Evaluation of the Nevada NEXUS NSF EPSCoR Project 2018 Summative Report

A Nevada System of Higher Education (NSHE)
Established Program to Stimulate Competitive Research (EPSCoR) project
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List of acronyms

CSN – College of Southern Nevada
DRI – Desert Research Institute
EF – Eigenfactor
EFn – Normalized Eigenfactor
EPSCoR- Established Program to Stimulate Competitive Research
HSI – Hispanic Serving Institution
IHE – Institution of Higher Education
MSI – Minority Serving Communities
NRDC – Nevada Research Data Center
NSC – Nevada State College
NSF – National Science Foundation
NSHE – Nevada System of Higher Education
PUI – Primarily Undergraduate Institution
REX – Summer Research Experience
RII – Research Infrastructure Improvement
SCIP – STEM Career Investigation Program
SISTEM – Student Interactions with STEM
STEM – Science, Technology, Engineering, and Mathematics
STEMBOPS – STEM Bilingual Online Peer Sessions
TMCC – Truckee Meadows Community College
UNR – University of Nevada, Reno
UNLV – University of Nevada, Las Vegas
URM – Underrepresented Minority
UROP – Undergraduate Research Opportunity Program

Executive summary

This report presents progress made by the Nevada NSF Established Program to Stimulate Competitive Research (EPSCoR) Research Infrastructure Improvement (RII) Track-1 NEXUS project towards accomplishing project goals. The information contained in this report should be used to demonstrate the impact of the project to NSF and to discuss ways to create effective future projects with similar scopes and topics. Across the five years, the NEXUS project made meaningful impacts on research, education, workforce development, and external engagement. At the end of Year 5, the project had successfully met Goal 1 (Research), and made notable progress in meeting Goals 2, 3, and 4 (Diversity, Education/Workforce Development, and External Engagement). Some aspects of Goals 2, 3, and 4 cannot be realized within a five-year period, however the project has put sustainable plans in place for many components which will allow the project to continue making an impact in the state. Notable successes of the project include the following:

- Produced 144 peer-reviewed publications (journal articles, books/book chapters, and conference proceedings).
- Developed partnerships and established infrastructure (e.g. new equipment, faculty hires) to support future research.
- Increased knowledge of topics related to the solar energy-water-environment nexus.
- Conducted direct outreach with 4749 K-12 students from diverse backgrounds. The percentage of female and URM students reached in project Year 5 exceeded that of female and URM students in the state.
- Increased K-12 student exposure to and interest in STEM topics.
- Increased K-12 student interest in STEM education and careers.
- Developed and strengthened collaborations with 76 external partners with outcomes including research projects, proposals, and publications.

The project was less successful in meeting the following three goal aspects. However, these are longer-term aims that require additional time to achieve beyond the grant period. Additionally, it should be noted that there are many factors external to the project that can and do influence these aspects.

- Impacting the number of URM students graduating in solar energy related fields.
- Enhancing job opportunities in STEM in Nevada.
- Impacting Nevada's economic development.

As the NEXUS project is in a no cost extension period and leads are applying for future grant funding, project leads should consider the following recommendations, which are presented in three major areas.

- Hire additional staff to help strengthen project implementation, including a specialist solely dedicated to leading external outreach efforts, and a researcher with an emphasis on multidisciplinary research and team science to help guide the development of research objectives and connecting individuals from different fields.
- Design and implement mechanisms to ensure impact of the project can be isolated and carefully examined. Continue to track the successes of external engagement efforts of both existing and future partnerships; implement follow-up surveys to assess the education and career trajectories of project students in STEM; define expectations regarding knowledge and skills to be gained by the public through interaction with the project; and set professional development objectives for researchers and faculty to ensure project activities, mentorship, and support are targeted accordingly so individuals are gaining the intended knowledge and skills.
- Enhance the impact of EPSCoR on participants through supporting students in forming greater connections with eternal partners to improve career opportunities; dedicating more resources for diversity and education/workforce development participants to attend conferences and produce papers to create a wider impact; and utilizing the logic model or theory of change in project meetings with evaluators and program leads to ensure that activities have clear intended outcomes and are engaging students along the education/workforce development pipeline to achieve those outcomes.

Introduction

Background

The mission of the Established Program to Stimulate Competitive Research project is to assist the NSF in its statutory function to strengthen research and education in science and engineering throughout the United States and to avoid undue concentration of such research and education.[1]

The goals of the NSF EPSCoR are to:

- Provide strategic programs and opportunities for EPSCoR participants that stimulate sustainable improvements in their research and develop capacity and competitiveness.
- Advance science and engineering capabilities in EPSCoR jurisdictions for discovery, innovation and overall knowledge-based prosperity.

The objectives of the NSF EPSCoR project are:

- Catalyzing key research themes and related activities within and among EPSCoR jurisdictions that empower knowledge generation, dissemination, and application.
- Activating effective jurisdictional and regional collaborations among academic, government, and private sector stakeholders that advance scientific research, promote innovation and provide multiple societal benefits.
- Broadening participation in science and engineering by institutions, organizations and people within and among EPSCoR jurisdictions.
- Using EPSCoR for development, implementation and evaluation of future programmatic experiments that motivate positive change and progression.

The Nevada RII Track-1 NEXUS project aimed to create a statewide interdisciplinary program that stimulated transformative research, education, and outreach on the effects of solar energy. The five-year award funded science, cyberinfrastructure, diversity, workforce development/education, and outreach at all Nevada System of Higher Education's (NSHE) institutions, which included the University of Nevada, Reno (UNR), University of Nevada, Las Vegas (UNLV), Desert Research Institute (DRI), Nevada State College (NSC), and community colleges to support the study of solar energy. The mission for this project, as stated in the Five-year Strategic Plan, was to advance knowledge and discovery through research on solar energy generation technology, its environmental impacts and associated water issues, and accelerate this research by developing new capabilities in cyberinfrastructure.[2]

1 http://www.nsf.gov/od/oia/programs/epscor/about.jsp

2 http://nvsolarnexus.org/wp-content/uploads/2013/12/NV-EPSCoR-Strategic-Plan-2013-Revised-12-18-13.pdf

Overview of the project

On June 1, 2013, the Nevada System of Higher Education received a National Science Foundation award to establish the EPSCoR Research Infrastructure Improvement (RII) Track 1 project: The Solar Energy-Water-Environment NEXUS in Nevada. As displayed below, the primary goals of the project addressed four areas. Cyberinfrastructure supported all goals and worked most closely with Goal 1.

Project Goals

Goal 1: Solar Energy-Water-Environment NEXUS Research - Advancement of new knowledge and discoveries regarding the nexus among solar energy development, limited water resources, and fragile environment (including cyberinfrastructure).

Goal 2: Diversity - Develop a comprehensive approach that leads to an increase in the number of underrepresented students graduating from STEM programs.

Goal 3: Workforce Development/Education - Developing a sustainable STEM workforce by creating a pipeline of STEM trained students, educators, and workers while increasing public understanding of solar energy, water, and the environment.

Goal 4: External Engagement - Enable Nevada scientists to collaborate and develop relationships with industry, institutions, and the public to strengthen research supporting economic development of Nevada.

Figure 1. NEXUS project goals

Background of the evaluation

Evaluation questions

Evaluation questions helped guide the direction of inquiry for the project's evaluation. Figure 2 outlines the connection between project goals and the corresponding evaluation questions.

NEXUS EPSCoR Evaluation Questions
Research: Has the project advanced knowledge and discoveries in solar energy, water, and environment?
• To what extent has the NEXUS project advanced knowledge and discoveries in solar energy, water, and environment? • To what extent has NEXUS increased Nevada's research capacity? • To what extent has NEXUS produced high impact publications in key research areas?   • How successful were interventions in increasing high impact publications in years 4 and 5?
Diversity: Has the project increased the number of underrepresented students who graduate from STEM degree programs?
• To what extent has NEXUS increased the number of URM students graduating in solar energy related fields? • To what extent has the project reached a diverse group of students? • To what extent has the project implemented outreach to students who were representative of the state's demographics?
Education/Workforce Development: Has the project developed a sustainable STEM workforce by creating a pipeline of STEM-trained students, educators, and workers while increasing public understanding of water and energy?
• To what extent has NEXUS increased K-12 exposure to STEM?

- To what extent has NEXUS increased K-12 interest in STEM?
- To what extent has NEXUS increased interest in undergraduate/graduate education?
- To what extent has NEXUS enhanced job opportunities in STEM in Nevada?

External Engagement: Has the project enabled Nevada scientists to collaborate and develop relationships with industry, institutions, and the public to strengthen research that will support the economic development of Nevada?

- To what extent has NEXUS developed new partnerships?
- To what extent has NEXUS strengthened research through partnerships?
- To what extent will the economic development of Nevada continue after funding ends due to partnerships?

Figure 2. NEXUS evaluation questions

Evaluation approach

The evaluators used two evaluation approaches, formative and summative evaluation, to assess the project at different stages. These approaches were not mutually exclusive and were used in combination throughout the project, helping to explore different evaluation questions. The two approaches are outlined in the following table (Figure 3). For each one there is a description of the conditions under which the approach was used and the strategic questions that were explored using the described approach.

Approach	Approach description	Strategic questions
Formative Evaluation	Used when the project team is implementing strategies and activities. This approach is appropriate at this stage as outcomes are becoming more predictable. The project's context is increasingly well known and understood.	• How well is it working? • How can the project enhance what is working well and improve what is not? • What effects or changes are appearing in targeted systems? • What factors are limiting progress and how can these be managed or addressed?
Summative Evaluation	Used when the project is stable and well established. Leads have greater certainty about 'what works' and the project is evaluated to determine impact, value, and significance.	• What difference did it make? • What about the process has been most effective, for whom, and why? • What ripple effects did the initiative have on other parts of the system/state?

Figure 3. NEXUS evaluation approach

Evaluation methods

This Summative Evaluation Report used data from the following sources: project baseline and post-surveys, project participant interviews, ERCore (project's platform for collecting project-wide data), graduation and degree attainment data from NSHE institutions, summaries of previous evaluation reports, and a summary of the external engagement report. Each data source is explained in detail below.

- **Project baseline and post-surveys**: all project participants were asked to complete a baseline survey upon entry into the project to assess their level of knowledge and participation in key initiatives and activities. During the final year of the project, participants were asked to complete a post-survey which assessed their level of knowledge and their

perception of the impact of the project on research, diversity/workforce development, and partnerships. Across all five project years, 138 respondents completed the baseline survey (82% response rate) and 56 respondents completed the post-survey (44% response rate). Forty-one completed both the baseline survey and post-survey. Unless otherwise noted, the sample for this report is the 56 post-survey respondents.

- **Project participant interviews**: the project director identified 21 NEXUS participants to be interviewed for the summative evaluation. These participants were identified based on project role (leadership member or activity lead, seed grant recipient, new faculty hire, or graduate student) and insights they could bring regarding their role in the project. Of the 21 participants, 14 (67%) were interviewed by evaluators. Interviewees were asked about research innovation and the impact of NEXUS funding on research, the lasting impact of NEXUS, education and workforce development activities among K-12 and undergraduate students, career opportunities for NEXUS students, creation of partnerships with external entities, products of these partnership, and impact of the partnerships on NEXUS and on the interviewee.
- **ERCore**: data were collected by project leads on the products and outputs of the NEXUS project, such as publications and proposals, participants' demographics, external outreach efforts, student graduation, and new faculty hires.
- **Graduation and degree attainment data from NSHE institutions**: institutional data were requested from all NSHE institutions regarding graduation and degree attainment rates among URM populations in fields related to NEXUS research. These data were used to assess the contributions the project may have had on URMs attaining post-secondary degrees in STEM.
- **Summaries of previous evaluation reports**: activities conducted during the NEXUS project were evaluated for effectiveness and impact on participants. These results were reported quarterly throughout the project to the leadership team. Overall impacts of the activities were assessed through examining previous reports to determine whether the activities increased K-12 student awareness of STEM and interest in pursuing STEM undergraduate or graduate education.
- **Summary of external engagement activities**: external engagement activities were conducted throughout the NEXUS project. During the final two years of the project, these efforts were evaluated to assess external partnerships and collaborations created and their impact on the project. A four-part continuum was developed to help establish the different stages of partnership development and assess the outcomes of the partnerships. A summary of the partnerships developed, including where the partnerships ended along the continuum and outcomes achieved with the partners, were included in this report to assess the overall impacts of the project.
- **Benchmarks and milestones tables**: project members annually updated benchmarks and milestones to track progress in meeting strategic plan goals. These were used to assess the completion of activities related to the project goals. The benchmark and milestones included

in this report were based on information included in the Year 5 report submitted by project leads to NSF. All objectives still in progress at the time of this report will be met by the end of the no-cost extension. Throughout this report, highlights of each area are included. For complete information on all benchmarks and milestones, please see Appendix A.

