

Engaging a Diverse Workforce in the Building Sciences Through the JUMP Into STEM Program: Impact Study

*Dr. Kerry Rippy, National Renewable Energy Laboratory
Westly Joseph, National Renewable Energy Laboratory
Emre Ustuner, National Renewable Energy Laboratory
Selam Haile, National Renewable Energy Laboratory
Jacob Votava, National Renewable Energy Laboratory
Dr. Kim Trenbath, National Renewable Energy Laboratory*

Abstract

Ensuring inclusivity in building science professions requires engaging people from underrepresented demographics; unfortunately, many races, ethnicities, and genders continue to be underrepresented. The JUMP into STEM program works to rectify this, encouraging creative ideation and highlighting the unique perspectives of a diverse array of students. The top students are awarded internships that provide opportunities to work in building science research with close supervision from mentors in the field. In the research presented here, *we investigate the impact of participation in JUMP into STEM on students' careers, including the impact on students from diverse backgrounds. Furthermore, we research students' awareness of career opportunities in building science, students' perception of their ability to meaningfully contribute to this field, and the career building opportunities that JUMP into STEM provides for students.* Through participant interviews and data analysis, we measure program diversity, inclusion, and effectiveness at achieving goals. We find that among the hundreds of students who have participated in this program, more than 25 different majors and/or educational degree programs are represented and more than 45% of students attend minority serving institutions or historically black colleges and universities. The JUMP into STEM experience had a significant effect on career choices or career development for more than 80% of participants. Our results also indicate that the JUMP into STEM program is effective at promoting diversity in the building sciences and is successfully contributing to the larger effort within the building science industry to promote and ensure equity in technological progress and innovation.

Introduction

It is essential that buildings evolve to be more efficient and to meet the needs of the communities that use them. The built environment is responsible for a significant portion of greenhouse gas emissions. Historically, buildings accounted for 32% of global final energy consumption and 19% of energy-related carbon dioxide emissions (Lucon et al. 2014). Therefore, reducing the built environment's carbon emissions is crucial to achieving a carbon-neutral society. A building science workforce with a broad and diverse array of perspectives and skill sets is also necessary. This workforce must be capable of representing different stakeholder perspectives, which is why the student competition detailed in this paper tackles equity and inclusion in the building sciences by encouraging underrepresented groups to consider careers in building science. It does so by encouraging currently underrepresented students from a variety of majors to solve building science problems and address future industry needs.

This is a critical objective. To truly understand and adequately address the challenges they face, the building science workforce must be as diverse as the communities that will occupy the buildings they build and renovate. This diversity must include both background and discipline. A diverse building science workforce will enable the industry to understand the needs of disadvantaged and underserved communities and contribute to the development of feasible and affordable climate change solutions. Representation of different races, ethnicities, and genders within the building science workforce will also encourage uptake of the solutions they bring to the table in their communities (EPA 2021).

Currently, many groups are underrepresented in the science, technology, engineering, and math (STEM) workforce. The Pew Research Center found that Black and Hispanic people are underrepresented in the STEM workforce, while women are underrepresented in math, physical science, computing, and engineering (Fry, Kennedy, and Funk 2021). This is problematic, as many of the underrepresented groups are disproportionately impacted by the effects of climate change and other challenges related to energy and infrastructure. For example, people who are socially vulnerable are impacted more than others by climate change because they are less likely to have the resources to cope with and recover from extreme weather. Socially vulnerable groups include those who are low income and individuals identifying as Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, and/or Hispanic or Latino (Fry, Kennedy, and Funk 2021).

The JUMP into STEM program seeks to address the issue of underrepresentation in the STEM workforce by giving students from underrepresented groups opportunities to engage in and learn about the building science workforce. Previous research has indicated that encouraging a more diverse workforce benefits diverse communities, leading to a more equitable energy system. The experiences of people from different races and backgrounds provide valuable perspectives for identifying solutions that address climate change. There is a need to educate students from these diverse backgrounds in STEM to fill the diversity gap. In addition, talented students from diverse backgrounds need to be encouraged to pursue STEM fields that address climate change to ensure that their communities' needs are considered as solutions are developed (EPA 2021).

The U.S. Department of Energy (DOE) Building Technologies Office sponsors JUMP into STEM. It is a college and university student competition intended to inspire students from diverse backgrounds to use creative ideation to solve real-world building science problems (Hubbard et al. 2020). The acronym "JUMP" stands for **J**oin the discussion, **U**neil innovation, **M**ake connections, and **P**romote tech-to-market. JUMP into STEM has been widely embraced by students, as is well summarized by a statement from a participant in the 2018–2019 cohort: ***"I still reflect on it as one of the best things I've done. It was an amazing experience."***

JUMP into STEM is jointly managed by the National Renewable Energy Laboratory (NREL) in Golden, Colorado, DOE's Building Technologies Office, and Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. In the 2021–2022 competition year, the Pacific Northwest National Laboratory (PNNL) was involved as well.

