Meeting STEM Workforce Demand in a Statewide Rural Community College Collaborative

Caroline VanIngen-Dunn, Science Foundation Arizona

Caroline VanIngen-Dunn is Director of Community College STEM Pathways at Science Foundation Arizona, providing services for Maximizing the Educational and Economic Impact of STEM. Ms. VanIngen-Dunn is the inspiration behind the programs and resources designed to assist community colleges, particularly rural and Hispanic Serving Institutions (HSIs), through a rigorous process leading to improvements in their capacity building, infrastructure, and proposal development efforts that support students in their STEM education and career pathways pursuits.

Prior to Science Foundation Arizona, Ms. VanIngen-Dunn served as President of CVID Consulting, building on years of experience as engineer and project manager in human crashworthiness and safety design, development and testing, working for contractors in commuter rail, aerospace and defense industries.

VanIngen-Dunn has an MS degree in Mechanical Engineering from Stanford University and a BSE degree in Biomedical Engineering from the University of Iowa. She serves on the University of Iowa's College of Engineering Advisory Board, the YWCA Metropolitan Phoenix Board of Directors, and the Maricopa Community College Workforce Development Leadership & Innovation Council, among other advisory committees.

Dr. Phil Blake McBride, Eastern Arizona College

Phil McBride received a B.S. from the University of Arizona in 1986, a M.A.T. in 1989 from Northern Arizona University and a Ph.D. in Chemistry from Miami University in 2003. He taught high school in Northern Arizona for 5 years before moving to Eastern Arizona College in 1991 to teach chemistry. He was recognized by the EAC Student Association as the most admired faculty in 1993, received the Alumni Faculty Recognition award in 1996, the distinguished service award in 1997, and in 2008 received the Rocky Mountain Region College Educator Award for Excellence in Teaching by the American Chemical Society. He has presented at the Southeastern Arizona Teachers Academy, the ASTA Annual Conference, NSTA, ACS, and the Biennial Conference on Chemical Education (BCCE). He is a member of ASTA, NSTA, AAPT, ACS, and 2YC3. He is the current membership secretary of ASTA, a position which he has held since 2010. He has been a volunteer with the Boy Scouts of America for the past 20 years. For the past 11 years, he has served as Dean of Instruction, while continuing to teach at least one course each semester.

Ms. Cynthia Kay Pickering, Science Foundation Arizona

Cynthia Pickering is a retired electrical engineer with 35 years industry experience and technical leadership in software development, artificial intelligence, information technology architecture/engineering, and collaboration systems research.

In September 2015, she joined Science Foundation Arizona (SFAz) to lead the Girls in STEM initiative and translate her passion for STEM into opportunities that will attract, inspire and retain more girls in STEM to make it the new norm. She has also architected SFAz's enhanced Community College STEM Pathways Guide that has received the national STEMx seal of approval for STEM tools. She integrated the STEM Pathways Guide with the KickStarter processes for improving competitive proposal writing of Community College Hispanic Serving Institutions.

Throughout her career, Ms. Pickering has written robotics software, diagnostic expert systems for space station, manufacturing equipment models, and architected complex IT systems for global collaboration that included engagement analytics. She holds a US Patent # 7904323, Multi-Team Immersive Integrated Collaboration Workspace awarded 3/8/2011. She also has twenty-five peer-reviewed publications.

Dr. Verlyn Fick, Cochise College

Dr. Verlyn Fick is the executive vice president and provost at Cochise College in southeastern Arizona. He has served as a principle investigator for National Science Foundation projects in collaboration with Science Foundation Arizona and several Arizona community colleges. These projects emphasize STEM pathways, specifically improving the success of engineering students as they pursue degrees from high school through graduate school. He has worked at other community colleges in Iowa and North Dakota as an administrator and a faculty member. Fick obtained his Ph.D. in Crop Production and Physiology from Iowa State University and BS degrees in Agronomy and in Soil Science from the University of Minnesota.

Ms. Judith M. Slisz, Judith Slisz Consulting

Judith Slisz has served as an external evaluator for NSF projects since 2011, working in concert with Science Foundation Arizona. She has contributed to the development of Advanced Technology Education projects and evaluated the effectiveness of these projects. She has also served as a reviewer of papers submitted to the International Mechanical Engineering Congress. She holds a master's degree in English and an MBA. She has over twenty years experience in higher education administration.

Mr. John Morgan, Yavapai College

John H Morgan – Biographical Sketch

(a) Professional Preparation

Undergraduate Institution: University of Arizona, Agriculture, Bachelor of Science, 1989 Graduate Institution: University of Phoenix, Administration and Supervision, Master of Arts, 2005

(b) Appointments

2/2011 to Present: Dean, School of Career and Technical Education, Yavapai Community College.

8/2005 to 2/2011: Dean, Chino Valley and CTEC Campuses, Yavapai Community College.

7/2000 to 8/2005: Associate Dean and Agriculture Professor, Chino Valley Campus.