- **Nevada Research Data Center (NRDC) analytics**: Cyberinfrastructure leads provided analytics on the usage of the NRDC website. These analytics were used to assess the reach of the data housed on the NRDC website and how often data were utilized by researchers and individuals outside the project.
- **Nevada Report Card**: Statewide education data on student attainment and demographics of all schools in Nevada. These data were used to determine whether project outreach activities were targeted at students who were representative of students overall in Nevada.

Background of participants

Increasing the involvement of women and URMs in STEM fields is a primary objective of the NSF EPSCoR, and the NEXUS project. This section provides information regarding project participants, with special attention paid to the number of women and URMs. There may be more female and URM participants than indicated in this report, as ERCore did not require participants to provide demographic information.

There were two types of participants in NEXUS. Primary project participants were involved with the project and contributed directly to project coordination and/or research. These participants included goal leads, activity coordinators, graduate students, researchers, and project administrators. These participants contributed to the project on a long-term, ongoing, and regular basis, paid or unpaid, and were involved in activities funded by the project.

The others were secondary participants and included K-12 teachers and students and undergraduates who participated in NEXUS activities, but did not have sustained, long-term participation in the NEXUS project.

Figure 4 shows primary project participants by institution and Figure 5 by gender and race/ethnicity. The tables below do not include the secondary participants. The number of participants involved increased each year of the project. Additionally, by the end of Year 5, the number of participants had doubled compared to Year 1. Notably, the number of participants at both Academic Research and Minority/Hispanic Serving Institutions increased each year, especially at UNR and UNLV. Very few members of the project left during the five years, thus demonstrating great participant retention.

NEXUS project participants by institution					
	Year 1 (n=108)	Year 2 (n=135)	Year 3 (n=183)	Year 4 (n=196)	Year 5 (n=216)
Academic Research Institutions	64[a]	67	107	109	118
Desert Research Institute	12	13	22	25	18
University of Nevada, Reno	52	54	85	84	100
Minority/Hispanic Serving Institutions	37	55	68	73	88
College of Southern Nevada [b]	0	1	0	2	0
Nevada State College [b]	0	5	5	1	7
University of Nevada, Las Vegas [c]	37	49	63	70	81
Primarily Undergraduate Institutions	0	5[a]	2	6	4
Great Basin College	0	1	1	1	1
Truckee Meadows Community College	0	3	1	3	2
Western Nevada College	0	1	0	2	1
Nevada System of Higher Education	7	7	6	8	6

a. Totals were reported differently in previous reports due to calculation errors. These numbers have been recalculated.

b. College of Southern Nevada and Nevada State College are also Primarily Undergraduate Institutions.

c. University of Nevada, Las Vegas is also an Academic Research Institution.

Figure 4. NEXUS project participants by institution years 1-5

The number and percentage of females increased each year, with the number of female participants in Year 5 triple that of Year 1. Hispanic/Latino participation increased across each year of the project with more than five times as many Hispanic/Latino participants in Year 5 as in Year 1. The number and percentage of other URM groups (African American or Black and American Indian or Alaskan Native) remained fairly consistent across all project years.

NEXUS project participants	Year 1 (n=108)	Year 2 (n=135)	Year 3 (n=183)	Year 4 (n=196)	Year 5 (n=216)
Gender					
Female	28 (26%)	42 (32%)	56 (31%)	64 (33%)	84 (39%)
Male	79 (73%)	92 (68%)	127 (69%)	130 (66%)	132 (61%)
Ethnicity					
Hispanic or Latino	7 (7%)	8 (6%)	25 (14%)	27 (14%)	38 (18%)
Not Hispanic or Latino	101 (93%)	127 (94%)	158 (87%)	169 (86%)	178 (82%)
Race					
Asian	27 (25%)	35 (26%)	47 (26%)	41 (21%)	47 (22%)
Caucasian or White (non-Hispanic)	75 (69%)	97 (72%)	132 (72%)	149 (76%)	158 (73%)
American Indian or Alaskan Native	0 (0%)	0 (0%)	2 (1%)	3 (2%)	2 (1%)
African American or Black	3 (3%)	2 (1%)	1 (0.5%)	2 (1%)	6 (3%)
Native Hawaiian or Pacific Islander	3 (3%)	1 (1%)	1 (0.5%)	1 (0.5%)	3 (1%)

Figure 5. NEXUS project participants by gender, ethnicity, and race for years 1-5

Figure 6 shows project participation by role and is further broken down by females and URMs. URM and female representation in the project overall increased in both number and percentage from Year 1 to Year 5. This indicates that efforts to recruit diverse sets of participants were successful. The roles that had the greatest increases in female and URM participation from Year 1 to Year 5 were faculty (9% increase in females), graduate students (12% increase in URMs) and undergraduate students (16% increase in URMs and 24% increase in females).

Role in project	Project year				
	Year 1	Year 2	Year 3	Year 4	Year 5
Faculty	41	40	52	53	42
URM	0%	0%	8%	9%	7%
Female	12%	13%	10%	19%	21%
Project Leads	12	12	13	13	14
URM	8%	8%	8%	8%	7%
Female	58%	58%	62%	62%	57%
Post docs	0	1	1	2	1
URM	0%	0%	0%	0%	0%
Female	0%	0%	0%	0%	0%
Graduate Students	17	28	45	47	46
URM	12%	18%	22%	21%	24%
Female	42%	32%	24%	21%	24%
Undergraduates	22	36	56	62	92
URM	18%	17%	21%	23%	34%

Role in project	Project year				
	Year 1	Year 2	Year 3	Year 4	Year 5
Female	27%	53%	48%	50%	51%
Support Staff	16	17	16	19	21
URM	38%	24%	13%	16%	14%
Female	38%	24%	21%	37%	43%
Advisory Board	23	24	24	22	22
URM	9%	8%	8%	5%	14%
Female	48%	46%	46%	41%	41%
Total	131	158	207	218	238
URM	12%	11%	15%	16%	21%
Female	27%	32%	32%	34%	39%

Figure 6. NEXUS participant roles by URM and female for years 1-5

Goal area 1: Research

The NEXUS project intended to create a strong infrastructure in the state of Nevada that supports research related to the solar energy-water-environment nexus. In order to accomplish the goal of advancing knowledge and discoveries in solar energy, a detailed research agenda was put in place, funds were dedicated to research and material and human infrastructure, opportunities were established to increase high impact publications, and resources (i.e. NEXUS 101, monthly research telecons, etc.) were developed and disseminated.

Achievement in research objective areas

According to the NEXUS Year 5 annual report developed by project leads in March 2018, all benchmarks and milestones related to advancing knowledge and discoveries regarding the nexus among solar energy development, limited water resources, and fragile environments were on track to be completed by the end of the project no-cost extension. See Appendix A for the full list of benchmarks and milestones that comprise each objective.

Goal 1 objectives	Number of benchmarks met	Status
Objective 1: Explore new technologies that could minimize water use at solar facilities.	3 of 6 met	On track
Objective 2: Understand environmental impacts of solar energy projects.	3 of 6 met	On track
Objective 3: Develop sustainable and advanced water/wastewater approaches to support water needs for solar energy development.	4 of 5 met	On track
Objective 4: Improve reliability, economic modeling, and sunlight forecasting for renewable/solar energy supply.	2 of 5 met	On track
Objective 5: Develop new and use existing cyberinfrastructure capabilities to accelerate the nexus research.	12 of 14 met	On track

Figure 7. Goal 1 benchmarks and milestones

Impact of project on respondents' knowledge

Survey respondents were asked to rate their level of knowledge regarding the project research objectives on the baseline and post-survey. For instance, they were asked to rate their knowledge regarding solar power plant improvements that increase efficiency and minimize cooling and cleaning water, as well as how solar plants impact soil crust degradation and how to mitigate those impacts. Across all five project years, 138 respondents completed the baseline survey and 56 respondents completed the post-survey. A total of 41 completed both the baseline survey and post-survey and these 41 respondents constitute the "matched" sample. To assess knowledge growth, a pre-post comparison was conducted on the matched sample. It is important to note that those who only completed the survey at one time point (those not included in the "matched" sample) had similar ratings to those who completed the survey at both time points.

It should be noted that these knowledge items were developed at the beginning of the project and because the project evolved and changed over the years, not all items may have been relevant at the end. However, in order to conduct baseline and post-survey comparisons, the project leads and program evaluators agreed the items needed to remain consistent on the post-survey. Project leads noted that they did not intend for participants to have knowledge increases in all areas nor was it feasible; therefore, the small increases in knowledge areas should not be surprising.

Overall, a majority of respondents reported they were slightly knowledgeable across the five research objectives at both the baseline and post-survey, with consistent minimal growth in knowledge across all objectives. Respondents were required to respond to all knowledge questions regardless of their research focus, which may have lowered the overall scores for each objective as many respondents indicated that they were "not knowledgeable at all". It was found that respondents conducting solar research rated they had low levels of knowledge on the post-survey for all non-solar research items.

A matched samples t-test was conducted to examine if there were statistically significant differences in levels of knowledge across all objectives for the matched sample respondents. Analyses revealed there were significant differences in levels of knowledge reported (denoted by the asterisk on the post-survey mean), indicating low, but significant knowledge growth, in all objective areas. Figure 8 displays the baseline-post comparisons for each research objective.

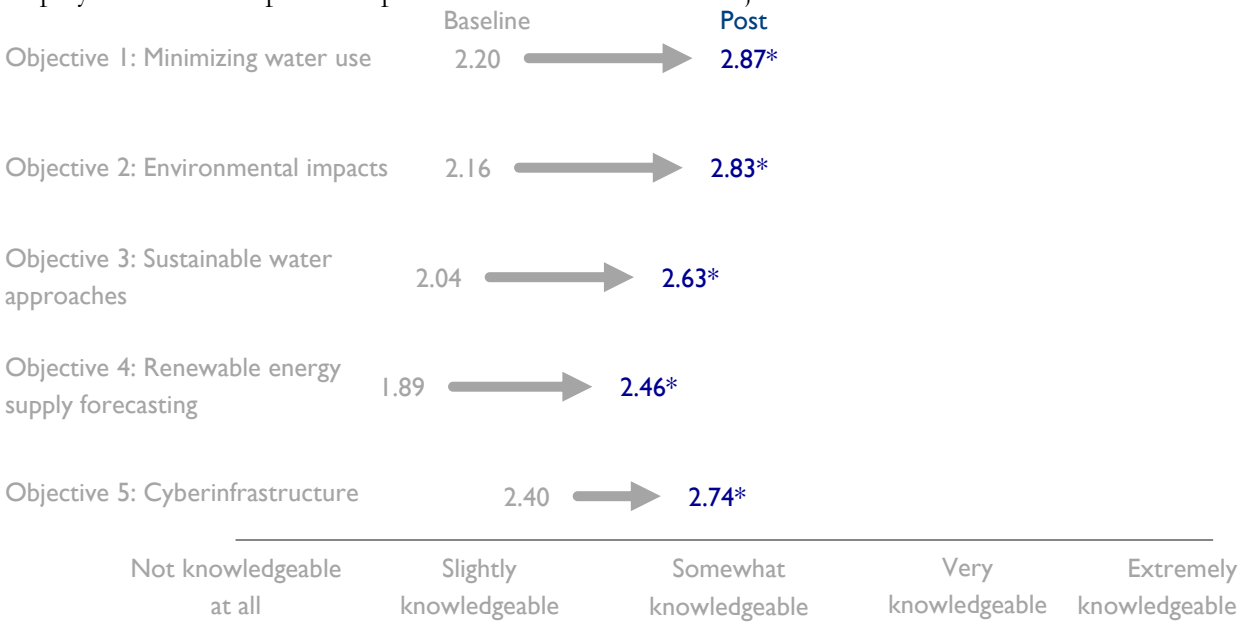


Figure 8. NEXUS goal 1 objectives

A closer look at the items within each objective area revealed that 46% (19 respondents) indicated that they were slightly knowledgeable or not at all knowledgeable about how membrane distillation of solar facility waters can be optimized (Objective 3). The low knowledge may be due to the water trailer being implemented later in the project, as it was a major component of this objective. Additionally, 21 respondents indicated that they were slightly knowledgeable or not at all

knowledgeable regarding advanced solar irradiance forecasting methods (Objective 4) and 21 respondents indicated that they were slightly knowledgeable or not at all knowledgeable regarding interaction patterns in the NEXUS that can be modeled as a complex network (Objective 5). This lack of knowledge may be due to timing of implementation or changes in the objectives over time.