JUMP into STEM is a student competition that focuses on workforce development at the collegiate level. The biggest technical climate change challenges need an educated workforce to address them. In addition, JUMP into STEM focuses on students' diversity, defined as including many different academic majors as well as a range of students with backgrounds currently underrepresented in STEM.

The competition has several stages, illustrated in Figure 1. To begin, participants form teams to submit responses to building-related challenges. Next, after scoring, selected teams are invited to a final competition.¹ Finally, students from winning teams are offered internships at NREL, ORNL, and PNNL. The program encourages participation from students with an interdisciplinary mix of majors and a diverse array of backgrounds. Aspects of diversity are considered in the scoring of team responses.

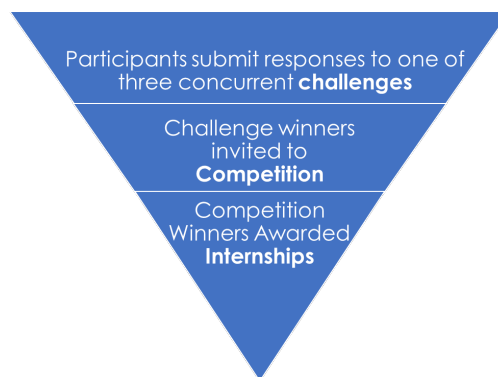


Figure 1. JUMP into STEM competition format.

Broadly, JUMP into STEM is meeting this goal. To date, **475 students have participated in JUMP into STEM**. Figure 2 shows the number of students by program year. These students represented **more than 25 different majors and/or educational degree programs**. Participants in JUMP into STEM also represent a diverse array of geographic backgrounds. Figure 3 illustrates that the geographic diversity of competition participants has increased over the years.

In addition to the diversity of disciplines and geographic distribution represented by participants, students from a variety of racial backgrounds are encouraged to participate. Although detailed demographic data are not available for all JUMP into STEM participants, **45% of JUMP into STEM participants attended minority serving institutions (MSIs) and/or historically black colleges and universities (HBCUs)**.

However, JUMP into STEM's overarching goal is to increase the number of students pursuing a career in the building sciences. In this paper, we are interested in the impact of JUMP into STEM on participants' careers. It is important to identify the impact of JUMP into STEM to demonstrate its support for workforce development and change in the industry, especially with regard to equitable climate solutions. This paper focuses on the impact of JUMP into STEM on advancing student careers in the building sciences, while documenting how JUMP into STEM reaches students from diverse backgrounds. As such, the guiding questions for this qualitative research are:

- Is JUMP into STEM successfully engaging a diversity of participants?
- What underrepresented groups are included among JUMP into STEM participants?
- How does the JUMP into STEM competition contribute to participants' educational and career trajectories?

¹ Challenge winners must fill out an internship application to be eligible for the competition.

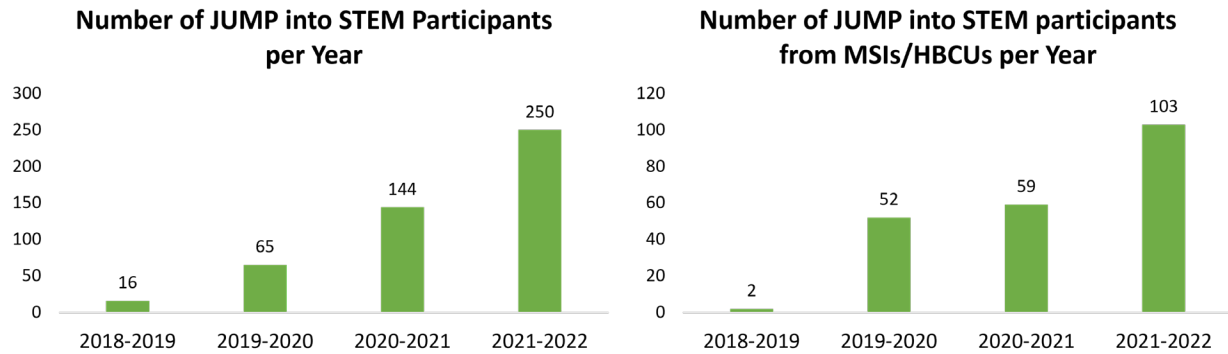


Figure 2. Total number of participants by year and total number of participants from minority serving institutions (MSIs) and/or historically black colleges and universities (HBCUs) by year.