7/1999 to 7/2000: Agribusiness Program Director and Faculty, Agribusiness and Science Technology Center, Yavapai Community College

7/1989 to 7/1999: Agriculture Instructor and CTE Director, Chino Valley High School

6/1986 to 6/1989: Research Assistant, U.S.D.A. Carl Hayden Bee Research Center, Tucson, Az

(c) Publications A list of: (i) up to five publications most closely related to the proposed project: No information to report.

and (ii) up to five other significant publications, whether or not related to the proposed project:

1. John H. Morgan. "Potential Sustainable Energy uses from Depleted Forests in the Prescott Basin", Council for Economic Development in the Tri-City area, September, 2003 2. John H. Morgan. "Developing a Sustainable Economy for Yavapai County", Verde Valley Sustainable Economic Development Summit, January, 2004 3. John H. Morgan."Water as a resource – To conserve or not to Conserve", Yavapai County Sustainable Economics Forum, 2005 4. John H. Morgan and Mike Henry."Supervised Experience: Urban Diversity Rural Style", National Agricultural Education Magazine, December, 1991, Volume 64, Number 6 5. John H. Morgan. "Teaching Aquaculture at the Secondary Levels", Arizona Aquaculture Magazine, September Edition, 1995

(d) Synergistic Activities

1. Directed college initiative to develop Applied Pre-engineering program and Integrated Systems Engineering program. 2. Developed 21 programs at Yavapai College in the Career and Technical Education areas with strong ties to engineering and advanced manufacturing principles. 3. Member of Articulation Task Force for statewide Agriculture initiative. 4. Served as advisory board member to the Mountain Institute Joint Technological District. 5. Established 12 major corporate partnerships for Yavapai College. 6. Participated in first AZ Science Foundation Initiative to develop STEM programs for rural community colleges in Arizona. 7. Chaired college committee for initiation of online education delivery standards.

(e) Collaborators & Other Affiliations • Collaborators and Co-Editors. No information to report.

• Graduate Advisors and Postdoctoral Sponsors. No information to report

• Thesis Advisor and Postgraduate-Scholar Sponsor. No information to report.

Meeting STEM Workforce Demand in a Statewide Rural Community College Collaborative

Introduction

Across Arizona's rural community colleges, administrators and faculty have been convening as a Rural Community College STEM Collaborative to develop and deliver programs for their STEM Pathways initiatives to increase the number of rural students pursuing STEM in support of the local and state workforce pipeline. The collaborative of eight rural Arizona community colleges is facilitated by Science Foundation Arizona (SFAz), a non-profit 501(3)(c) whose charter includes K-Career STEM education and a team with focus on Community College STEM Pathways. At the onset of this program, funded by NSF in Fall 2014, all eight colleges were awarded a 3-yr grant (totaling on average $75K per college). Participating rural colleges included Arizona Western College (AWC), Central Arizona College (CAC), Cochise College (CC), Coconino Community College (CCC), Eastern Arizona College (EAC), Mohave Community College (MCC), Northland Pioneer College (NPC), and Yavapai College (YC). The collaborative convened regularly to share knowledge and discuss STEM Pathway gaps, outcomes, and best practices. Over the course of this collaboration, the participants have developed a trust and a bond that has led to sharing of ideas and best practices, as well as a recognition of common challenges that would be better addressed together rather than alone.

Program Vision / Goals

The Rural Community College STEM Collaborative (SFAz+8) vision is to accelerate development and delivery of key STEM Pathway programs and activities through collaborations among a network of rural community colleges to prepare more students with STEM certifications and degrees that support local and state workforce demands in Arizona. In support of this vision, the program established three goals: (1) Establish and Strengthen the Rural Arizona Community College STEM Collaborative, (2) Assist the colleges in the Collaborative to build their STEM Pathway Programs, and (3) Increase the pipeline of rural students pursuing STEM degrees to meet local workforce needs.

Demographics of the Institutions Participating in the Program

Rural colleges play a critical role in meeting local and state industry workforce needs as well as transitioning students to 4-year STEM degree programs through targeted partnerships with Arizona's three public universities. The eight partnering rural colleges shown in Figure 1 serve ten of Arizona's 13 rural counties, while the remaining three counties are served through a contract for educational services with one of the project colleges. Rural Arizona counties are defined as all Arizona's counties *except* Maricopa and Pima counties where the metropolitan cities of Phoenix and Tucson are located. The eight rural community colleges serve diverse underrepresented groups, including Native Americans, Hispanics, and Females. The industries they support are as diverse as aerospace, defense, mining, manufacturing, automotive, construction, and agriculture.

Approximately 1.67 million Arizonans reside in the rural colleges' service areas, an area encompassing over 95,000 square miles[1], roughly the size of the state of Michigan. The percent of rural Arizona residents 25 years and older that hold a bachelor's degree or higher ranges by county from 9.9% to 33.5%[1]. Apache, Navajo, and Coconino counties in northern Arizona have the largest Native American populations at 75.4%, 46.2%, and 27.5%

respectively[1]. Santa Cruz, Yuma, Cochise, Greenlee, and Graham counties in southern Arizona have higher Hispanic (or Latino) populations at 83.3%, 62.8%, 46.1%, 35% and 32.6% respectively[1].

Based on Fall 2016 data from the aggregated Integrated Postsecondary Data System (IPEDS)[2], the eight rural community college districts combined served 71,836 students, of which 55% are part-time students. Fifty-four percent of the student population is female with an almost 50 percent minority population, in which Hispanics represent 28.7% of total enrollment. The retention rate among the colleges ranges from 38% to 70% for full-time students with declining rates of 28% to 45% for part-time students. Graduation rates range from 5% to 30% for degree/certificates earned within 100% of normal time and for degrees/certificates earned within 200% of normal time they range from 12% to 41%. In 2016, the colleges collectively awarded 1,501 STEM-related Associate Degrees and 1,650 STEM-related Certificates[2]. The ethnic percentages of the enrolled students trend toward the population percentages in the counties the colleges serve: Native American enrollment is higher in the northern colleges at Northland Pioneer and Coconino Community Colleges compared to those in the southern part of the state where the Hispanic enrollment is higher at Arizona Western, Cochise, and Central Arizona Colleges.