Key trends in respondents' knowledge growth

The data were examined to determine if there were trends in the level of knowledge respondents reported and the year in which they joined the project. It was found that respondents who joined the NEXUS project in Year 1 were more knowledgeable of the five Goal 1 objectives by the end of the project than respondents who joined the project in later years. Generally, respondents who joined NEXUS earlier in the project had slightly higher knowledge growth than those who joined in Years 4 and 5, which is to be expected.

Subsequently, the data were also examined to determine if there were trends in the levels of knowledge by role. Results suggest that slightly more faculty/university academic researchers and graduate students were knowledgeable in these objective areas compared to those in other roles (e.g., professional staff, technicians, and governmental agency employees). This however could be due to the fact that the sample was mostly comprised of faculty/academic researchers or graduate students (68%), who were generally more involved in the research than those in other roles.

On the post-survey, respondents were also asked how the NEXUS project enabled them to learn about other fields outside their area of expertise. Twenty-two (39%) shared that attending workshops, annual meetings, and presentations enabled them to learn about other fields, and 17 (30%) stated collaborating/networking and interdisciplinary interactions helped them to do so. One respondent said, "By bringing me together with colleagues I would not have connected with if it were not for this project. Giving me the opportunity to meet with people outside my field around a topic of common interest." In addition, two respondents shared that they learned about fields outside of their own through research/lab experience. However, one respondent shared that the NEXUS project did not help him/her learn about fields outside his/her own area of expertise but did not specify why. Some interviewees noted that the project enabled them to learn about other fields, with one stating, "[NEXUS] gave me an opportunity to do research in an application area that I hadn't done work in in the past. This has great value because when you train new people in a topic, you get new ideas."

Impact on research fields

Post-survey respondents were asked how the results of their research laid a foundation for future solar energy and water research, as well as how their research contributed to knowledge in the scientific community. As the comments were similar for these two questions, they were presented together in Figure 9. The majority of respondents shared that the results of their research will and have contributed to non-EPSCoR funded research and that their results can be applied to the

field/community. While respondents did not specify further on how their research would contribute to future work, some of the fields and communities that results could be applied to include water utilities, solar facilities, and environmental scientists. Some interview participants noted that the research they were conducting focused on investigating gaps in the literature or applying existing research and theory to other areas of solar energy or environmental research. They also noted that some of their research was applicable to the solar energy industry, including water use in solar power plants, weather forecasting, and utility companies. Interviewees also relayed similar thoughts about connections with industries, with one interviewee noting, "We leveraged [industry partnerships] to other activities on commercializing research. This led to a series of conversations with industry people to better understand industry's problems and how our research could help solve those issues." Other interviewees shared that students were able to also make connections with all types of partners, suggesting that the foundation for future relationships was created during NEXUS.

Respondents further explained that the project gave them the resources and financial support needed to conduct their research, which led to publications and presentations, as well as development of helpful products (e.g., new technologies, model for training teachers in engineering design, and applications to use the sensor data in new ways). Some participants noted that the NEXUS project enabled them to further explore areas of their research that required advanced equipment or infrastructure and that this laid the foundation for future research related to NEXUS. Interviewees elaborated on how the project affected infrastructure, sharing that there was the development of solar towers, a water trailer for education outreach, and large data sets for weather forecasting. One interviewee noted that his/her team created "some structures" that were not there before the project that they can now utilize and build upon. Five post-survey respondents also mentioned the project aided with STEM outreach in schools.

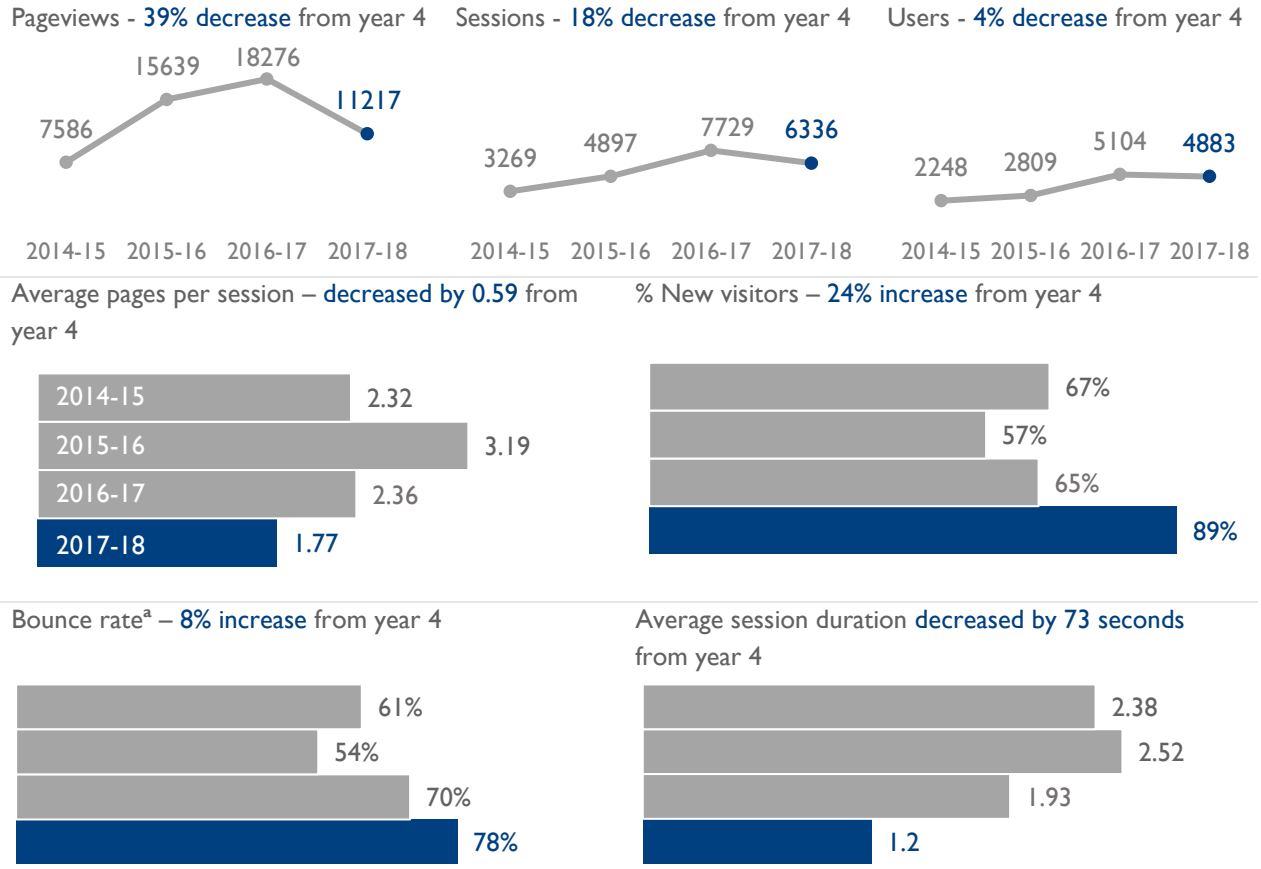
Result of research laid a foundation for future solar energy and water research (n=49)	
Helped with/contributed to future research (n=15)	Gained student and faculty interest in STEM (n=3)
Results could be applied to the field (n=7)	Increased knowledge of the research process (n=2)
Led to publications (n=4)	Developed of contacts/relationships (n=1)
Impact on current projects (n=4)	Continued conducting research (n=1)
Results of research contributed to knowledge in the scientific community (n=51)	
Results could be applied to the field/community (n=12)	Developed helpful resources (e.g. videos, models, and applications) (n=6)
Publications/presentations (n=9)	Outreach in schools led to increased knowledge in STEM topics and supported the STEM pipeline (n=5)
Helped with/contributed to future research (n=8)	Increased knowledge of nexus topics (n=2)

Figure 9. Results of research impact on future research and contributions to knowledge

Impact of shared data on research visibility and usage

The Nevada Resource Data Center (NRDC) was launched during Year 2 of the NEXUS project to serve as a hub for researchers to post their data for public access. The analytics information provided by NRDC staff allowed project leads and evaluators to determine whether data portal usage was increasing, which would indicate increased project visibility and data sharing between

researchers. Figure 10 displays the analytics from the NRDC. Portal usage data are available for Year 2 (May - December 2014[3]), Year 3 (January - December 2015), Year 4 (January - December 2016), and Year 5 (October 2017 – October 2018) and are shown below. It should be noted that data for January – September 2017 were not provided to the evaluators. For the following figures, data for Years 2-4 are colored in **grey** and data for Year 5 are colored in **blue**. From Year 2 to Year 5, use of the NRDC increased. However, pageviews, sessions, and number of users decreased from Year 4 to 5, with the greatest decrease in pageviews (39%). The number of users decreased 4%, from 5,104 in Year 4 to 4,883 in Year 5. This general decrease may be due to the NEXUS project wrapping up in Year 5, and project participants focusing on finishing their work and therefore not needing to download data as often as before. Another reason may be that some education data on the NRDC website were moved to the NSHE project website, which may have resulted in more viewers visiting that site instead. Data, especially due to the number of users and pageviews, suggest that the NRDC helped to increase the visibility of the NEXUS project over the four years.



a. Bounce rate is the percentage of single-page visits (or web sessions) where a person leaves the website from the landing page without browsing any further.

Figure 10. NRDC website analytics

3 It should be noted that while Year 2 pageviews, sessions, and users were provided for a seven-month period, the NRDC project staff were able to extrapolate the numbers to report the full year of information.

Increased research capacity

Cumulative submitted	Cumulative funded	Success rate
132 ($68,297,663)	53 ($58,470,712)	40%

Figure 11. Cumulative proposal, grant, and contract submissions

EPSCoR encourages grant participants to submit proposals, grants, and contracts to help bring additional support to the state. To date, 53 of 132 proposals, grants, and contracts submitted by project participants have been funded for a success rate of 40%, which is consistent with Year 4 (40% success rate) and Year 3 (45% success rate). Almost all submissions were to support research projects, though some were related to education and workforce development. The large number of grant submissions shows that the NEXUS project members were committed to obtaining funding to supplement or sustain their research or outreach activities. The 40% success rate demonstrates that many research projects or outreach activities will be sustained beyond the project. Appendix B displays submissions by year and by goal area. No patents were awarded, pending, or licensed by the end of the project.

Nexus has provided technical writing assistance to project members since Year 1. Project members need to apply to NEXUS to receive this assistance, which aimed to improve the quality of grant proposals and publications by NEXUS participants. Eighty percent of the requests for technical assistance met the requirements and received assistance. Additionally, 25% of proposals/publications that received technical assistance were funded/accepted (Figure 12).

Project Year	Number technical assistance requests	Technical assistance received	Number proposals/publications funded/accepted	Percent proposals/publications receiving technical assistance funded/accepted[a]
Year 1	3	2	1	50%
Year 2[b]	6	6	3	50%
Year 3	2	2	0	0%
Year 4	3	1	1	33%
Year 5[c]	6	5	0	NA
Project total	20	16	5	25%[d]

a. Percentage was calculated based on known funding outcomes of proposals or status of publications, therefore pending proposals or publications submitted/under review were not included in the percentage.
b. The status of one Year 2 proposal was unknown as project leads could not get in contact with the individual.
c. Three proposals have not been yet submitted and one is under review.
d. Percentage of proposals/publications funded/accepted may increase once the status of pending items is known.

Figure 12. Technical assistance requests, approvals, and proposals funded

Quality of research

To assess the quality of research in the NEXUS project, scholarly publications, presentations, and other academic work were tracked and, where applicable, assessed for impact on the field. Figure 13 shows the combined total for professional presentations, posters, and invited talks by goal and year. By the end of the project, 149 posters, presentations, or talks were given by project participants. Year 4 was the high point for these activities, during which members from three of the four project goals participated in dissemination of work. The decrease in presentations and talks during Year 5

could be attributed to project participants focusing more on completing their research objectives and meeting the goals set for their research components. Project participants may have also submitted to give presentations or talks on project research they were concluding at the time of this report, but perhaps had not yet completed these talks. The project participants were engaged in a large number of presentations and talks over the five years, thus generating scientific visibility for Nevada, NEXUS, and the project researchers, including graduate and undergraduate students.