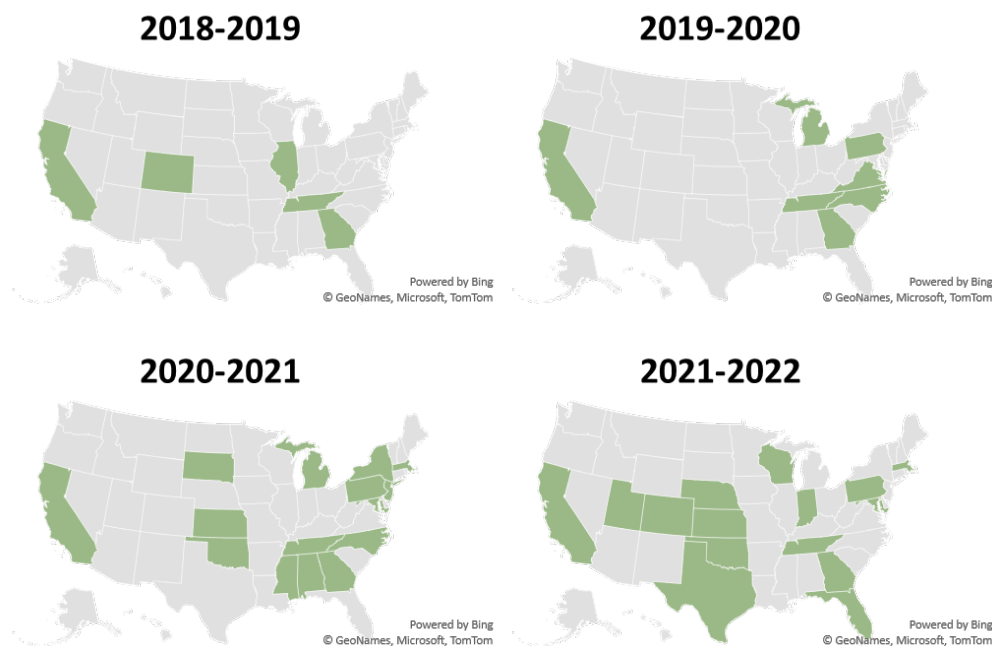


Figure 3. Geographic distribution of participants by year.

Figure 2 illustrates the growth of this competition during the 4 years of its existence. The total number of student participants has grown steadily, and participation by students from MSIs/HBCUs has grown at a similar rate with the exception of the 2019–2020 competition. In that year, there was an unusually high percentage of students from MSIs/HBCUs compared to other competition years.

Despite the high number of JUMP into STEM participants from MSIs/HBCUs, a smaller percentage of students from these institutions progress to the competition or internship stages of the process. This is a current focus area for the JUMP into STEM competition. We have worked to remove all barriers for student attendance at the final competition. Sponsorship funds will allow us to pay for student transportation and lodging during years when the competition is in person, removing financial obstacles.

This trend is caused by the fact that a lower percentage of student submissions from MSIs/HBCUs are judged high quality enough for invitation to the competition. This may reflect systemic barriers faced by students from MSIs/HBCUs prior to participation in JUMP into

STEM. Based on the trend in the data presented here, it appears that *students from MSIs/HBCUs may not be as prepared to be equally competitive with non-MSIs/HBCUs. We assert that this trend emphasizes the need to provide further educational opportunities for students from MSIs/HBCUs, and highlights the importance of diversity and inclusion.* We are working on ways to address this issue in JUMP into STEM, such as:

- Provide more support for professors so that the professors can help their students prepare a submission that meets the requirements. This would include a template for the students.
- Invest in more direct engagement with faculty and students, paying particular attention to HBCUs/MSIs.
- Recruit judges from these organization in the hope that they will institutionalize the competition.
- Students from HBCUs/MSIs are in high demand in industry. Communicate this to students, making our internship opportunity more appealing by emphasizing the value of participation.
- Follow up with students who had lower submission scores to debrief and help them improve.