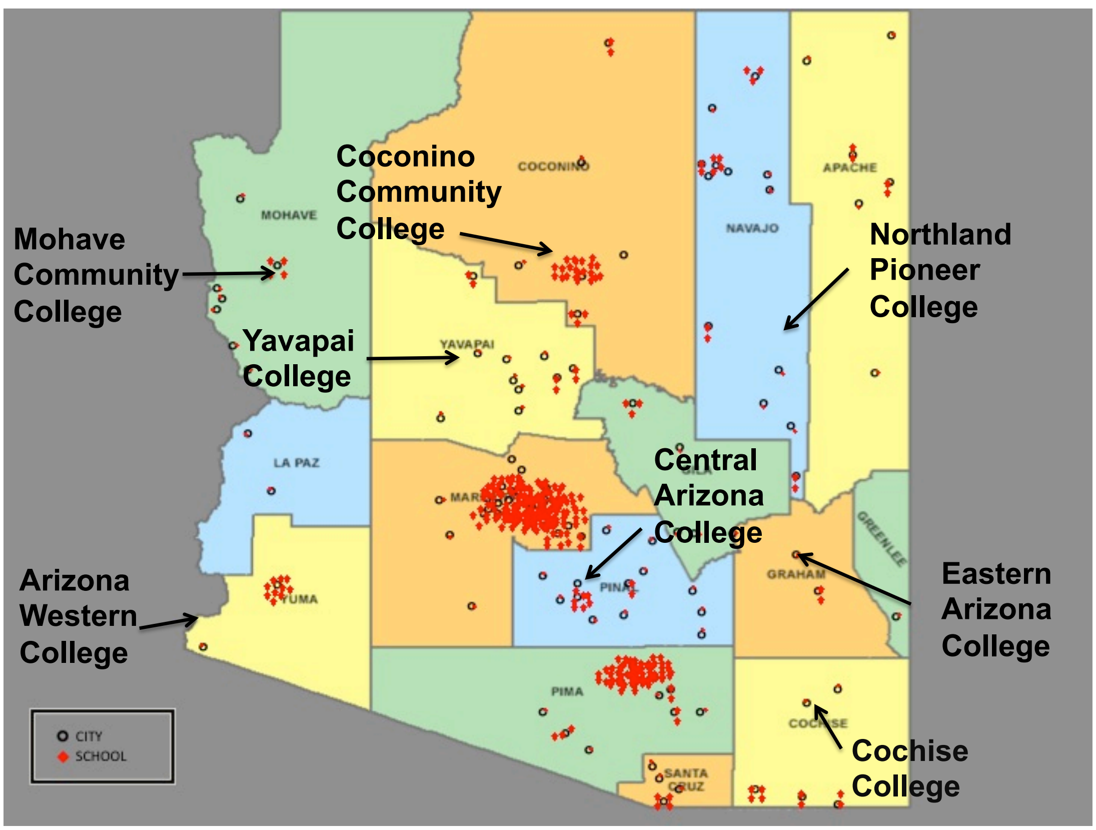

Figure 1: Arizona map locating rural community colleges

Some of Arizona's most critical industries are based in its rural communities, including three in Southeastern Arizona that are dependent on their local community colleges for workers: Fort

Huachuca (intelligence, IT and defense), Freeport-McMoRan Copper and Gold (mining), and Northrop Grumman and Lockheed Martin (aerospace and defense). Purina and Frito Lay (manufacturing), Gowan Company (agriculture), and Salt River Project and Arizona Public Service (utilities) are critical employers in other parts of the state. Properly skilled workers are needed to support the workforce demands of these and other Arizona companies statewide, requiring colleges to augment their existing programs and develop new ones to close the skills gap that prevails.

In 2010, the governing boards of Arizona's ten community college districts adopted the *Arizona Community Colleges: Long-Term Strategic Vision*[3] marking the first time in Arizona history that the ten locally-governed districts have taken formal action to establish a common vision to increase the number of Arizonans who achieve their postsecondary education and training goals, complete a degree or certificate, and/or transfer to a university. The *Vision* sets out agreed-upon key indicators and strategies for three goals: (1) broad access to education and training, (2) improved retention, and (3) greater completion and transfer. The Rural Community College STEM Collaborative aligns its STEM-focus directly toward achieving this vision and these goals.

STEM Pathways Model as a Guiding Framework

The STEM Pathways Model [4] [5] [6] is a conceptual model that links student experiences across K-16 education sectors through programs and activities that engage and excite students about STEM career opportunities, prepare them for college-level coursework, and support their acquisition of meaningful workplace knowledge and skills leading to credentials and degrees and eventually jobs. The STEM Pathways Model was developed during the *Engineering Pathways Partnership Project (EP3): A Rural Model for a Modern World*, Grant Award No. 1003847, 2011-2015 and is shown in Figure 2. Loosely categorized into three components, the programs and activities of a STEM Pathway are anchored by the community colleges and closely tied to local employers. The three components are (1) Outreach and Career Exploration; (2) Foundational Knowledge and Skills; and (3) Transferable Certification and Degree Programs.