Goal	Year 1	Year 2	Year 3	Year 4	Year 5	Cumulative total
Research	4	15	34	68	21	142
Diversity	0	0	0	0	0	0
Education/Workforce Development	0	0	0	3	2	5
External Engagement	0	0	0	2	0	2
Overall	4	15	34	73	23	149

Figure 13. Presentations, posters, and talks by project participants

Figure 14 shows the number of peer-reviewed publications[4] (journal articles, books/book chapters, and conference proceedings) produced during the five years of the project. By the end of the project, at the time of this report, 144 publications were produced by project members in the research component, with the highest number being produced in Years 4 and 5.

	Year 1	Year 2	Year 3	Year 4	Year 5	Cumulative total
Publications	2	10	32	53	47	144

Figure 14. Publications by project year

Publication impact was assessed using two bibliometrics[5]: Eigenfactor (standard [EF] and normalized [EFn]) and Impact Factor, as well as the number of NEXUS articles published in each journal. For all bibliometrics used, there is no set range of values, rather each factor is computed within themselves and allows for comparisons between journals. **Eigenfactor** measures the importance a journal has in the scientific community and includes the number of articles published in a journal and its citations compared to all scientific articles published. **Normalized Eigenfactor (EFn)** is the same measure as Eigenfactor, except all scientific journals are standardized, so that the average journal has a score of 1. Journals with EFn>1.0 are more influential than the average journal. **Impact Factor** measures how frequently the average article published by a journal is cited. Both bibliometrics utilized the most up-to-date information available at the time of this report, and therefore may not reflect the status of the journals at the time in which the articles were published.

Figure 15 displays the journals where the 74 NEXUS articles have been published by project members and the respective bibliometrics for those journals (only published submissions were included in the table). The journal name for one article was not provided; therefore, it was not included in the table. Not all journals provided information on both Eigenfactors and Impact

4 While it was not confirmed if all conference proceedings were peer-reviewed, likely all products in Figure 14 were peer-reviewed.

5 H-index was used in previous evaluation reports. However, it was not included in this summative report as the evaluators were unable to access this information.

Factors, therefore the information below varies by journal. Cases where bibliometric information was not available were noted as "N/A." Of the 28 journals below with available Eigenfactors, 15 had above average Normalized Eigenfactors (EFn = 1.0). The two most impactful journals based on both bibliometrics were *IEEE Communications Surveys and Tutorials*, which had an Impact Factor of 20.23, and *Scientific Reports*, which had a Normalized Eigenfactor of 23.8. The average Normalized Eigenfactor for all listed journals was 2.9 and the average Impact Factor was 3.965. Based on the bibliometrics and number of publications, project participants successfully increased the visibility of their research and NEXUS among the scientific community.

Journal	# articles	Years published	EF	EFn	Impact factor
ACS Sustainable Chemistry and Engineering[a]	2	Y4	0.009	1.0	6.140
Advances in Image and Video Processing	2	Y2, 3	N/A	N/A	N/A
Applied Geology of California	1	Y4	N/A	N/A	N/A
Chemical Engineering Journal	1	Y5	0.091	10.3	6.735
Chemosphere	1	Y5	0.065	7.4	4.427
Computer Networks	1	Y3	0.013	1.5	2.522
Electric Power Systems Research[a]	4	Y4	0.010	1.2	2.856
European Polymer Journal	1	Y5	0.016	1.8	3.741
Frontiers in Ecology and the Environment	1	Y5	0.019	2.1	8.302
IEEE Communications Surveys and Tutorials	1	Y3	0.020	2.3	20.230
IEEE Conference on Computational Intelligence and Games	1	Y4	N/A	N/A	N/A
IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing	1	Y3	0.011	1.2	2.777
IEEE Transaction on Power Systems	3	Y2, 3	0.036	4.1	5.255
IEEE Transactions on Computational and Artificial Intelligence in Games[a]	2	Y4	0.001	0.1	.0897
IEEE Transactions on Power Delivery	1	Y3	0.021	2.4	3.350
IEEE-ACM Transactions on Networking	2	Y4	0.015	1.7	3.110
Intelligent Automation and Soft Computing[ab]	3	Y4	<0.001	<0.1	0.652
International Conference on Ubiquitous and Future Networks[c]	1	Y2	N/A	N/A	N/A
International Journal of Advanced Computer Science and Applications	1	Y3	N/A	N/A	N/A
International Journal of Advanced Robotic Systems[b]	1	Y2	0.002	0.3	0.952
International Journal of Communications, Network and System Sciences	3	Y1, 3	N/A	N/A	N/A
International Journal of Computer and Electrical Engineering[b]	1	Y2	N/A	N/A	N/A
International Journal of Computer Applications	3	Y2, 3, 4	N/A	N/A	N/A
International Journal of Computer Science & Information Technology	1	Y5	N/A	N/A	N/A
International Journal of Computer Theory and Engineering	1	Y3	N/A	N/A	N/A
International Journal of Computers and Their Applications	2	Y4	N/A	N/A	N/A
International Journal of Electrical Power & Energy Systems[b]	1	Y4	N/A	N/A	3.610
International Journal of Electronics and Telecommunications	1	Y2	N/A	N/A	N/A
International Journal of Environmental and Science Education	1	Y3	N/A	N/A	N/A
International Journal of Services Computing	1	Y3	N/A	N/A	N/A

Journal	# articles	Years published	EF	EFn	Impact factor
International Journal of Software Innovation	1	Y3	N/A	N/A	N/A
IEEE International System-on-Chip Conference	1	Y2	N/A	N/A	N/A
Journal of Advanced Optics & Photonics	1	Y5	N/A	N/A	N/A
Journal of Applied Remote Sensing	1	Y5	0.003	0.3	0.976
Journal of Bioinformatics and Computational Biology	1	Y4	0.002	0.2	0.991
Journal of Combinatorial Mathematics and Combinatorial Computing	1	Y3	N/A	N/A	N/A
Journal of Computational Methods in Sciences and Engineering	1	Y4	N/A	N/A	N/A
Journal of Geophysical Research: Atmospheres	1	Y5	0.320	N/A	N/A
Journal of Network and Computer Applications	1	Y3	0.008	0.9	3.991
Journal of Photochemistry and Photobiology A-Chemistry	1	Y5	0.010	1.2	2.891
Journal of Software Networking[a]	3	Y4	N/A	N/A	N/A
Journal of Systems and Software	1	Y3	0.008	1.0	2.278
Journal of Wind Engineering and Industrial Aerodynamics	1	Y5	0.006	0.7	2.689
Mountain Research and Development[a]	2	Y4	0.001	0.1	1.216
Pervasive and Mobile Computing[ab]	2	Y3	0.003	0.4	2.974
Renewable and Sustainable Energy Reviews[a]	3	Y4, 5	0.075	8.5	9.814
Scientific Reports	1	Y5	0.209	23.8	4.122
Solar Energy	3	Y5	0.023	2.6	4.374
Vadose Zone Journal	1	Y5	0.008	0.9	2.710
Wireless Communications & Mobile Computing	1	Y5	0.003	0.4	0.869
Average across journals			0.036	2.9	3.965

a. Publication was incorrectly logged as conference proceeding in previous years. The article is an academic publication in a journal and is counted as such in this report for the purpose of the external evaluation.
b. Article appeared twice, sometimes for different project years, in the list provided to the evaluators. In this table, articles were only counted in the project year they were first reported. Therefore, the total number of articles by year may not match previous evaluation reports.
c. It is uncertain whether submissions for this conference are peer-reviewed. Evaluators reached out to the journal publishers and did not get a response. Since the conference proceeding was reported as a peer-reviewed publication by project members, the evaluators have included it in this section.

Figure 15. Academic journals in which project members have published

Project leads implemented two interventions during the NEXUS project to assist project members with producing high impact publications. The first intervention was implemented during the first year and consisted of seed grants and technical writing services. The second intervention was implemented during the final two years and consisted of publication pledges, seed grants, impact awards, publication writing assistance, and sandbox writing sessions. To assess the efficacy of these interventions, the impact of publications (Impact factor and Eigenfactor) between the years before intervention two (Years 1-3) and after intervention two (Years 4-5) was assessed. Only journals with bibliometrics available were included in this comparison. The number of journals that project members published in, increased from nine to 20 after intervention two. The average impact of the journals as measured through standard (0.014 to 0.031) and normalized (1.6 to 3.6) Eigenfactors more than doubled. The average Impact factor, however, decreased after intervention two. This

could be attributed to the change in the Impact factor of the journals over time or due to the broader range of journals published in. It is important to note that many factors may have influenced the increase in articles published and no causal inferences should be made.

Project years	Number of journals published	EF[a]	EFn[a]	Impact factor
Year 1, 2, 3	9	0.014	1.6	4.925
Years 4, 5	20[a]	0.031	3.6	3.516

a. While total number of journals published in Years 4 and 5 with available bibliometrics equaled 21, only 20 had an Impact factor or Eigenfactor respectively.

Figure 16. Comparison of publications Years 1-3 and Years 4-5

NEXUS project members were also featured 49 times in 28 conference proceedings, with 40 of the proceedings being published in the final two years of the NEXUS project.

Conference Proceeding	# articles	Years published
ASME International Mechanical Engineering Congress Exposition	1	Y5
Complex Networks	1	Y5
Complex Networks and Their Applications	1	Y5
Conference on Computer Communications Workshops	1	Y4
ICT Systems Security and Privacy Protection	1	Y3
IEEE Annual Computing and Communication Workshop and Conference	4	Y4, 5
IEEE Congress on Evolutionary Computation	3	Y5
IEEE Global Communications Conference	1	Y5
IEEE International Conference on Industrial Informatics	1	Y3
IEEE International Conference on Information, Intelligence, Systems & Applications	1	Y4
IEEE Power & Energy Society General Meeting	1	Y3
IEEE-ACM International Conference on Advances in Social Network Analysis and Mining	4	Y4, 5
International Conference on Computer and Information Science	1	Y3
International Conference on Computer Applications in Industry and Engineering	1	Y4
International Conference on Computer Systems, Electronics and Control	2	Y5
International Conference on Computers and their Applications	2	Y3, 5
International Conference on Control Systems and Computer Science	1	Y5
International Conference on High Performance Computing Simulations	1	Y4
International Conference on IT Convergence and Security	4	Y4
International Conference on Optimization of Electrical and Electronic Equipment	2	Y5
International Conference on Software Engineering and Data Engineering	4	Y4, 5
International Conference on Systems Engineering	2	Y5
International Joint Conference on Neural Networks	1	Y3
International Workshop on Heat Transfer Advances for Energy Conservation and Pollution Control	1	Y3
International Workshop on Measurement and Networking	1	Y5
Internet Technologies and Applications	2	Y5
Workshop on Feedback Computing	1	Y5
World Environmental and Water Resources Congress	3	Y3, 4, 5

Figure 17. Conference proceedings in which project members have published

In addition to the information above, during Year 4, one NEXUS member published a book and another published a book chapter. Both members were associated with the cyberinfrastructure component of the project. Ten theses or dissertations were written during the five years of the project, with four each being written during Years 3 and 4. Additionally, a conference abstract was submitted during Year 5 by project members, but no further details regarding its status were provided.

Over the five years, the NEXUS project has successfully educated researchers and students on solar energy, water, and the environment, improved the research infrastructure in the state through building partnerships, purchasing equipment and developing products, and disseminated the research widely through high impact publications, presentations, and other outreach avenues. Overall, the breadth and reach of NEXUS publications increased, thus creating more knowledge and impact of NEXUS research. These successes demonstrate that the project has achieved the agenda set for this research goal area.

Goal areas 2 & 3: Diversity & Workforce development/education

The Diversity and Workforce Development/Education goals of the NEXUS project aimed to create a pipeline of diverse students both trained in STEM and interested in pursuing STEM education and/or careers. These goals were supported through project activities that reached diverse students throughout the state of Nevada and the funding for those activities.

Achievement of diversity & workforce development/education objectives

All benchmarks and milestones related to developing a comprehensive approach that leads to an increase in the number of underrepresented students graduating from STEM programs were met or on track to be completed by the end of the project no-cost extension. See Appendix A for the full list of benchmarks and milestones that comprise each objective.