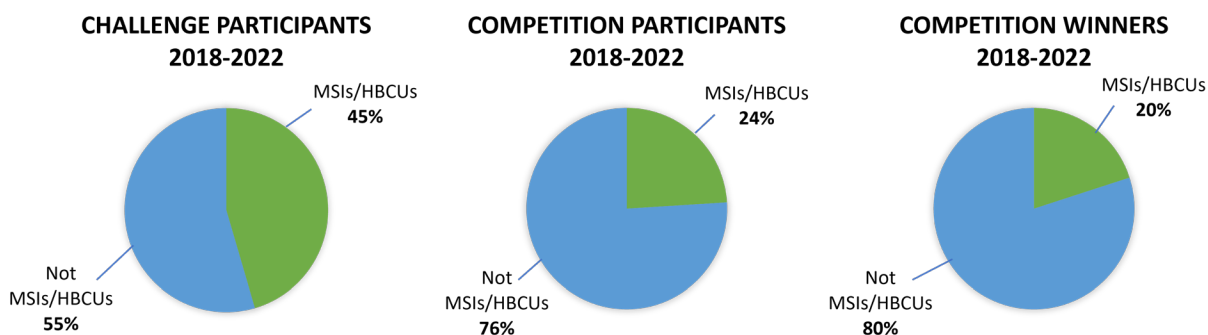


Figure 4. Students from minority serving institutions (MSIs) and/or historically black colleges and universities (HBCUs) at each level of competition.

Method

To assess the impact of the JUMP into STEM program on past participants, we interviewed 17 students. To arrange these interviews, we reached out via email to a randomized group of 146 past participants (30% of all participants over the life of the program), requesting their participation in this impact study. We received responses from 20 past participants indicating their willingness to participate. After answering follow-up questions regarding the interview protocol from several of these respondents and working to accommodate scheduling conflicts, we were able to conduct 17 interviews.

With the permission of participants, interview audio was recorded. Interviews began with a brief introduction to the study, its intended outcomes, and clarification of any questions the subjects had regarding participation.

After a series of demographic questions, we asked questions focused on the participant's experiences in the JUMP into STEM program and on the impact of the JUMP into STEM program on their career paths. In general, the intent of our questions was to encourage dialogue

and allow interview subjects to elaborate on their personal experiences participating in the competition. Follow-up questions were based on student responses.

At the conclusion of the interview, the subject was given time to ask any further questions and share any feedback. After responding to the subject, we thanked them for their time and concluded the interview.

Subsequent to interviews, the audio recordings were transcribed and the content was analyzed for the purposes of this study. After transcription, the audio recordings were destroyed. All quotes reported within this document have been confirmed with participants by email prior to publication, and explicit permission has been given to utilize them.

Demographics of Impact Study Participants

JUMP into STEM emphasizes inclusion of underrepresented groups. These groups include, but are not limited to, those based on race, ethnicity, and gender (Pearl-Martinez and Stephens 2016). Analysis of participant responses to the demographic questions indicate that the program has been successful in engaging these underrepresented groups to a far greater degree than is currently common in the building science workforce. This analysis is illustrated in Figure 5.

Of the participants interviewed, 24% attended an MSI or HBCU. This is less than the JUMP into STEM program average of 45% of students from MSIs or HBCUs. However, with the more detailed demographic information collected in these surveys, we were able to determine that many of the students attending non-MSIs or HBCUs were also students from underrepresented backgrounds. In fact, 71% of the participants identified with a race that is currently underrepresented in the building energy sciences. Thus, it is possible that *the diversity of JUMP into STEM is underestimated by considering the number of students from MSIs/HBCUs, as many JUMP into STEM participants from non-MSIs/HBCUs are from diverse backgrounds.*

It is clear from these data that the JUMP into STEM program has successfully engaged a much more diverse workforce than is common in the building energy sciences. For example, in 2018, only 24% of the energy efficiency workforce were women, whereas 65% of participants in this impact tracking study were women (Figure 5). Still more strikingly, only 8% of the energy efficiency workforce identified as African American in 2018, while 23% of participants in this study were African American (Barrett and Yadken 2019). Additionally, 35% of participants in this study were first-generation college students, slightly more than the national average of 31% (Cataldi, Bennett, and Chen 2019).