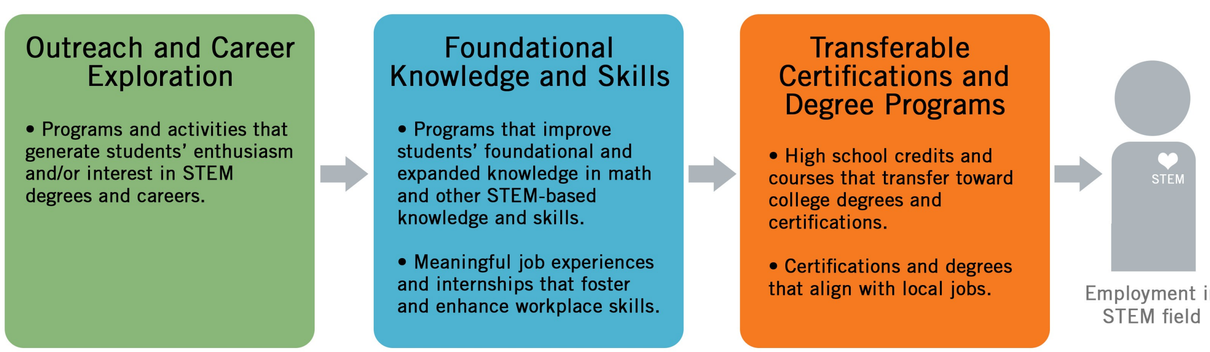

Figure 2: STEM Pathways Model Components

Outreach and Career Exploration focuses on engaging and exciting students about STEM careers at an early age. Reaching large groups of students, this category reinforces and motivates students to acquire strong math and science knowledge and skills by demonstrating the relevance of their academic studies. Engaging industry early in the process to bring to light the relevance of theoretical math and science concepts to students is critical. Examples of early engagement with industry include STEM Camps, STEM career exploration events, and Summer Math Academies.

Foundational Knowledge and Skills is at the heart of the STEM pathway, and the colleges, because it is the component representing curriculum and programs that they deliver to meet industry workforce needs. Industry participation involves helping colleges define and deliver up-to-date and relevant programs that can lead to certifications and degrees. To support students' success in these programs, there is a critical need to ensure students have the requisite math skills. Current literature indicates that mathematical knowledge and understanding serves as a gatekeeper to students entering and successfully completing STEM programs of study. Student enrollment in remedial mathematics coursework, particularly at public 2-year institutions, is historically high (59.3 percent between 2003 and 2009)[7]. This is a substantial problem for many institutions due to very low completion rates for remedial coursework. Nearly half (49 percent) of students enrolled in these classes fail to finish their programs[7]. Of the 3,527 recent Arizona high school graduates (2009-10) enrolling in a math course at a rural community college, almost 80 percent enrolled in high-school level pre-intermediate Algebra or intermediate Algebra courses. The success rate of students enrolled in developmental math courses and then completing a college-level program is a dismal 20 percent combined for all Arizona community colleges [8].

Transferable Certification and Degree Programs is the articulation of credits and programs such as early-college options and transferable degrees that intentionally lead students toward a particular STEM career. This component of the STEM Pathway Model reinforces the importance of establishing strong partnerships with universities to facilitate successful student transitions across education sectors. Industry participation in this category includes becoming familiar with these programs and degrees and agreeing to hire students with these credentials. The value of industry-based internships is well documented in such models as Learn and Earn [9], and the President's Council of Advisors on Science and Technology (PCAST) [10]. Early-college programs offer students accelerated learning opportunities, including pre-engineering or applied technology, that typically are not available in rural schools. High school math and science teachers credentialed to teach Advanced Placement courses are not as readily available in rural schools as they are in many suburban schools of Phoenix and Tucson, suggesting that community college math and science faculty have the opportunity to offer early college options to high school students at their college campuses. These courses should all be offered with transferable credits that can be used toward an engineering or similar degree.

Operation of the Statewide Rural Community College Collaborative

Facilitated by SFAz whose charter includes K-Career STEM education and a team with focus on Community College STEM Pathways, the collaborative convened virtually on a monthly basis to share knowledge and discuss STEM Pathway gaps, outcomes, best practices, and potential partnerships to address common challenges. At least one face-to-face meeting was held annually. The Arizona STEM Network online platform was also available to all eight rural colleges to access, share, and interact with information e.g., best practice examples pertaining to the components of the STEM Pathways Model.

A Network Council consisting of the PIs from all eight colleges and an Executive Council which was a subset of three college PIs comprised the operating structure of the Collaborative. The non-profit PI for the NSF grant chaired meetings with both Councils. The Executive Council usually met prior to Network Council meetings to pre-work and champion upcoming Network Council meeting agendas, often inviting guests with experience and expertise related to the specific agenda topics to help inform the Network Council.

At the onset of the program, all eight colleges were awarded a 3-yr grant (totaling on average $75K per college) to deliver their proposed STEM programs. The non-profit team provided grant management and oversight for the colleges' funded STEM programs, requiring quarterly reporting of their financial expenditures and budget balances, progress against their proposed timelines, and narratives describing program status, outcomes, and challenges. The SFAz PI responded to these reports with emails, phone calls and site visits when appropriate, providing ongoing support and guidance to the college PIs to ensure their program's success.

STEM Metrics Development Approach

From its onset, the SFAz+8 program was designed to generate evidence to validate achievement of the program goals. Objectivity was ensured through the use of an external evaluator. Each program goal had associated measurable outcome(s) and yearly strategies and metrics that built on the prior year's achievements. The outcome of Goal 1: Strengthen the Collaborative, was oriented to partnerships and collaborations among the participating colleges and with universities and industry demonstrating a shared commitment to improve the local and state workforce pipeline. The associated Goal 1 metrics captured numbers of institutional partnerships, industry advisory boards (IABs), and professional learning councils (PLCs) consisting of groups of faculty researching and addressing issues in student learning, achievement, retention, and completion. The desired outcome of Goal 2: Build STEM Pathway Programs, assisted participating colleges with adding, expanding or improving component(s) of their STEM Pathways. Thus the Goal 2 metrics focused on measuring whether more colleges were offering or facilitating more STEM outreach, early college academies, industry internships, teacher PD, and STEM degree and certificate programs. In contrast, outcomes for Goal 3: Grow the STEM Student Pipeline, centered on the level of student engagement in the Goal 2 offerings and the Goal 3 metrics captured student participation in outreach activities, internships, and enrollment and completion of STEM certificates and degrees.

