can address issues that increase likelihood of dropout (i.e., advising and student success centers)	Georgia State University, Temple University; University of Texas at Austin;	Mis- and over-identification of at-risk students can diffuse resources, watering down support for those in need
Invest in data analytics packages that help identify students at risk of STEM dropout and target support effort	NSHE schools already possess the data needed to inform models, and employees with expertise to provide support students . Proprietary tools can help identify courses that induce dropout; within-course modeling & intervention can help students pass these courses.	Proprietary tools: • EAB Academic Performance Solutions Course-specific Modeling & Support: • LearningTAGs Project (UNLV)	Proprietary tools require adaptation to account for the unique features of institutions and degree programs Course-specific at-risk prediction modeling can be precise but requires collaboration between a data scientist, instructor, and information technology

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