Goal 2 & 3 objectives	Number of benchmarks met	Status
Goal 2		
Objective 1: Increase participation of a diverse pool of NSHE students and faculty in the NEXUS Research project.	4 of 4 met	Met
Objective 2: Increase knowledge of a more diverse group regarding STEM fields and research.	3 of 3 met	Met
Objective 3. Support the advancement of a diverse pool of STEM graduates	1 of 1 met	Met
Goal 3		
Objective 1: Increase K-12 students' awareness of STEM opportunities and careers.	3 of 3 met	Met
Objective 2: Increase the number of graduate students who complete Ph.Ds. and pursue a career in a STEM field.	1 of 1 met	Met
Objective 3: Promote careers in science through providing authentic undergraduate research experiences for undergraduates.	1 of 1 met	Met
Objective 4: Increase K-12 STEM teachers' curricular knowledge and use of effective pedagogical strategies.	3 of 4 met	On track
Objective 5: Increase public understanding of on-line learning opportunities for students, teachers, and the general public.	1 of 2 met	On track
Objective 6: Enhance educational and workforce opportunities to sustain and leverage established programs through increasing the number of students who pursue STEM careers by increasing their pre-employment skills.	2 of 2 met	Met

Figure 18. Goal 2 & 3 benchmarks and milestones

Increased number of URMs graduating with STEM degrees

Almost all Nevada System of Higher Education institutions provided institutional data on STEM degree attainment among URM populations in fields related to NEXUS research. This information was utilized to assess the changes in URM attainment of post-secondary degrees in fields related to

NEXUS research. Figure 19 below displays the percentage of URMs awarded degrees in fields related to NEXUS research in the year prior to the NEXUS project (2011-12 academic year) and in the final project year (2017-18 academic year), while Figure 20 displays the same information but for only Hispanic or Latino students. Appendix C displays detailed demographic data for each degree field. UNLV could only provide data on fields with five or more degrees awarded; therefore, some data could not be included (noted by "Less than 5" in the table) or percentages calculated (noted by "N/A" in the table). While the evaluators requested institutional data from UNR, their data were not included as 2017-18 information was not yet available. Overall, the number of URMs awarded post-secondary degrees in fields related to NEXUS research increased across all NSHE institutions. The percentage of URMs awarded these degrees doubled in most institutions. The extent to which the NEXUS project affected this change cannot be directly assessed, however, NEXUS very likely played a role in the increases.

URM degrees awarded	2011-12		2017-18	
	#	%	#	%
Total NSHE institutions[a]	15	20%	58	35%
College of Southern Nevada	14	22%	41	34%
Computing and Information Technology	10	19%	39	35%
Economics	1	33%	0	0%
Physical Sciences-Engineering	1	33%	0	0%
Physical Sciences-Environmental Science	1	33%	1	33%
Physical Sciences-Geology	1	100%	1	50%
Physical Sciences-Geography	0	0%	0	0%
Water/Wastewater Treatment Program	0	0%	0	0%
Great Basin College	0	0%	1	25%
Natural Resources	0	0%	1	25%
Nevada State College	0	0%	1	100%
Environmental and Resource Science	0	0%	1	100%
Truckee Meadows Community College	1	17%	13	38%
Computer Information Technology - Computer Programming	0	0%	5	50%
Computer Science	1	33%	5	45%
Energy Technologies - Solar Energy and Wind Energy	0	0%	1	50%
Engineering	0	0%	2	29%
Environmental Science	0	0%	0	0%
University of Nevada Las Vegas[b]	54	N/A[c]	76	N/A
Earth and Environmental Science	Less than 5[c]	N/A	8	50%
Civil & Environmental Engineering	20	44%	12	26%
Computer Science and Engineering	19	40%	35	32%
Economics	15	26%	21	33%
Geology and Geoscience	Less than 5	N/A	Less than 5	N/A
Water Resources Management	0	0%	0	0
Western Nevada College	0	0%	2	33%

URM degrees awarded	2011-12		2017-18	
	#	%	#	%
Computer Information Technology	0	0%	2	33%

a. Total NSHE numbers and percentages do not include UNLV, as complete data were not provided for some areas.
b. Overall totals and percentages could not be calculated for UNLV, as some cells had less than five individuals and the institutional research office did not share these data as these individuals could be identified. N/A indicates the percentage could not be calculated as the total number of graduates was not known.
c. UNLV could only provide data on fields with five or more degrees awarded; therefore, some data could not be included (noted by "Less than 5" in the table) or percentages calculated (noted by "N/A" in the table).

Figure 19. Degrees awarded to URM students for select fields in 2011-12 and 2017-18

As NEXUS activities focused on URM participants and the Hispanic/Latino population is the largest minority group in Nevada,[6] the evaluators examined degrees awarded for this group. Overall, Hispanic or Latino students awarded post-secondary fields related to NEXUS research (Bachelors, Masters, and Doctoral) increased in the identified fields across all but one of the NSHE institutions. This was especially true for CSN, TMCC, and UNLV. Almost all institutions increased their number of Hispanic or Latino students awarded degrees two-fold. The extent to which the NEXUS project affected this change cannot be directly assessed, however, NEXUS very likely played a role in the increases. Appendix C displays detailed demographics data for each degree field.

Hispanic/Latino degrees awarded	2011-12		2017-18	
	#	%	#	%
Total NSHE institutions[a]	9	12%	32	19%
College of Southern Nevada	9	14%	19	16%
Computing and Information Technology	7	13%	17	15%
Economics	1	33%	0	0%
Physical Sciences-Engineering	0	0%	0	0%
Physical Sciences-Environmental Science	0	0%	1	33%
Physical Sciences-Geology	1	100%	1	50%
Physical Sciences-Geography	0	0%	0	0%
Water/Wastewater Treatment Program	0	0%	0	0%
Great Basin College	0	0%	0	0%
Natural Resources	0	0%	0	0%
Nevada State College	0	0%	1	100%
Environmental and Resource Science	0	0%	1	100%
Truckee Meadows Community College	0	0%	11	32%
Computer Information Technology - Computer Programming	0	0%	3	30%
Computer Science	0	0%	5	46%
Energy Technologies - Solar Energy and Wind Energy	0	0%	1	50%
Engineering	0	0%	2	29%
Environmental Science	0	0%	0	0%
University of Nevada Las Vegas[b]	16	N/A[c]	47	N/A
Earth and Environmental Science	0	0%	5	31%

6 According to the US Census Bureau and the NV State Report Card, 29% of the state's population and 42% of Nevada K12 students are Hispanic/Latino.

Hispanic/Latino degrees awarded	2011-12		2017-18	
	#	%	#	%
Civil & Environmental Engineering	10	22%	5	11%
Computer Science and Engineering	Less than 5 [c]	N/A	22	20%
Economics	6	11%	15	24%
Geology and Geoscience	Less than 5	N/A	Less than 5	N/A
Water Resources Management	0	0%	0	0%
Western Nevada College	0	0%	1	17%
Computer Information Technology	0	0%	1	17%

a. Total NSHE numbers and percentages do not include UNLV, as complete data were not provided for some areas.
b. Overall totals and percentages could not be calculated for UNLV, as some cells had less than five individuals and the institutional research office did not share these data as these individuals could be identified. N/A indicates the percentage could not be calculated as the total number of graduates was not known.
c. UNLV could only provide data on fields with five or more degrees awarded; therefore, some data could not be included (noted by "Less than 5" in the table) or percentages calculated (noted by "N/A" in the table).

Figure 20. Degrees awarded to Hispanic/Latino students for select fields in 2011-12 and 2017-18

Increased K-12 interest in STEM

Throughout the five years of the NEXUS project, five activities were conducted among K-12 populations to increase interest in STEM topics: Stem Career Investigation Program (SCIP), solar kit demonstrations in classrooms and outreach activities, STEM Bilingual Online Peer Sessions (STEMBOPS), Student Interactions with STEM (SISTEM), and Summer Research Experience (REX). All five activities assessed interest in STEM topics. However, for the first three years, the only activity assessment that included questions on interest in STEM topics was SCIP in Northern Nevada. While some activities (STEMBOPS, REX, solar kits, SISTEM) were implemented earlier in the project, assessments either were not implemented or did not include questions on interest in STEM topics until Years 4 and 5. The solar kits, which were originally designed by a graduate student in the project, were implemented as a project activity to different schools throughout the state. While the evaluators only assessed increased interest in STEM from participation in some of the solar kit demonstrations, the total impact was much greater. An interviewee estimated that over 4,500 students in the state had been reached through classroom demonstrations and other events in the community. The interviewee also noted that this would not have been possible without funding from NEXUS.

Across all activity evaluations, survey respondents reported increased levels of interest in STEM education, careers, or in STEM, generally. Respondents tended to be high school students, though there were some elementary and community college students involved in the activities. A large proportion of respondents were from diverse backgrounds (URM- 27% to 62%; female- 52% to 82%). All respondents had high ratings for their interest in STEM and related measures both before and after participating in activities. Although direct comparisons could not be made to other activities, respondents from Summer REX had large gains in their interest in STEM. This was likely due to the length of the Summer REX program, which was 10-weeks and because it provided respondents with hands-on experience in research. Interviewees, also noted the impacts of the

workforce development and education opportunities, especially those of solar kits and SCIP/SISTEM, highlighting that they influenced students to participate in undergraduate research, pursue graduate education, and increased their general interest in STEM. Overall, NEXUS outreach activities seemed to successfully improve student interest in STEM.

Increased interest in STEM education

Throughout the five years of the NEXUS project, eight activities were conducted among high school, community college, and undergraduate students to increase their interest in STEM education. These eight activities included student mentoring, BrightStars at TMCC, TMCC STEM Society, UROP, UROP application writing workshops, SCIP, SISTEM, and Summer REX. Surveys asked questions that helped to gauge students' interest in STEM education, such as motivation to follow through on the next steps to fulfill their STEM career decisions and their commitment to continue studies and/or professional development activities in STEM.

Across all activities, survey respondents reported increased motivation and commitment to continue pursuing STEM education and careers. There was a wide range of respondents from diverse backgrounds (URM- 10% to 63%; female- 29% to 82%). While direct comparisons could not be made to other activities, respondents who participated in BrightStars had large gains in their commitment to pursue STEM education or professional development. This could potentially be due to respondents in other activities having higher levels of commitment at the beginning of their participation in the activities compared to BrightStars respondents who had lower levels of commitment. Only Summer REX respondents answered questions regarding their likelihood to enroll in STEM graduate programs (Ph.D., M.A., and M.D./Ph.D.) Overall, Summer REX students had an increased likelihood of enrolling in Masters or Doctoral programs in STEM after participating in the program. Although increased interest in pursuing STEM undergraduate or graduate degrees was not directly measured, NEXUS activities, such as UROP, successfully increased respondents' motivation to follow through on the next steps to fulfill their STEM career decisions and their commitment to continue studies and/or professional development activities in STEM, which could indicate an increased interest to pursue higher education and careers in STEM.

Through both project participation and activities like UROP and Summer REX, high school, community college, and undergraduate students were able to participate in research opportunities. Most interviewees noted that the students they worked with developed their research, academic writing, presentation, organization, and soft skills. One interviewee stated that he/she was able to improve his/her students' interest in STEM by mentoring them and providing them with opportunities to discuss their research and how they should approach it as well as provided feedback on their research papers and manuscripts for publication. Having this kind of mentorship likely helped to increase students' interest in STEM education. Additionally, these professional skills gained likely has helped and will help in supporting the future careers of the students.

Enhanced job opportunities and career preparedness

Opportunities for students

NEXUS exposed students to different types of STEM careers and research so that they could gain a better understanding of their future career or education possibilities and develop the necessary skills for those future plans. Post-survey student respondents were asked about the impact the project had on their education and career plans. Three (15%) of the 20 graduate student respondents stated that they planned to continue pursuing research, with one stating he/she planned to research renewable energy and another sharing that he/she wanted to research wastewater management. Another two (10%) shared that the NEXUS project introduced them to an interdisciplinary/group work environment, with one stating that the project made him/her excited to be part of an interdisciplinary team. Lastly, two (10%) plan to pursue careers in academia and another two (10%) changed their research area of interest after participating in the NEXUS project.

In addition, seven (35%) respondents indicated that participating in the NEXUS project helped or encouraged them to pursue and finish graduate school. In fact, one stated he/she was not planning on pursuing a Ph.D., but that NEXUS provided the opportunity to do so. Another respondent said that "NEXUS has been a positive influence on obtaining my terminal degree by providing both much appreciated financial support and the ability to work closely with great mentors and colleagues." Moreover, three (15%) respondents changed their research or career interest to align more with the project goals once they became involved with the NEXUS project. One (5%) respondent stated his/her education plans did not change because he/she had graduated.

Although the survey items did not directly measure students' attainment of STEM careers, they did yield information on whether respondents were engaging in skill development in areas related to

their education or career plans. The students also engaged in career development through continuing their education. For future rounds of funding, project leads could consider ways to continue to support students in the next steps to attaining their careers, such as supporting them with research or mentorship opportunities.