Early on, the SFAz+8 collaborative agreed to establish a shared definition of STEM - in terms of the Classification of Instructional Program (CIP) Codes[11] developed by the U.S. Department of Education's National Center for Education Statistics (NCES). The common STEM definition included CIP Codes 26, 27, 40, and 42 for the typical math and science programs; CIP 11 for CS and CIS programs; 14,15 for engineering and engineering-related programs like mechatronics, and 47, 48 for technology programs such as welding, automotive, machining and electronics. Mapping to CIP Codes enabled a standard basis for STEM metrics and data collection across the colleges to measure student participation in the agreed-upon areas of focus (engineering, engineering technology, and computer science). In Fall 2014, the program's external evaluators designed a baseline survey that was completed by each college. The collection of baseline and subsequent annual data was organized according to the three program goals and their underlying metrics, which were designed to assess achievement of desired outcomes for each college and in total, as compared to the annual goal for each metric. Table 1 illustrates the format for reporting annual data gathered from the participating colleges and also provides a comprehensive view of all of the data that was collected by the program. The survey instrument requested these numbers separately from each college. Typically the college PIs worked with their college's institutional research department to gather the data and the results were aggregated into a summary report by the evaluator. The survey also aligned to key components of the STEM Pathways Model including K-12 Outreach, K-12 Professional Development, Industry Engagement, and Foundational Skills.

Over the period of the grant there was heightened interest and commitment to collect demographic information on students participating in outreach events, students enrolled in early college programs, and students enrolled in degree and certificate programs. There were also refinements in the categories of data collected and improvements in the accuracy and completeness of the data collection. These refinements and improvements were incorporated into the annual survey and a formal STEM Metrics Suite was established that has served as a tool for annual data collection (Annual STEM Metrics Report), a repository for longitudinal analysis, and formatted statistical data.

STEM Metrics Survey Results and Other Outcomes

Overall, colleges participating in the SFAz+8 collaborative have seen significant year to year student increases in the STEM pipeline via outreach, early college programs, internships, and students enrolled in and completing degree and certificate programs, serving as the achievement measure for STEM pipeline progress and success. They have also experienced improvements in the quality in STEM student advisors' services and approaches. The colleges have enhanced their leadership role in their communities through outreach events, workshops for K-12 teachers, and STEM kit and equipment donations to area schools. They have increasingly leveraged industry partners to provide students with internship opportunities and participate in outreach events.

Implicitly, this group and the way in which it operated, has evolved to become a community of innovation defined in the literature as organizations that encourage ideation resulting from diverse yet collaborative thinking, facilitate creative problem solving, and ultimately provide the monetary, human and physical resources to execute the solutions that are imagined. [12][13][14][15]

As shown in Table 1, all eight colleges (exceeding the targeted goal of 6 colleges) have industry advisory boards (IABs) that meet per schedule at each college. The main contributions of these 200 plus members include developing program content and sharing information about workforce needs. The businesses also contribute $227,800 monetary support and $384,605 in in-kind support during 2015/16. Table 1 also compares enrollment and completions, by college, to Year 3 goals. In almost all categories the student numbers meet or significantly exceed the modest goals that were established at the outset of the project. Therefore, the growth in numbers from year to year becomes the more significant measure of progress and success.

Table 1: Report on Year 3 (2016-17) Enrollment and Completion Goals vs. Achievement										
7/27/17	Yr. 3 Goal	AWC	CAC	CC	CCC	EAC	MCC	NPC	YC	Total
Establish and Strengthen the Rural Arizona Community College STEM Collaborative										
IAB Members	28	66	22	74	13	9	9	12	12	217
PLC	3		1	1		1			1	4
Partnerships	2	P	P	P	P	P	P	P	P	8
Assist the colleges in the Collaborative to build their STEM Pathway Programs										
STEM outreach programs	6	1	1	1	1	1	1	1	1	8
Math interventions	6	1	1	1	1	1	1		1	7
Early College Programs	4	1	1	1	1	1	1	1	1	8
K12 Science PD	3	1	1	1	1	1		1	1	7
Internships	3	1		1	1	1	1		1	6
AAS engr. degree programs	3			1					1	2
Tech AAS>industry	3	1	1	1	1	1	1	1	1	8
Certification programs	3	1	1	1	1	1	1	1	1	8
Pre-engineering courses	4		1	1	1	1	1			5
Increase pipeline of rural students pursuing STEM degrees to meet local workforce needs										
Outreach activities	90	1,100	413	716	7	5,211	591	448	370	8,856
Math interventions	80	1,478	31	997		596	1200		240	4,542
Early college enrollments	70	711		31	218	143	379	544	35	2061
Early college completions	new	711		5	179	133	322	512	33	1895
Internships	20	56		78	22	13	8		11	188
HS teachers PD	20	62	15	25	10	271		2	37	422
AAS Engr. degree enrollments	new			38					139	177
AAS Engr. degrees completed	15			23					29	52
AS Engr. degree enrollments	new	348		0		74	46	1		469
AS Engr. degrees completed	new	24		0		14	1			39
CIP 11,14,15 AAS enrollments	new	237	96	565	171	111	456	13	566	2215
CIP 11,14,15 AAS completed	new	18	6	43	12	11	34	3	86	213
CIP 11,14,15 Cert enrollments	new	366	6	18	106	7	32	12	650	1197
CIP 11,14,15 Cert completed	new	213	1	3	3	3	11	4	169	407
Pre-engr. course enrollments	30		20	46	28	89	10			193
Pre-engr. courses completed	new		18	42	24	80	10			174

Table 2 shows trends in student numbers for the focus areas (engineering, engineering technology, and computer science) from baseline to Year 3 and calculated percent changes from Year 2 to Year 3. There is a notable increase in the number of students in outreach, early college programs, internships, and in degree and certificate programs. A comparison of baseline data to Year 3 data shows growth in almost all categories.