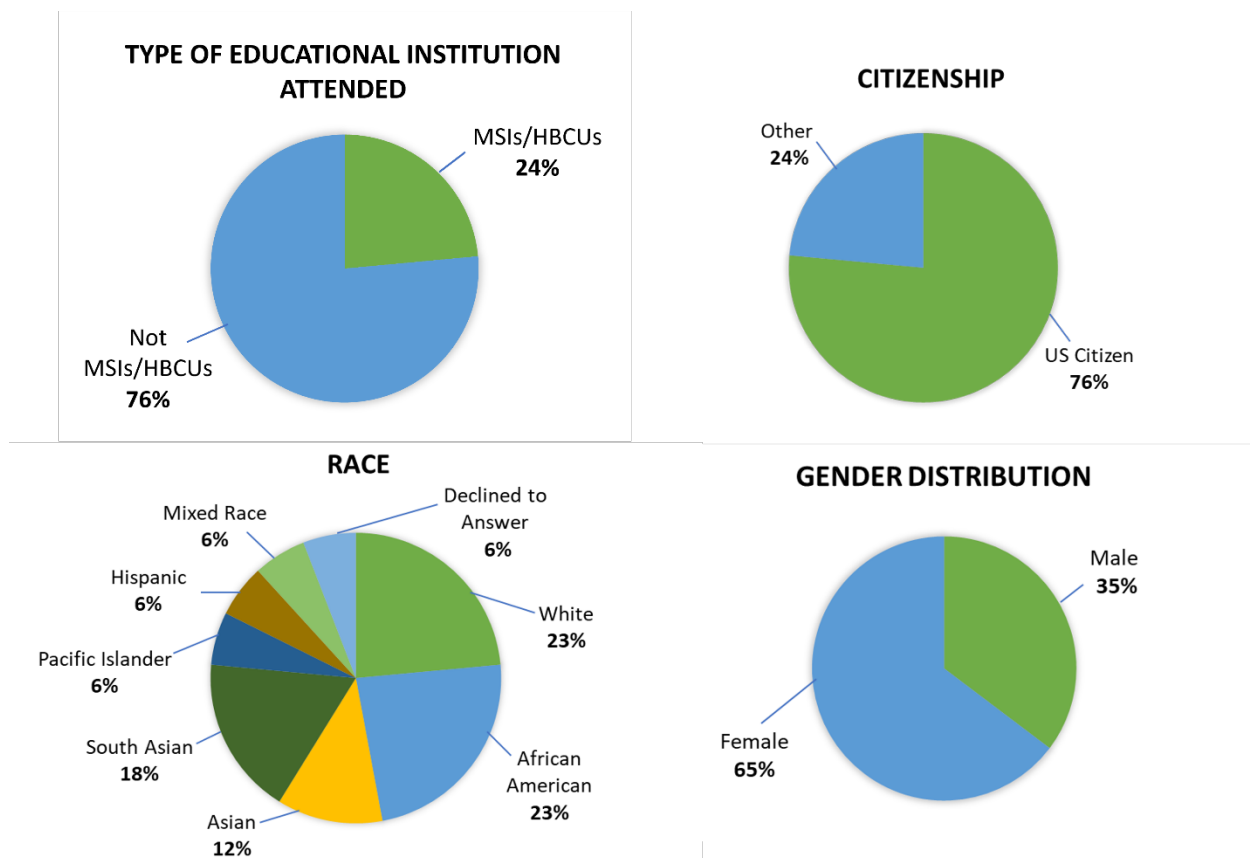


Figure 5. Demographic data for participants in impact study.

Furthermore, the impact study participants were involved in many different majors and degree program focus areas, illustrating the broad diversity of disciplines encouraged by the program. Specifically, the 17 interviewees represented the following majors and degree program focus areas:

- **Undergraduate majors represented in impact study**
 - Aerospace and Physics Engineering
 - Architecture
 - Architectural Engineering
 - Civil Engineering
 - Computer Science
 - Economics
 - Electrical Engineering
 - Mechanical Engineering
 - Nuclear Engineering
 - Physics
 - Public Policy
 - Theater Arts and Technology
- **Graduate degree programs represented in impact study**
 - Civil Engineering

- Data Analytics
- Economics and Public Policy
- Energy Management
- Environmental Engineering
- Mechanical Engineering
- Sustainable Architecture

The impact study was also representative of all three levels of participation in JUMP into STEM, as illustrated in Figure 6. The highest percentage (41%) of impact study participants competed in the challenge competition but did not progress further. This is consistent with the fact that although all students participate in the challenge competition, only a select few winners of this stage advance to the final competition and only a select few winners of the final competition advance to an internship. Based on this distribution, participants who received internships are slightly overrepresented in the impact study. This may be attributable to the fact that students who participated in internships had the longest and most involved experience with the JUMP into STEM program and therefore may have been more likely to respond to the request for an interview.

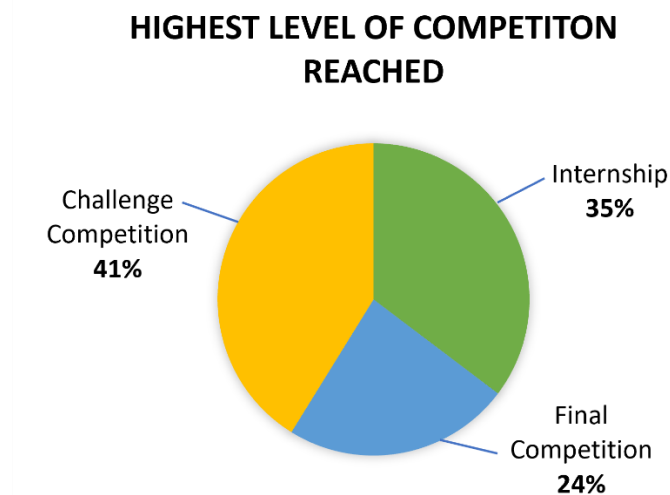


Figure 6. Impact study participants by level of competition reached.