Eighteen of 20 post-survey graduate respondents shared which aspects of the NEXUS project were most impactful on their future plans. Four (20%) shared it was the multi/interdisciplinary scientific approach of the NEXUS project that was the most impactful. In fact, one respondent said, "NEXUS has provided a solid and successful example of research and discipline integration that I will take with me and will implement in my career. I believe this positive integration of multiple expertise provides sustainable results." Additionally, three (15%) respondents stated the most impactful part of NEXUS was the research projects, with one respondent sharing that the research projects made him/her want to pursue research as a career. Furthermore, one (5%) respondent shared that the annual meetings were the most impactful as they allowed for peers to make connections, while another stated the solar kits were the most impactful as they could see the work being conducted by the undergraduates and found it inspirational.

Opportunities for K-12 teachers

K-12 teacher trainings were also implemented by the education and workforce development team. These teacher trainings were conducted through two main activities: NERDS and the solar kits. NERDS teachers were trained in the Nevada state science education standards through hands-on field experiences in using NEXUS related research. Teachers then developed lesson plans utilizing both the NEXUS related research and knowledge of the science education standards. Teachers also built their own solar kits and designed lesson plans around them, with the intention of continuing to provide students hands-on exposure to STEM topics related to NEXUS research and increase students' interest in STEM. Some outreach activities involved working with teachers to develop solar kits to use in their classrooms, as well as lessons to go with these demonstrations. These lessons and kits will likely continue to be utilized by teachers beyond the grant period thus demonstrating this aspect of the project will be sustained and can continue to make an impact.

Career growth for faculty

Leadership, activity leads, and seed grant recipients explained in interviews the ways in which participating in NEXUS influenced their career skills and professional development. Most frequently, they noted growth in their abilities to work on large and diverse teams, manage large projects, and write proposals/grants. One noted that he/she had managed smaller grants before, but nothing to this extent and that it was enlightening to learn how a large project operates and what it takes to keep things running smoothly. Another noted that he/she learned that having multidisciplinary teams was beneficial not only for the larger project, but for individual's own research, as having other perspectives and expertise allowed for one to understand his/her research in different ways. These project members also noted that they had made new contacts with others both within and outside the project and that these contacts opened up new opportunities for them to collaborate, including with researchers in China and large solar energy companies.

Increased K-12 exposure to STEM through outreach to diverse students

Figures 21 and 22 display the number of teachers, faculty, and students reached through education and workforce development activities. The number of K-12 teacher and student participants, MSI faculty and students, and students from PUIs involved in education/workforce development activities increased notably from Year 4 to Year 5. In Year 5, a majority (61%) of K-12 participants were URM and approximately half of K-12 institutions (51%) and half of higher education (IHE) (55%) were female. Increases in K-12 participants and participants from HSI/PUIs were likely due to the project leads' concerted efforts to target outreach to these schools in the later years of the project.

Role	Project year				
	Year 1	Year 2	Year 3	Year 4	Year 5
Teachers (K-12)	3	22	14	21	261
URM	100%	0	57%	33%	43%
Female	100%	18%	93%	90%	62%
Students reached directly (K-12)	46	83	23	1651	4749
URM	37%	25%	65%	86%	81%
Female	72%	27%	57%	49%	54%
Students reached via teacher training (K-12)	N/A[a]	1800	1481	2654	7609
URM	N/A[a]	13%	30%	52%	50%
Female	N/A[a]	33%	0%	48%	48%
Other	1649[b]	0	0	0	0
URM	79%	0%	0%	0%	0%
Female	53%	0%	0%	0%	0%
K-12 total participants	1698	1905	1518	4326	12619
URM	78%	13%	31%	65%	61%
Female	54%	33%	2%	49%	51%

a. N/A signifies that no activities were conducted.

b. For Year 1, "Other" includes 1,587-Nevada GEAR-UP Undergraduate students and Ambassadors and 62-stakeholders.

Figure 21. K-12 teachers & students in diversity and education/workforce development activities

Role	Project year				
	Year 1	Year 2	Year 3	Year 4	Year 5
Faculty from academic research institutions	30	92	18	28	21
URM	7%	21%	17%	39%	14%
Female	27%	39%	33%	50%	48%
Students from academic research institutions	19	152	246	118	119
URM	32%	26%	24%	35%	31%
Female	47%	45%	45%	51%	51%
Faculty from PUIs	35	26	36	25	7
URM	11%	12%	8%	48%	29%
Female	46%	46%	64%	60%	71%
Students from PUIs	99	38	170	83	110
URM	45%	32%	25%	39%	89%
Female	60%	53%	56%	60%	65%
Faculty from MSIs	3	38	30	15	29
URM	0%	24%	17%	20%	24%
Female	33%	37%	60%	67%	55%
Students from MSIs	4	49	160	28	64
URM	0%	49%	45%	57%	31%
Female	50%	45%	60%	54%	47%
Other	1649[a]	0	173	13	0
URM	79%	0%	12%	62%	0%
Female	53%	0%	16%	54%	0%
IHE faculty and students total	1888	395	833	310	350
URM	73%	27%	25%	40%	48%
Female	53%	44%	45%	55%	55%

a. For Year 1, "Other" includes 1587-Nevada GEAR UP Undergraduate students and Ambassadors and 62-Stakeholder Meetings.

Figure 22. IHE faculty & students in diversity and education/workforce development activities

Overall, the project was successful in reaching students that were representative of students in the state, especially URM and female populations. In comparing state data obtained from Nevada Report Card to project data of K-12 students reached directly in Years 4-5, the years the project consistently reached a large number of females and URM populations, it was found that the project reached a higher percentage of URM (81-86% compared to 56% statewide) and female (49-54% compared to 48% statewide) students than URM and female students overall in the state. The following chart presents percentages of female and URM participants reached in project Year 5 compared to the percent of K-12 female and URM students in the state in 2017-18.

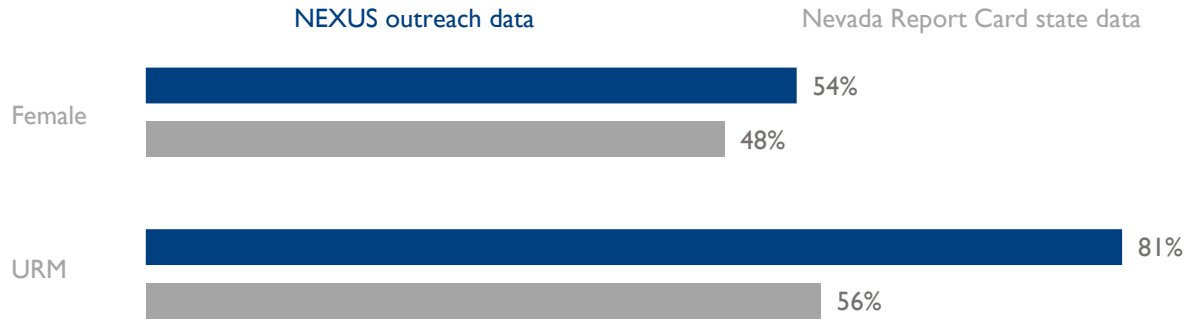


Figure 23. Nevada K-12 student demographics compared to NEXUS student participants in 2017-18

By the end of the NEXUS grant, the project had partially met the diversity and education/workforce development goals through educating and conducting outreach with a group of students whose makeup was more diverse than K-12 students in the state, and increasing K-12 exposure to STEM topics, interest in STEM topics, and interest in STEM education and careers. Directly impacting the number of URM students graduating in solar energy related fields and enhancing job opportunities in STEM in Nevada were difficult to achieve and measure, especially through one five-year project. There may be lasting impacts beyond the project in both of these areas that cannot be captured at this time.

Goal area 4: External Engagement

The External Engagement goal of the NEXUS project intended to create partnerships with external entities in order to strengthen research supporting the economic development of Nevada and sustain that work beyond the grant period. This goal was supported through funding for outreach activities, including conference attendance and meetings with stakeholders. Leads also engaged in meetings with potential partners and then connected them to the NEXUS researchers that best fit their needs and expertise.

Achievement in external engagement objectives

All benchmarks and milestones related to enabling Nevada scientists to collaborate and develop relationships with industry, institutions, and the public to strengthen research supporting economic development of Nevada were met or on track to be completed by the end of the project no-cost extension. See Appendix A for the full list of benchmarks and milestones that comprise each objective.

Goal 4 objectives	Number of benchmarks met	Status
Objective 1: Develop and sustain key stakeholder collaborations and partnerships.	1 of 4 met	On track
Objective 2: Increase public knowledge of project activities and benefits through media development and dissemination	9 of 9 met	Met

Figure 24. Goal 4 benchmarks and milestones

Development and impact of new partnerships

The intention of external engagement was to create partnerships between NEXUS researchers and participants with external entities (i.e. businesses, other universities, government, etc.) to strengthen the research supporting the economic development of Nevada and to create a sustainable system for project research and infrastructure. Evaluators assessed the efforts and impacts of this component of the project and found that 18 NEXUS participants were engaged in external engagement efforts that led to targeted outcomes with 76 external partners in 2017.

To assess the outcomes of these partnerships, evaluators and project leads designed a four-part continuum to better understand partnership development and the impact of the resulting partnerships. Partnerships could fall into any one of four stages and could move from one stage to another in different project years. Figure 25 below displays the four-stages of the continuum and the outcomes that could occur in each of those stages. Most connections did not progress beyond awareness of the NEXUS project (151) or initial contact (41). However, the project was successful in fostering partnerships with 21 partners who created products and achieved long-term outcomes (Making Impact stage in continuum), most of which were achieved during the final years of the project. Some of the partnerships that did not develop past the first stage of the continuum may have been due to limited capacity and resources among the external engagement team or due to misalignment between the external partners' goals and the project's goals.

Figure 25. External engagement continuum with outcomes

The 21 partnerships that reached the long-term (Making Impact stage in continuum) stage, resulted in several products including 10 research projects, five proposals, one of which was submitted, and two publications. These long-term partnerships have resulted in outcomes and products that reflect strengthened research capacity and suggest some partnerships may continue beyond the grant period.

Eight (20%) of the 40 post-survey respondents who answered this indicated that the NEXUS partnerships contributed to their research by facilitating collaborations/networking, and seven (18%) stated that the partnerships enabled them to expand their research in addition to contributing to it. For instance, one respondent stated, "In addition to providing critical infrastructure for completing the research, industry partnerships have enabled understanding of what questions are most relevant and which answers are most needed. This enabled prioritization of work and, more importantly, provided an understanding of how results of the work ought to be presented." The table below demonstrates how the different partnerships contributed to NEXUS research.

How the NEXUS partnerships contributed to the research (n=40)	
Facilitated collaborations/networking (n=8)	Funding opportunities (n=3)
Expanded/contributed to research (n=7)	They have not (n=4)
Publications, presentations, proposals (n=3)	Do not know/ NA (n=15)

Figure 26. Contributions of partnerships to research

Interviewees noted that working with external partners, especially industry partners like SEMPRA, First Solar, and Valley Electric, allowed them to have access to data that was valuable to their research. However, the interviewees did not elaborate further on this topic. Many of the successful

partnerships have resulted in joint proposals, international exchanges of students and researchers, or further networking opportunities for project researchers to connect to other industries and partners. Many partnerships progressed over time and interviewees involved in external engagement hope and plan for them to continue beyond the grant funding period.

Forty post-survey respondents who answered this question shared which NEXUS partnerships have been the most impactful. Three (8%) respondents stated partnerships regarding water research/water treatment plants have been most impactful, with one respondent sharing he/she has been collaborating with a researcher at UNLV on hydrologic research and that they have published many papers together. Furthermore, two (5%) respondents indicated partnerships with alternative energy companies have been most impactful, while another two said partnerships with SEMPRA have been most impactful. For instance, one noted, "Partnerships with SEMPRA energy was most impactful because it enabled for collection of unique data that would have been impossible otherwise." Another respondent shared federal partnerships were the most impactful because they resulted in new grants. Seven (18%) respondents shared that they were not sure or not knowledgeable about which NEXUS partnerships have been most impactful. Five of these individuals were graduate students, so they may not have had as much knowledge of these partnerships.