	Table 2: Key STEM Pipeline Metrics for Baseline Data and Years 1, 2, and 3 Percent Change from Year 2 (2015-16) to Year 3 (2016-17)					
Metric	Baseline: 2014	Year 1: (2014-15)	Year 2: (2015-16)	Year 3: (2016-17)	Increase (Decrease) Yr2 to Yr3	% Increase (Decrease) Yr2 to Yr3
Students in K-12 Outreach programs	9,887	7,857	8,752	8,856	104	1.19%
Dual enrollment; early college programs enrolled	2,861	2,723	1,542	2,061	519	33.66%
Early college completed		404	1,438	1,895	457	31.78%
Students in internship programs	42	125	147	188	41	27.89%
AAS Engineering enrolled			44	177	133	302.27%
AAS Engineering completed			30	52	22	73.33%
AS Engineering enrolled	185	421	633	469	(164)	(25.91%)
AS Engineering completed	11	29	33	39	6	18.18%
CIP 11,14,15 AAS enrolled	2,555	2,507	2,215	2,215	0	0.00%
CIP 11,14,15 AAS completed	246	202	160	213	53	33.13%
CIP 11,14,15 Cert enrollments	740	733	1,440	1,197	(243)	(16.88%)
CIP 11,14,15 Certs completed	249	222	254	407	153	60.24%
Pre-engineering courses enrolled	149	191	203	193	(10)	(4.93%)
Pre-engineering courses completed	124	122	172	174	2	1.16%

The following outcomes are the most notable of the Year 3 student participation trends:

- Outreach programs have held steady with on average 8,500 K-12 students across rural Arizona impacted each year by community college-led STEM experiences in summer camps, workshops, clubs, and events.
- Dual enrollment numbers recovered upward by 33.7% from a dip in Year 2 that was most likely a reaction to changes in accreditation from the Higher Learning Commission (HLC). School districts and colleges are working within the new requirements, finding credentialed instructors, and offering a number of new courses along with effective advising and support systems, resulting in 2061 students in dual enrollment, a number that is approaching the Year 1 level of 2723 students.
- Early College completion numbers (not including Dual Enrollments) have increased 32% since Year 2, from 1438 to 1895 students.
- The number of internships is up 27.9% due to a new internship program at MCC and the expansion of internship programs from the previous year, especially at AWC and CCC.
- The aggregated number of AS and AAS Engineering Degree completions experienced a 36.32% increase.
- Certificate program completions were up significantly at 60.24%.

The colleges are a diverse group demographically, geographically, and in their STEM intervention focus areas. These differences may contribute to which segment of the STEM pipeline they are focusing their student engagement activities on: Recruitment, Persistence, or Completion. For example, EAC's K-12 STEM outreach numbers suggest a focus on long-term recruitment: they leverage their annual Sci-Tech Festival and deliver a wide range of engineering, math and science summer camps producing participation numbers representing nearly 60% of the outreach participants among all colleges (Figure 3 and Table 1). In contrast NPC, AWC, and MCC have higher percentages of students enrolled in early college STEM programs (Figure 4 and Table 1). YC, AWC and CC reported AAS and AS engineering degree completions representing a combined 83% of all eight rural AZ colleges (Figure 5 and Table 1). In Figure 6, we see that YC and AWC represent 93% of the reported engineering certificate program completions. Observations like these could lead to a promotion of best practices for other colleges ready to follow suit.