Key Outcomes

Impact of JUMP Into STEM on Career Path

The impact study revealed that participation in JUMP into STEM has a significant influence on career trajectory, as illustrated in Figure 7. Overall, 35% of impact study participants stated that their career path was impacted by JUMP into STEM, and 12% percent stated that, although they are still deciding on a career path, JUMP into STEM is a strong influence on their decision-making process. Combined, ***more than 47% of impact study participants stated that JUMP into STEM is or was influential in deciding on their career paths.*** Only 12% of JUMP into STEM participants indicated that JUMP into STEM had no impact on their career trajectory.

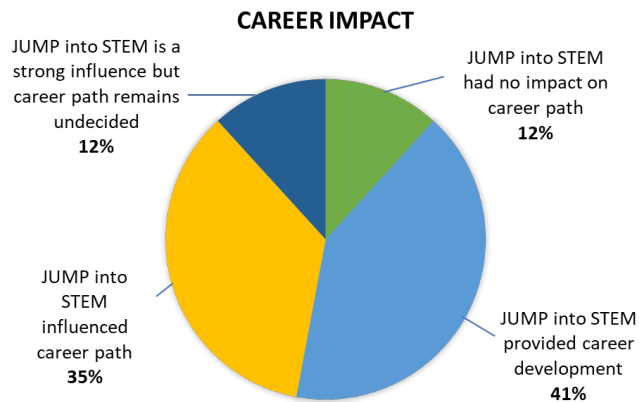


Figure 7. Impact of JUMP into STEM on career path for participants in impact study.

Data collected on current and planned career paths also illustrated the impact of JUMP into STEM on student outcomes. The JUMP into STEM program has only existed for 4 years, so only 35% of impact study participants are currently employed; the majority are still completing their undergraduate or graduate degrees. However, most of them have already decided on a career path.

Consistent with their reports that JUMP into STEM influenced their career paths, **41% of impact study participants currently work in or plan to work in the building sciences.** An additional 12% work in or plan to work in fields related to building science.

CURRENT OR PLANNED FIELD OF WORK

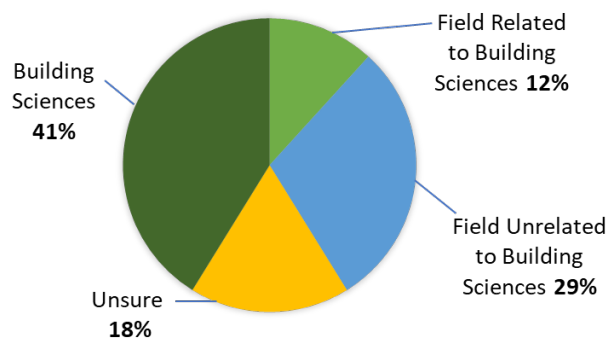


Figure 8. Percentage of participants in impact study by current or planned career path. Career paths are specified in text below.

Specifically, impact study participants are currently working in or plan to work in the following fields:

- **Current or Planned Career Paths in the Building Sciences:**

- Sustainable Architecture
- Mechanical Engineering/Building Science
- Construction Engineering and Environmental Engineering
- Civil Engineering, Construction Materials/Material Science
- Space Planning/Building Science
- Architectural Engineering Design and Project Management
- Commissioning Engineering
- **Current or Planned Career Paths Related to Building Sciences:**
 - Energy Industry
 - Data Science/Energy Management
- **Current or Planned Career Paths Unrelated to Building Sciences:**
 - Software Developer
 - Government Contractor at National Nuclear Administration
 - Military—Unspecified
 - Medical Engineering
 - Data Analytics and Economics/Public Policy

In addition to the statistical data suggesting that JUMP into STEM had a significant impact on student outcomes, many students provided narratives suggesting that learning about the rigorous science and engineering involved in building science research was extremely valuable for them in deciding on their career paths. One student currently working in commissioning engineering said, “***JUMP into STEM showed me the depth of science and engineering that there is behind building energy.*** Beforehand, I would have said HVAC and building controls didn’t really interest me, but when I understood more about the foundational science and engineering in that field and how significant the solutions can be, then ***it helped me see the value of the research and industry work in that field and has been part of my route to my current job.***” Similarly, a student from the 2018–2019 cohort who is currently working in the energy industry stated, “I didn’t know what I wanted to do, but I was interested in maybe research and grad school, so JUMP into STEM was a great opportunity to get exposed to that...I began realizing I was more interested in the industry side, but ***what was really neat about JUMP into STEM and interning at Oak Ridge was seeing how closely the research was tied to industry work.***”