On the other hand, one respondent stated he/she had unsuccessful attempts to work with external stakeholders, while another stated he/she did not interact with external stakeholders. Some interviewees mentioned something similar, stating that extra efforts could have been made towards building partnerships with specific groups of external partners, including solar energy and energy companies, other academic institutions, local K-12 schools, and the general public. Interviewees suggested that it would have been helpful to have a dedicated outreach staff in charge of both making connections and following-up with those connections. Faculty or graduate students who more focused on the research activities were those who were unaware of the external engagement efforts or less involved in these efforts.

Creation of intellectual property

No project participants developed intellectual property during the project. Figure 27 displays the reasons why respondents did not pursue intellectual property. Seven (19%) of 36 faculty/academic researcher and graduate student post-survey respondents shared that their research was not yet to that point. Three (8%) indicated that they were not aware of the campus office or other support available that could help create intellectual property. Another 10 respondents (28%) stated that

Went to campus office to receive help in creating intellectual property or business (n=36)	
Did not create intellectual property (n=13)	Project has high-level security management (n=1)
Research not yet to that point (n=7)	Not applicable (n=12)
Not aware of office/opportunity (n=3)	

Figure 27. Respondents reasons for pursuing or not pursuing IP opportunities

creating intellectual property was not applicable to their work, with half sharing intellectual property was not part of their research/program, and the remaining five not explaining further.

By the end of the NEXUS grant, the project had partially met the external engagement goal through developing and strengthening the collaborations between project researches and industries, universities, and governments. The extent to which the project was successful in impacting Nevada's economic development was undeterminable as the impact on this may take more time to achieve and was beyond the scope of the project.

Project challenges

Some interviewees felt that their research and outreach initiatives were not as supported, either financially or with personnel, as they would have liked. They added that this lack of support limited the impact their work could have had on the larger project. Some also noted that they would have liked more assistance in developing their projects and help making the project multidisciplinary. One interviewee suggested that the program could hire a researcher who specializes in multidisciplinary team development to help guide the researchers to create multidisciplinary teams. Additional interviewees noted that they would have liked clearer communication between leads and other project members as they sometimes did not have a full picture of what was happening in the project which would have enabled them to better plan their research agenda or outreach activities.

Overall experience

Eleven (28%) post-survey respondents stated that the most important outcome of the NEXUS project was networking/collaborations and the partnerships that were formed. Nine (17%) respondents shared that the most important outcome was the increase in knowledge/understanding of NEXUS related topics, with some respondents stating that they learned more about energy, water, and the environment, and one shared that he/she learned about preparing and carrying out a proposal. STEM/student outreach was the most important outcome for four (7%) respondents. In fact, one respondent said, "The most important outcome was creating connections with UNLV faculty and graduate students. The use of the kits in class has led to several students participating in the SISTEM program and hopefully have started some students down the road to a STEM career." Interviewees shared many of the same thoughts about project outcomes, which were synthesized and presented in the five main themes shown below:

- NEXUS succeeded in developing both research and a workforce – for example, one interviewee was impressed with how NEXUS addressed a number of issues from manpower development to environmental concerns.
- NEXUS increased awareness of regional environmental issues and context – four interviewees noted that there was an increase of solar energy-water-environment nexus knowledge and how it works in Nevada among students, industry, and businesses.

Interviewees specifically mentioned they gained knowledge growth in building solar facilities to minimize water usage and the impact on the natural environment.

- NEXUS offered helpful resources for participants to conduct their research – two interviewees noted that NEXUS funding enabled them to complete their research as young faculty and doctoral students, and that without the funding they would not have had as much to work with during their time in the project.
- NEXUS improved communication among stakeholders – two interviewees noted that NEXUS allowed them to successfully connect with external partners and that through these partnerships they were able to start influencing how these entities operate, such as by offering guidance for new projects.
- NEXUS developed connections among researchers around the state – three interviewees noted that the project enabled them to meet others within the state that they did not know were working on similar topics, and to strengthen bonds to create new research.

Key findings & recommendations

Overall, the NEXUS project participants successfully made meaningful impacts on research, education, workforce development, and external engagement. NEXUS successfully impacted the research infrastructure in Nevada through investment in both physical and human infrastructure. The following paragraphs highlight the major successes of each of the four project goals.

To achieve the research goal, project participants created strong and lasting bonds with other project members across the various disciplines to further NEXUS as a statewide multidisciplinary research project and to lay the foundation for future research. Project participants also published 144 research publications (journal articles, books/book chapters, and conference proceedings) and were featured in more than 50 conference proceedings, indicating that the project reached audiences outside of NEXUS.

Although there was limited information regarding career and future education plans of NEXUS participants, NEXUS has contributed to building the future STEM workforce. This was accomplished through a number of activities that engaged a large and diverse student population throughout the state. For example, during Year 5, project participants directly engaged 4749 K-12 students of whom 81% identified as URM and 54% as female. K-12 students had increased interest in STEM topics, especially those who engaged with the solar kits, which enabled them to engage directly with how solar energy and water work within the topic of energy generation. Other activities were focused on encouraging students to pursue undergraduate or graduate studies in STEM. These activities were most successful when they allowed students to engage in the research process directly, like Summer REX.

The project partially achieved the external engagement goal through helping participants develop and strengthen collaborations with external partners within Nevada, the US, and internationally, including partners in China and Brazil. In total, 76 external partners were engaged by project participants, and those partnerships in the most advanced stages produced research projects, proposals, and publications. The strong partnerships that were built will help ensure that aspects of the project are sustainable beyond the grant period, especially the research and some outreach activities, and will provide opportunities for students to connect and form relationships with industry. Many of the partners are leaders in solar energy or utility companies, like SEMPRA, First Solar, and Valley Electric, which indicates that the NEXUS project attracted large and influential companies likely due to the quality of the research being conducted. Some of these relationships will continue beyond the grant, helping to sustain the important work started by NEXUS.

As the NEXUS project wraps up its no cost extension period, leads should consider the following recommendations for both continuing NEXUS initiatives once funding ends and for future EPSCoR projects or other large grants.

To help strengthen project implementation

- Consider hiring an individual solely dedicated to developing partnerships with stakeholders and leading external engagement efforts. This person could have a background in public relations and/or industry relationship development. Interviewees shared that it would be helpful to have someone hired specifically for this role, instead of the individual splitting their time between these external engagement and research. This individual could work with researchers and communications staff to develop the outreach materials, train researchers on how to most effectively network and build partnerships, and disseminate project research in a clear and meaningful way.
- Recruit an individual who specializes in multidisciplinary research and team science to guide the development of the research objectives starting in the proposal stage to help researchers from different disciplines form teams and integrate their research. This individual could help to alleviate some of the confusion among researchers and students who many not understand how their work fits into the larger project and enable the research to extend further than the bounds of the individual fields.

To ensure impact can be isolated and carefully examined

- Continue to track the successes of the external engagement efforts. Project leads should utilize the continuum developed between the external engagement team and evaluators to track the successes and impacts of these efforts to NSF. Current evaluators will provide a database of external engagement partners so future EPSCoR projects can build upon partnerships already developed and to help further the impact of those partnerships. By continuing to track partnerships on the continuum and building on this effort, project leads can set goals around partnerships and understand the status and impact of them as they develop.
- Implement a follow-up survey in the final years of future projects to assess whether students pursued further STEM education or STEM careers to ensure that outreach and education activities are effectively providing students with valuable information about education and career opportunities and the necessary tools and skills to pursue these opportunities. Because NEXUS was only a five-year project, it was difficult to determine the full impact on the educational trajectories of students.
- Define the expectations regarding the knowledge or skills that the general public should learn from project information/activities. This will help leads to create and target activities appropriately, which could result in greater impact. Informal conversations between evaluators and project leads/participants yielded that they would have liked to have more interaction with the public regarding project research.
- Set professional development objectives for project researchers and faculty to encourage professional growth and development among these participants. This could be accomplished through encouraging the identification of skills individuals would like to develop and setting targets for knowledge gains among participants. Overall, participants had slight knowledge

gains of project research, which could be due to respondents learning less about areas outside of their own research. However, project participants did note that the project increased their project management, communication, and teamwork skills, which were not intended outcomes. By setting these goals upfront, project activities, mentorship, and support can be targeted accordingly so individuals are gaining the intended knowledge and skills.

To enhance the impact of the project on participants

- Support students in forming more connections with external partners to enable them to have more access to career opportunities and understand the skills needed to pursue these opportunities. Although participants noted that they were aware of some job opportunities, some noted that these opportunities were limited by the industries in the state. More connections to external partners within and outside of the state could help increase students' awareness of and preparedness for future jobs. Future projects should consider encouraging research and faculty mentors to talk with their students about career plans and assist them with making connections and networking.
- Dedicate more resources (e.g. additional funds and graduate assistants) for diversity and education/workforce development participants to attend conferences and produce papers to create a wider impact. Although this was not a priority or focus for this round of EPSCoR, the NEXUS project produced seven publications were produced in the education/workforce development and external engagement goals. By dedicating more resources to dissemination in future rounds, best practices that are developed and impact of activities can be shared widely. Publishing this literature could help bolster the STEM education pipeline and further economic development of the state.
- Maintain and utilize a logic model or theory of change for future projects to ensure that activities have clear intended outcomes and are engaging students along the education/workforce development pipeline to achieve those outcomes. Having the evaluator and the project leads use the logic model during project meetings will help more clearly establish which participants should experience which outcomes and how best to track and follow-up with specific participants.

Appendix A: Benchmarks and Milestones

The benchmark and milestones included in this report were based on information included in the Year 5 report submitted by project leads to NSF. All objectives still in progress at the time of this report will be met by the end of the no-cost extension.

Status Key

Green: Met; Yellow: In progress; Red: Not met

Objectives and benchmarks	Status
Goal 1: Advance new knowledge and discoveries regarding the nexus among solar energy development, limited water resources, and fragile environments.	
1. Minimize cooling and cleaning water use through improvements to the power plant	
2. Hire new faculty member in high temperature materials	
3. Understand dust deposition and removal from panels and mirrors	
4. Use nanotechnology to mitigate dust accumulation	
5. Detect and remove particle deposition on panels and mirrors	
6. CI: Expand the connectivity network to collect science nexus data for the GIS Vis Lab, NRDC	
Objective 2: Understand environmental impacts of solar energy projects.	
1. Enhance habitat quality of desert tortoise impacted by solar energy facilities	
2. Understand microclimate change on desert plant communities	
3. Understand impact of solar arrays on the water balance of arid soils	
4. Understand soil crust degradation and mitigation	
5. Remote sensing investigation for pre - syn - and post-installation of solar energy plants	
6. Reduce environmental footprint	
7. Hire new faculty member in Restoration Ecology	
8. CI: Expand the connectivity network to collect environmental data in the NRDC	
Objective 3: Develop sustainable and advanced water/wastewater approaches to support water needs for solar energy development.	
1. Understand energy intensity, carbon footprint for transport/treatment of water/wastewater	
2. Membrane Distillation of solar facility waters	
3. Hire new faculty in a project-related discipline where expertise at DRI is currently lacking	
4. Research groundwater for renewable energy	
5. CI: Establish CI Connectivity	
Objective 4: Improve reliability, economic modeling, and sunlight forecasting for renewable/solar energy supply.	
1. Understand energy generation in landholdings	
2. Forecast solar irradiance	
3. Preform economic analysis of solar / renewable energy projects	
4. Hire new faculty in Economics of Energy Projects	
5. CI: Expand connectivity to incorporate solar data within the NRDC for sunlight forecasting	
Objective 5: Develop new and use existing cyberinfrastructure capabilities to accelerate the nexus research.	
5.1 Data Processing and analysis	
5.1a: Research and develop advanced data services	