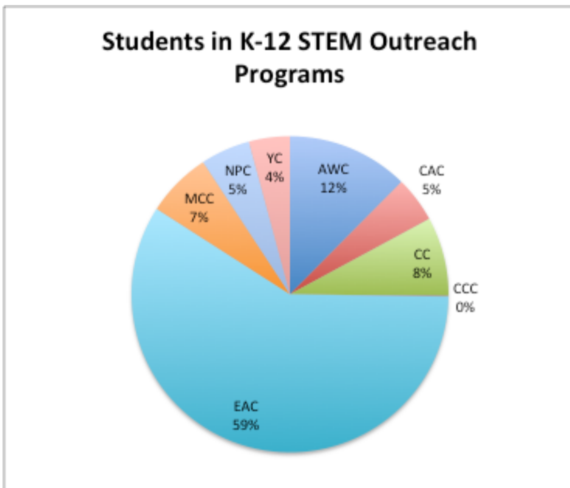

Figure 3: K-12 STEM Outreach Percentages

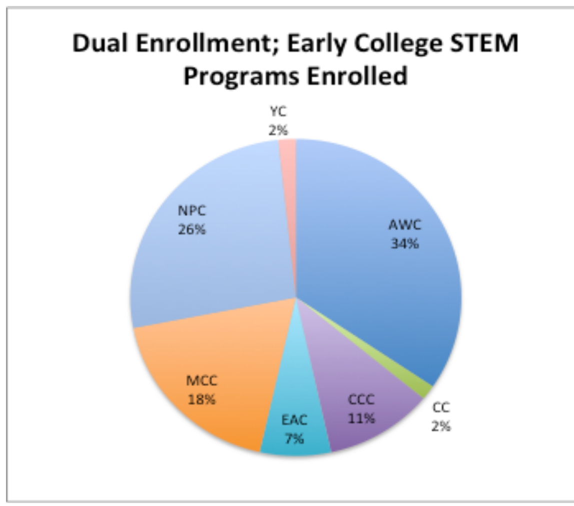

Figure 4: STEM Dual Enrollment Percentages

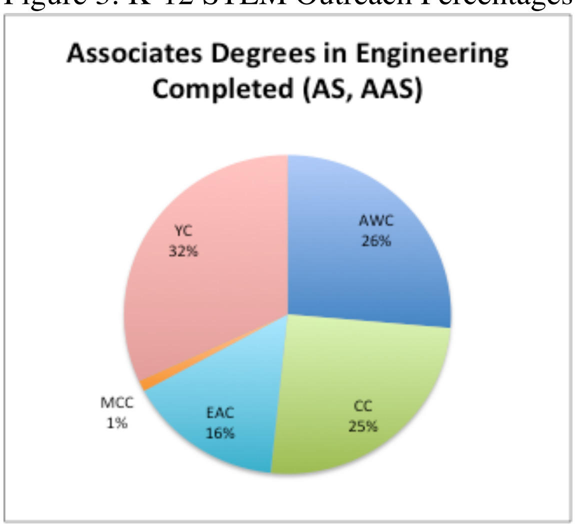

Figure 5: Percent Engr. Degrees Completed

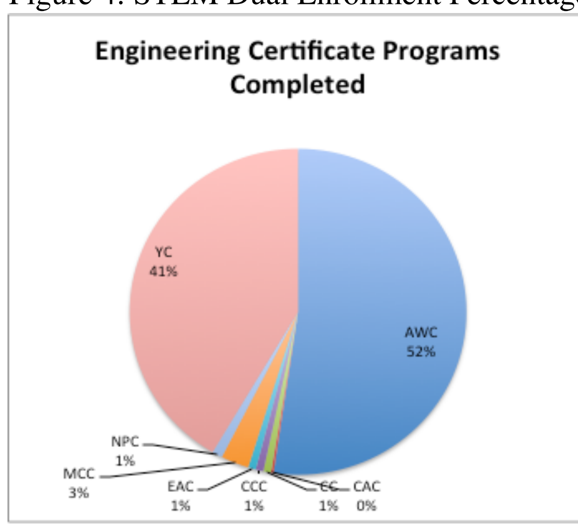

Figure 6: Percent Engr. Certificates Completed

The Annual STEM Metrics Report completed by the colleges captured STEM Professional Development (PD) results shown in Table 3. The overall increase in teacher PD for the Network was 31.9%. EAC's steady delivery of STEM Professional Development increased 20% from 226 teachers to 271 teachers, mainly through teacher participation in an annual STEM Conference hosted at EAC. Three colleges, namely AWC, CC, and YC, expanded the number of teachers and faculty in professional development programs this year by 210% from 40 to 124 faculty. In many cases, but not all, instructional personnel were paid stipends from the grant.

Table 3. Professional Development Programs for STEM Faculty (Numbers of Teachers participating in PD)					
College	Year 1	Year 2	Year 3	Increase (Decrease) Yr2 to Yr3	% Increase (Decrease) Yr2 to Yr3
AWC	41	24	62	38	158.33%
CAC	14	13	15	2	15.38%
CC	39	12	25	13	108.33%
CCC	12	8	10	2	25.00%
EAC	209	226	271	45	19.91%
MCC	NR	NR	NR	NR	NR
NPC	3	33	2	(31)	(16.50%)
YC	NR	4	37	33	825.00%
Total	318	320	422	102	31.88%

NR = Not reported

Common Challenges Identified

Despite the results achieved by participating colleges over the past three years, challenges remain across the collaborative such as finding better ways to <u>connect community college STEM students to employers</u>. All of the colleges have traditional, highly localized industry advisory boards and internship programs. Some local companies connect with Tech faculty at community colleges for hiring and internships, but a two-way link to broader job opportunities across the state or region is needed. Some rural colleges have noticed a growing trend of rural college graduates being recruited by metro area companies. As a result, there is a desire to have an efficient way for students in rural colleges to learn about jobs in the metro Phoenix and Tucson areas. Multiple tools and resources exist for students to show their project/skills portfolio, such as using Linked-In to post Physics and other student projects. Other technologies for connecting students to employers are being targeted for implementation in Arizona and must address the needs of rural students.

The colleges are all working on ways to improve their <u>remedial math (or math development)</u> offerings. At Network Council meetings, a recurring theme among the Academic officers has been the difficulty in getting students to take required mathematics courses early on in their academic program and complete them successfully. As this theme came to the forefront, Academic Officers from the various colleges brought in their Career Technical Education (CTE) counterparts to help address the problem and search for solutions to help Tech Students complete. This positive outcome has resulted in math and CTE faculty across community colleges working together to find solutions.

Moving forward, the colleges have agreed to address the common problem of overcoming the barriers that technicians face in achieving the math credits required to earn technician certification and/or an associate's degree. In a collaborative effort, academic (math) and CTE (tech) faculty across colleges have joined together to explore a collaborative approach to systematically contextualize math modules into CTE programs (Math-in-CTE) and embed CTE problem modules that illustrate applied math concepts into required Tech Math courses (CTE-in-Math). The research will focus on how system-wide modular contextualization approaches overcome the barriers that technicians face in achieving the math credits and skills needed to complete CTE credentials that meet local workforce needs.

Supporting programs for dual enrollment, early college academies, and outreach activities with high schools are critical to colleges maintaining a strong feeder pipeline for their STEM programs. Addressing the importance of CTE funding and the Higher Learning Commission requirement of a master's degree plus 18 graduate hours in the field to be taught, are critical.

Providing students with high quality engineering education at widely geographically separated colleges, each with limited lab, equipment and faculty resources, is both a challenge and opportunity for the Rural Community College Collaborative. Supporting Engineering programs across multiple rural colleges, sharing resources, faculty, perhaps including a mobile lab and developing an Introduction to Engineering Project between colleges could potentially lead to new ways of delivering Engineering education in rural Arizona. Using remote access labs, sharing key faculty/lab resources, and employing on-line web delivery of programs are examples of this model.