Many students also appreciated the insights gleaned from JUMP into STEM even before they decided on their career paths. For example, a student who studied computer science and electrical engineering said, “I hadn’t decided my major when I was participating, so it kind of inspired me...***I think JUMP into STEM is one of the reasons that I chose my major.***” A student currently working in the energy industry who competed in 2018–2019 said, “I really didn’t know what all was out there, so I benefitted most from hearing about fellowships and what those look like, and about research opportunities and grants as well as how all of that research ties in with industry.” A participant from the 2021–2022 cohort who has not yet decided on a career path but is majoring in architectural engineering said, “I do think [JUMP into STEM] expands my horizons concerning choosing my career path.” This is consistent with the data presented in Figure 7 indicating that JUMP into STEM has been influential even for students who have not yet chosen their career paths.

Overall, JUMP into STEM seems to have imbued the vast majority of participants with excitement about the building sciences, perhaps best summarized by the following enthusiastic

quote from a member of the 2021–2022 cohort who plans to pursue a career in the building sciences: “Before [JUMP into STEM] I just was just kinda...like a crazy nerd who does math for fun and happened to be useful occasionally. ***In presenting at the JUMP into STEM at a national level, I said ‘Hey wait a minute, I’m doing national level stuff!’ And there is a reasonable career path ahead of me!’***”

Impact of JUMP Into STEM on Career Development

Although influence on career choice was perhaps the most evident outcome of the impact study, another theme that emerged nearly equally strongly was that participants valued the opportunity to engage in career development. In fact, ***41% of students reported that they had already decided on their career path at the time of their participation in JUMP into STEM, but JUMP into STEM provided career development opportunities for them.*** Without exception, they reported that the program was an extremely valuable experience for them, helping them facilitate their matriculation to building science fields.

This is consistent with JUMP into STEM program goals. There are many aspects of the JUMP into STEM program that facilitate career development. From the start, students must work as part of a team to come up with an innovative solution to a building science problem. Each level of the competition provides students with valuable career development opportunities. From learning how to write a proposal with a budget to working on teams with diverse backgrounds to networking with other participants and current national lab employees to earning the opportunity to work at a national lab, students are able to learn and improve on skills that are essential to being successful in the workforce.

Diverse Perspectives Valued and Promoted by JUMP Into STEM

JUMP into STEM has engaged an extremely diverse body of participants, and the data collected by the impact study indicate that the program is successfully supporting, encouraging, and engaging them. In fact, ***100% of the impact study participants reported that they felt their ideas were valued and heard.*** Furthermore, 53% of them felt that they definitely contributed to building science, while an additional 30% felt they likely contributed.

When asked an open-ended question about what they enjoyed about the JUMP into STEM program, impact study participants mentioned diversity most frequently. Numerous participants detailed their positive experience and appreciation of the diversity offered by the program.

For example, a student who was a final competition winner in 2020–2021 said, ***“I saw that many judges and many people who work at NREL are of different races and different ethnicities and it’s just very diverse... people of different races and genders and ethnicities [who] work together for the greater good of people as a whole.”*** Similarly, a student who was a final competition participant in 2018–2019 and who completed an internship at NREL said, “It was such a great, welcoming environment there, even though it was me as an underclassman undergraduate talking with these people who have Ph.D.s in their disciplines and were amazing researchers...The entire time I felt incredibly valued.” A student that competed in the final competition in 2021–2022 said, “I thought the entire event was very inclusive of all of the participants.”

Furthermore, many students said they enjoyed the fact that they were encouraged to work on projects related to diversity and inclusion. A student who was a challenge participant in 2021–

2022 said, “I appreciated the ability to be able to express ourselves and our creativity through an educational perspective concerning the various demographics that my group members and I are interested in or have come across...That was probably my favorite part of [JUMP into STEM].” A student who was a final competition winner in 2020–2021 said, ***“What encouraged me to go into that field [construction engineering and environmental engineering] was seeing how many people of color are disproportionately affected by housing and transportation.”***

The diversity of disciplines and educational backgrounds was also appreciated. A student who is majoring in mechanical engineering said, ***“Mainly, what I really loved about [JUMP into STEM] is working with other people in a team, especially since everyone in my team was in a different field of study.”*** Similarly, a student who is currently working in the buildings sciences at PNNL said, “I come from the architectural fields, it’s more about the designing part, but then JUMP into STEM gave me the opportunity to collaborate with people...in the same industry but they had more technical knowledge in sense of like the structural.”