5.1b: Research data mining for predictive model construction in interdisciplinary NEXUS studies	
5.1c: Create real-time data streaming and visualization	
5.2 Software engineering and human-computer interactions	
5.2a: Create interactive software tools that facilitate scientific research and education	
5.2b: Systems/software engineering and HCI process model	
5.3 Communication Networks	
5.3a: Enhance network connectivity to facilitate remote research efforts	
5.3b: Research cloud computing in support of large scale, interdisciplinary NEXUS research	
5.3c: Study congestion and traffic control to improve network performance	
5.3d: Communication protocol vulnerabilities of control systems, enhance cybersecurity/privacy	
5.3e: Complex network analysis of energy-environment-water interactions	
5.4 Database architecture and data management	
5.4a: Enhance data processing infrastructure, including QA/QC processes	
5.4b: Extend data curation activities and facilities	
5.4c: Apply cognitive methods to enhance access to energy-environment-water databases	
5.5 Increase CI Faculty and Personnel capacity in needed areas	
5.5a CI: Hire CI Assistant Professor and technical personnel	
Goal 2: Develop a comprehensive approach that leads to an increase in the number of underrepresented students graduating from STEM programs.	
Objective 1: Increase participation of a diverse pool of NSHE students and faculty in the NEXUS Research project.	
1. Engage faculty and students from primarily undergraduate (PUIs), minority serving institutions (MSIs)	
2. Provide undergraduate research opportunities for under-represented students	
3. Recruit students into undergraduate research	
4. Develop Hands on Training (HOT) in solar energy for first generation and underrepresented students	
Objective 2: Increase knowledge of a more diverse group regarding STEM fields and research.	
1. Increase access to the Nevada STEM Pipeline website for workforce development and external engagement	
2. Develop Nevada STEM Mentor Network website for workforce development and external engagement	
3. Develop and host New Faculty Training Workshop	
Objective 3. Support the advancement of a diverse pool of STEM graduates	
1. Increase graduate student solar research opportunities for underrepresented minorities and females	
Goal 3: Develop a sustainable STEM workforce by creating a pipeline of STEM-trained students, educators, and workers while increasing public understanding of solar energy, water, and the environment.	
Objective 1: Increase K-12 students' awareness of STEM opportunities and careers.	
1. Engage first-generation students in NEXUS via participation in established programs	
2. Increase the number of high school students who choose careers in STEM disciplines	
3. Provide educational opportunities to K-12 students so they are prepared to enter postsecondary STEM fields of study	
Objective 2: Increase the number of graduate students who complete Ph.Ds. and pursue a career in a STEM field.	
1. Engage graduate students in a proposal writing workshop focusing on NSF	

Objective 3: Promote careers in science through providing authentic undergraduate research experiences for undergraduates.	
1. Enhance institutional commitments to support research opportunities for undergraduates	
Objective 4: Increase K-12 STEM teachers' curricular knowledge and use of effective pedagogical strategies.	
1. Increase the number of teachers prepared to effectively engage students in STEM-related science (NERDS)	
2. Develop online resource for lesson plans developed by participating teachers, aligned with current science standards, vetted by education professionals, available for all teachers in NV	
3. Guide teams of teachers and scientists in developing curriculum and curricular materials (Solar and Water Kit and lecture development)	
4. Provide online professional development to K-12 teachers on Solar energy-water environment science and provide interactions with scientists	
Objective 5: Increase public understanding of on-line learning opportunities for students, teachers, and the general public.	
1. Deliver online learning opportunities for students, teachers, and the general public "STEMBOPS"	
2. Disseminate on-line resources with emphasis on geographically remote regions of Nevada	
Objective 6: Enhance educational and workforce opportunities to sustain and leverage established programs through increasing the number of students who pursue STEM careers by increasing their pre-employment skills.	
1. Identify industries and agencies that want to partner with NEXUS by offering internships	
2. Engage undergraduate and graduate students with industry agency partners through internships focusing on the solar energy-water-environment nexus and cyberinfrastructure.	
Goal 4: Enable Nevada scientists to collaborate and develop relationships with industry, institutions, and the public to strengthen research supporting economic development of Nevada.	
Objective 1: Develop and sustain key stakeholder collaborations and partnerships.	
1. Identify key stakeholders	
2. Develop conduits for communication between the NEXUS project and stakeholders	
3. Identify opportunities for collaboration and funding	
4. Disseminate research from the NEXUS project to stakeholders	
Objective 2: Increase public knowledge of project activities and benefits through media development and dissemination	
1. Create roadmap for launching marketing efforts (Communication Plan)	
2. Create and optimize NEXUS web site	
3. Create messaging for NEXUS project	
4. Develop traditional media relations	
5. Utilize social media	
6. Communicate project information to NSHE VPRs, NVEAC, and Chancellor's office	
7. Integrate the NEXUS project into the Nevada community	
8. Produce NEXUS informational and educational videos	
9. Support stakeholder engagement activities	

Appendix B: Proposals submitted and funding proposed by year & goal area

Goal area	Year 1	Year 2	Year 3	Year 4	Year 5
Research	12 ($7,613,630[a])	14 ($11,816,368)	20 ($6,539,500)	35 ($19,919,306)	31($12,038,713)
Education/ Workforce Development	0 ($0)	0 ($0)	0 ($0)	0[b] ($0)	3 ($1,923,531)
External Engagement	0 ($0)	0 ($0)	0 ($0)	0 ($0)	1 ($250,000)

a. Amount was incorrectly listed in previous evaluation reports and has been updated here.

b. One proposal submitted in Year 4 between the cyberinfrastructure and education/workforce development goals.

Appendix C: Degree attainment at NSHE institutions for select fields

College of Southern Nevada

Academic year 2011-12

Field	Race/Ethnicity of students graduating with degree														
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
Computing and Information Technology	52	6	12%	0	0%	3	6%	7	13%	0	0%	32	62%	4	8%
Economics	3	0	0%	0	0%	0	0%	1	33%	0	0%	2	67%	0	0%
Physical Sciences-Engineering	3	0	0%	0	0%	1	33%	0	0%	0	0%	1	33$	1	33$
Physical Sciences-Environmental Science	3	0	0%	0	0%	1	33%	0	0%	0	0%	1	33%	1	33%
Physical Sciences-Geology	1	0	0%	0	0%	0	0%	1	100%	0	0%	0	0%	0	0%
Physical Sciences-Geography	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Water/Wastewater Treatment Program	1	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	1	100%

Academic year 2017-18

Field	Students graduating with degree														
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
Computing and Information Technology	110	16	15%	2	2%	16	15%	17	15%	4	4%	39	35%	16	15%
Economics	4	1	25%	0	0%	0	0%	0	0%	0	0%	2	50%	1	25%
Physical Sciences-Engineering	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Physical Sciences-Environmental Science	3	0	0%	0	0%	0	0%	1	33%	0	0%	2	67%	0	0%
Physical Sciences-Geology	2	0	0%	0	0%	0	0%	1	50%	0	0%	1	50%	0	0%

Physical Sciences-Geography	1	0	0%	0	0%	0	0%	0	0%	0	0%	1	100%	0	0%
Water/Wastewater Treatment Program	1	0	0%	0	0%	0	0%	0	0%	0	0%	1	100%	0	0%

Great Basin College

Academic year 2011-12

Field	Race/Ethnicity of students graduating with degree														
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
Natural Resources	7	0	0%	0	0%	0	0%	0	0%	0	0%	6	86%	1	14%

Academic year 2017-18

Field	Race/Ethnicity of students graduating with degree														
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
Natural Resources	4	0	0%	1	25%	0	0%	0	0%	0	0%	3	75%	0	0%

Nevada State College

Academic year 2011-12

Field	Race/Ethnicity of students graduating with degree														
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
Environmental and Resource Science	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%

Academic year 2017-18

Field	Race/Ethnicity of students graduating with degree													
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
Environmental and Resource Science	1	0	0%	0	0%	0	0%	1	100%	0	0%	0	0%	0	0%

Truckee Meadows Community College

Academic year 2011-12

Field	Race/Ethnicity of students graduating with degree													
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
Computer Information Technology - Computer Programming	1	0	0%	0	0%	0	0%	0	0%	0	0%	1	100%	0	0%
Computer Science	3	0	0%	0	0%	1	33%	0	0%	0	0%	2	67%	0	0%
Energy Technologies - Solar Energy and Wind Energy	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Engineering	1	0	0%	0	0%	0	0%	0	0%	0	0%	1	100%	0	0%
Environmental Science	1	0	0%	0	0%	0	0%	0	0%	0	0%	1	100%	0	0%

Academic year 2017-18

Field	Race/Ethnicity of students graduating with degree													
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
Computer Information Technology - Computer Programming	10	0	0%	1	10%	1	10%	3	30%	0	0%	4	40%	1	10%
Computer Science	11	0	0%	0	0%	0	0%	5	46%	0	0%	5	46%	1	9%
Energy Technologies - Solar Energy and Wind Energy	2	0	0%	0	0%	0	0%	1	50%	0	0%	1	50%	0	0%

Engineering	7	0	0%	0	0%	0	0%	2	29%	0	0%	4	57%	1	14%
Environmental Science	4	0	0%	0	0%	0	0%	0	0%	0	0%	4	100%	0	0%

University of Nevada Las Vegas

Academic year 2011-12

Field	Race/Ethnicity of students graduating with degree									
	Hispanic or Latino		Not Hispanic or Latino		URM		Not URM		Other	
	#	%	#	%	#	%	#	%	#	%
Earth and Environmental Science	0	0%	10	100%	Less than 5	N/A	8	80%	0	0%
Civil & Environmental Engineering	10	22%	36	78%	20	44%	24	52%	Less than 5	N/A
Computer Science and Engineering	Less than 5	N/A	44	92%	19	40%	28	58%	Less than 5	N/A
Economics	6	11%	51	90%	15	26%	37	65%	5	9%
Geology and Geoscience	Less than 5	N/A	17	85%	Less than 5	N/A	15	75%	Less than 5	N/A
Water Resources Management	0	0%	Less than 5	N/A	0	0%	Less than 5	N/A	0	0%

Academic year 2017-18

Field	Race/Ethnicity of students graduating with degree									
	Hispanic or Latino		Not Hispanic or Latino		URM		Not URM		Other	
	#	%	#	%	#	%	#	%	#	%
Earth and Environmental Science	5	31%	11	69%	8	50%	8	50%	0	0%
Civil & Environmental Engineering	5	11%	42	89%	12	26%	35	75%	0	0%
Computer Science and Engineering	22	20%	88	80%	35	32%	73	66%	Less than 5	N/A
Economics	15	24%	48	76%	21	33%	42	67%	0	0%
Geology and Geoscience	Less than 5	N/A	18	95%	Less than 5	N/A	17	90%	0	0%
Water Resources Management	0	0%	Less than 5	N/A	0	0	Less than 5	N/A	0	0%

University of Nevada Reno

Academic year 2011-12

Field	Race/Ethnicity of students graduating with degree													
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other: non-resident alien or multiracial	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
Atmospheric Science	8	2	25%	0	0%	0	0%	2	25%	0	0%	3	38%	1	13%

Civil & Environmental Engineering	96	5	5%	0	0%	0	0%	11	11%	0	0%	61	64%	19	20%
Computer Science & Engineering degree	56	5	9%	0	0%	1	2%	3	5%	0	0%	25	45%	22	39%
Ecology, Evolution & Conservation Biology	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Economics	74	5	7%	1	1%	0	0%	6	8%	0	0%	55	74%	7	9%
Environmental Science	9	0	0%	0	0%	0	0%	0	0%	0	0%	9	100%	0	0%
Geography	16	0	0%	0	0%	0	0%	0	0%	0	0%	15	94%	1	6%
Geology	16	0	0%	0	0%	0	0%	0	0%	0	0%	15	94%	1	6%
Natural Resources & Environmental Science	7	0	0%	0	0%	0	0%	0	0%	0	0%	6	86%	1	14%

Academic year 2015-16

Field	Race/Ethnicity of students graduating with degree														
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other: non-resident alien or multiracial	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
Atmospheric Science	12	0	0%	0	0%	0	0%	2	17%	0	0%	7	58%	3	25%
Civil & Environmental Engineering	106	4	4%	0	0%	4	4%	12	11%	0	0%	57	54%	29	27%
Computer Science & Engineering degree	71	12	30%	0	0%	1	1%	8	11%	0	0%	46	65%	4	6%
Ecology, Evolution & Conservation Biology	4	0	0%	0	0%	0	0%	0	0%	0	0%	3	75%	1	25%
Economics	105	10	10%	2	2%	1	1%	19	18%	0	0%	65	62%	8	8%
Environmental Science	22	0	0%	1	5%	0	0%	1	5%	0	0%	17	77%	3	14%
Geography	27	1	4%	1	4%	0	0%	2	7%	0	0%	23	85%	0	0%
Geology	28	0	0%	0	0%	0	0%	4	14%	0	0%	21	75%	3	11%
Natural Resources & Environmental Science	3	0	0%	0	0%	0	0%	0	0%	0	0%	2	67%	1	33%

Western Nevada College

Academic year 2011-12

Field	Race/Ethnicity of students graduating with degree													
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
A.A.S. Technology - Computer Information Technology	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%

Academic year 2017-18

Field	Students graduating with degree													
	Total graduates	Asian		American Indian or Alaskan Native		Black or African American		Hispanic or Latino		Native Hawaiian or Pacific Islander		White or Caucasian		Other	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%
A.A.S. Technology - Computer Information Technology	6	0	0%	1	17%	0	0%	1	17%	0	0%	4	67%	0	0%