Sharing of Ideas and Best Practices

The colleges' sharing of ideas, resources, and even faculty through the Network has strengthened the community and yielded collective impact as follows:

- Shared experiences and best practices led to an appreciation for high quality work being accomplished on each campus.
- Increased dual enrollment, early college academies, and outreach activities with high schools, all critical to maintaining a strong STEM feeder pipeline.
- Expanded opportunities for students through shared Physics and Calculus instructors via online platforms such as Zoom (EAC and CC)
- Leveraged industry partners and provided students with internship opportunities.

Lessons Learned

Participants came to realize that it takes time to define what data to collect, normalize the data across institutions, and establish regular data gathering practices to attain accurate data that can be used to measure progress. This initial investment has paid off. Participants now see the value and the power of the data to drive decision-making as they create new and expand current initiatives. Being part of a grant that requires colleges to provide comprehensive data initially helped participants become aware of the data's availability. They have since used the data to better understand the status of their programs and make decisions for improvement. For example, when the Collaborative decided to focus on addressing the math barrier, the colleges immediately concluded that they would have to collect and share data on the interventions being piloted. Data gathering has become standard procedure.

Participants agree that the value of the Collaborative goes beyond network meetings and reporting. It extends to the strengthened relationships within communities, K-12 and industry partners, to the information gained from aggregated data, and to the ideas and information sharing among participants. For example, E_ used the STEM Assessment Survey to determine strengths and weaknesses in their community. Based on the results, EAC formed a professional learning council based on the CC model. The council has brought together K-12 school, colleges, universities, industry, local businesses, and city governments in a collaborative effort to promote STEM in their community. NPC partnered with the Navajo County School Superintendent's Office to deliver "Kids College" (summer camps with increasing emphasis in STEM) in a number of towns and communities in their expansive rural county. Through the delivery of these camps, NPC developed a number of partnerships with K-12 schools and teachers who now advocate to their students for NPC as a desirable component of their education pathway. Stories like these are shared among the network colleges, reinforcing the value of the work and inspiring others to follow suit.

Conclusion

The program results demonstrate successful achievement of the three goals to establish a viable collaborative of rural Arizona community colleges around STEM education, assist participating colleges to build programs that support their STEM pathways development, and engage in systematic data tracking that in the aggregate has shown an increase in the number of rural students enrolling in and completing STEM programs. Common challenges were identified by the collaborative and can be shared by rural colleges nationwide as key issues for STEM education success. The Rural Arizona Community College Collaborative will continue in its quest to collectively address these challenges that in turn will serve as an incentive for the colleges to continue to work together. A Collaborative-wide focus on just one of these key areas will be facilitated in the upcoming year to foster long-term sustainability of the Collaborative and generate results that demonstrate the value of participating in a Statewide Rural Community College Collaborative.

References

[1] U.S. Census Bureau, "U.S. Census Bureau QuickFacts selected: Arizona Rural Counties," Jul-2016. [Online]. Available: https://www.census.gov/quickfacts/fact/table/AZ,US/PST045216. [Accessed: 28-Sep-2017].

[2] IPEDS, "Integrated Postsecondary Data System - Data Report for Eight Rural AZ Community Colleges," 2016. [Online]. Available: https://nces.ed.gov/ipeds/datacenter/Data.aspx. [Accessed: 27-Sep-2017].

[3] ACC, "Arizona Community Colleges: Long Term Strategic Vision." 2012.

[4] Caroline VanIngen Dunn and Verlyn Fick, "Key Success Factors of a Replicable Engineering Pathway Model in Rural Arizona," presented at the HI-TEC Conference, Austin, TX, 2013.

[5] C. VanIngen-Dunn, C. Pickering, L. Coyle, A. Grierson, S. Frimer, and V. Fick, "Community College STEM Pathways Guide: A Collaborative Online System for Design and Implementation of STEM Pathway Programs," in *Collaboration Technologies and Systems (CTS), 2016 International Conference on*, 2016, pp. 158–164.
[6] Pickering, Cynthia and VanIngen-Dunn, Caroline, "Community College STEM Pathways Guide," *STEM Network, Science Foundation Arizona*, 2016. [Online]. Available: http://stem.sfaz.org/?page=stempathways. [Accessed: 07-Dec-2017].
[7] Xianglei Chen and Sean Simone, "Remedial Coursetaking at U.S. Public 2- and 4-Year Institutions: Scope, Experiences, and Outcomes," National Center for Education Statistics, U.S. Department of Education, Sep. 2016.
[8] Arizona Community College Presidents Council, "A Statewide Report on the Performance of High School Graduates Enrolling at a Community College," 2011.
[9] Jan Morrison, "Learn & Earn | TIES." [Online]. Available: http://www.tiesteach.org/solutions/learn-and-earn/. [Accessed: 04-Jan-2018].
[10] J.P. Holdren and E. Lander, "President's Council on Science and Technology (PCAST) Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing," Jul. 2012.
[11] "IES NCES CIP 2010." [Online]. Available: https://nces.ed.gov/ipeds/cipcode/Default.aspx?y=55. [Accessed: 10-Sep-2017].
[12] J. Kim-Han, "Leadership and Innovation: Social Networks for Change," The Claremont Graduate University, 2016.
[13] R. E. West, "What is shared? A framework for understanding shared innovation within communities," *Educ. Technol. Res. Dev.*, vol. 57, no. 3, pp. 315–332, Jun. 2009.
[14] R. E. West, "Communities of innovation: Individual, group, and organizational characteristics leading to greater potential for innovation," *TechTrends*, vol. 58, no. 5, pp. 53–61, 2014.
[15] L. C. Moll, C. Amanti, D. Neff, and N. Gonzalez, "Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms," *Theory Pract.*, vol. 31, no. 2, pp. 132–141, 1992.