Networking, Mentorship, and Team-Forming Experiences Provided by JUMP Into STEM

When asked to describe something they enjoyed about the JUMP into STEM program, more than 58% of participants mentioned that they enjoyed the networking and team building opportunities offered by the program. More than 70% of participants stated that they made meaningful connections with peers, while 47% stated that they made meaningful connections with professors. Twenty-nine percent indicated that they made meaningful connections with professionals in the building sciences. This sentiment is reflected by this quote from a challenge participant from 2021–2022, ***“I have people I can always reach out to if I ever maybe need a job in the future or have questions about that field of study.”***

Opportunities to build professional networks and teams as well as to develop relationships with mentors are essential for all students, but research has shown that these opportunities can have a particularly profound effect for students from underrepresented backgrounds. For example, it was reported that to form STEM-identity in girls, strategies should include combining inclusive curriculum and pedagogies with exposure to female role models (Prieto-Rodriguez, Sincock, and Blackmore 2020). Similar studies have indicated that same-gender peer mentoring, which several female JUMP into STEM interns experienced, promotes women’s success and retention in engineering (Dennehy and Dasgupta 2017).

Similarly, mentorship plays an important role for underrepresented students’ success in undergraduate and graduate STEM programs. Success factors for underrepresented students include advising, mentoring, and networking; the importance of a supportive, inviting environment; and targeted support programs. Mentor training for research advisors, student career coaching, and individualized career development plans have all been identified as contributing to the completion of degree programs (Byars-Winston et al. 2011).

Real-World Experience and Applied Learning Opportunities Provided by JUMP Into STEM

When asked to describe something they enjoyed about the JUMP into STEM program, 41% of participants mentioned that they enjoyed the real-world experience and/or the competition framework offered by the program. Furthermore, 30% stated that they enjoyed the career development potential, such as the opportunity for an internship. This sentiment is illustrated by quotes from students.

A student who was a final competition winner in 2018–2019 stated, “[The proposal was] the first time I got to have a really flexible research project and explore data in a way that was related to my own research. It was certainly the only time I had presented that to a group of people and...answer[ed] questions about it. *That was an experience I really enjoyed and hadn’t had the opportunity to do before, and it’s something I’ve done quite a few times since, and I haven’t really been as nervous as I was the first time.*”

A student who was a final competition winner in 2020–2021 said, “I’ve never done a project where I came up with a market analysis and gone so in detail about it. *I enjoyed being able to speak with that level of detail about my project and implement it into my community.*” Similarly, a student challenge participant in 2021–2022 said, “*It has also helped me look at things from a bigger perspective...I do have plans to...help contribute to creating a better planet in the future but I didn’t realize how much research and work would go into that.*”

The value that impact study participants placed on applied learning opportunities is consistent with evidence suggesting that exposure to STEM careers through field experiences can trigger students’ interest. Students who attend workshops express interest in career-related content in addition to scientific content, so exposure to real-world science work can spark interest in STEM careers (Clarke, Sharma, and Schiller 2019).

Impact on Energy Efficiency and Equity

JUMP into STEM is one pathway to achieving equitable climate solutions by growing the energy industry workforce into a more diverse and educated labor pool. These workers bring the experiences, backgrounds, and knowledge necessary to identify energy-efficient, low or zero carbon solutions for homes, industrial facilities, and commercial buildings. In addition, JUMP into STEM promotes successful commercialization by increasing the number of workers with diverse personal and educational backgrounds. JUMP into STEM encourages the next generation of building science students to bring a social and environmental justice perspective as well as a rigorous science background to the process of solving real-world problems like climate change.

Conclusions

Achieving equitable decarbonization in the built environment will require diverse perspectives from energy efficiency professionals with diverse personal and educational backgrounds. There is a need to continually encourage students from diverse backgrounds to pursue energy efficiency to increase and maintain the pipeline of talented building scientists.

The results of the impact study clearly show that JUMP into STEM has achieved its goal of encouraging diversity in the building sciences. More than 45% of those participating in JUMP into STEM attended MSIs/HBCUs. However, focusing on students from MSIs/HBCUs may lead to underestimation of the diversity of the JUMP into STEM program. Based on analysis of the randomly selected subset of participants from all past years of competition and all levels of competition who participated in this impact survey, the majority (71%) of JUMP into STEM participants are from underrepresented and diverse backgrounds.

Although the vast majority of findings from this study were positive, we have identified a trend showing that students from MSIs/HBCUs underperform at the challenge level of competition compared to students from non MSIs/HBCUs. JUMP into STEM is already working on programmatic solutions to this issue and will continue to do so.

However, the key finding of this study was encouraging—the JUMP into STEM has been successful at inspiring students from diverse backgrounds to pursue careers in building sciences and has provided career development opportunities for students from historically underrepresented backgrounds.

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