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Arkansas Summer Research Institute: The Evolution of an Engaging Online Training Program in Data Analytics and Research Targeting Underrepresented Students in STEM

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ABSTRACT: Shortage of highly-skilled STEM workers, lack of critical technical skills, and persistence of underrepresentation are key problems for our nation's future. The Arkansas Summer Research Institute (ASRI) incorporates novel approaches to broaden participation in STEM, research, and data analytics, especially among URM students (over 50% of ASRI participants). The ASRI has evolved from in-person to a virtual model that includes innovations in organization, engagement technologies, personalization, gamification, mentoring, and networking. Students conduct independent research projects and present their findings. Student confidence in coding, research, statistics, and visualization skills improved significantly (p<0.001) during this two-week summer program. Furthermore, the use of continuous communication, ongoing help, extremely low student-to-mentor ratios, and one-on-one coaching led to excellent overall satisfaction scores on a 5-point scale, which were surprisingly higher in a virtual environment (N = 148, M = 4.73, SD = 0.53) than an in-person one (N = 133, M = 4.11, SD = 0.87, p < 0.001). The ASRI has trained over 300 students and involved over 130 STEM professors and professionals from across Arkansas in the pursuit of equitable and productive training and can serve as a model for other groups seeking to develop similar programs in the future.

INTRODUCTION

Challenge of Inadequate Student Representation in STEM Research and Careers. For decades, there has been a shortage of well-prepared STEM students, particularly in underrepresented minorities (URM) (Brown et al., 2016; Mau, 2016). In the 1970s, this lack of adequate preparation prompted the development of what is often referred to as the STEM pipeline. This structure was meant to prepare students for STEM degrees with specific policies, procedures, and course requirements. The emphasis on STEM education grew from a concern regarding the low number of future workers to fill the STEM jobs needed to keep the United States competitive globally; however, this emphasis was not always well-understood or implemented (Brown et al., 2011). In fact, the STEM pipeline has many gaps and leaks and has not delivered the sizable, diverse STEM workforce that is needed (Cannady et al., 2014). The failures are especially notable among URM groups in STEM from various racial, ethnic, gender, socioeconomic, and rural backgrounds (Brown et al., 2016; Mau, 2016; Niu, 2017; Saw and Agger, 2021). The STEM workforce has persistently low participation of women and people identified as URM. The National Science Board has described this talent gap as 'the Missing Millions' (2022). Some challenging aspects include low enrollment (Wang, 2013; Sargent, 2017) and completion of STEM-related degree programs (Mau, 2016). Graduates also tend to lack critical technical skills necessary to keep pace with the growing needs of the STEM professional workforce (McGunagle and Zizka, 2020; Zaza et al., 2020).

Increasing the size and diversity of the STEM-skilled workforce necessitates focused, creative, and effective methods to attract and matriculate students, especially in female and URM populations. Though there are programs to motivate students to enter and persist in STEM careers, many are prohibitively expensive, time consuming, ineffective, and/or inequitable; as a whole, they are only moderately effective at increasing student GPA and retention (Bradford et al., 2021). A systematic review of thirty STEM bridge programs since 1992 suggests that although many fulfill their goals at least in part, they vary greatly in length (3 days to 8 weeks) and the goals they set, suggesting more detailed program descriptions and specific lessons learned need to be shared with scientific and educational research communities via publication. This meta-analysis also presented evidence for the importance of positive relationships with faculty to student success, but found that only eight of thirty programs had a stated goal of students building relationships with faculty and only four measured outcomes associated with this goal, while none made a deliberate effort to increase student access to female or URM faculty mentors (Ashley et al., 2017).

Negative Impacts of the COVID-19 Pandemic on STEM Educational Preparation. COVID-19 was an additional setback, forcing cancellation of numerous STEM summer programs in 2020. Many university research labs transitioned to work-from-home models and eliminated their support for new students with some providing virtual mentorship. This shift curtailed essential training opportunities that serve as steppingstones for students because most were not prepared to implement this drastic pivot (Berr et al., 2021; Chandrasekaran, 2020; Speer et al., 2021; Sutherland et al., 2020). Virtual mentoring has been used to support students at different times, often successfully (Adams and Hemingway, 2014; Ensher et al., 2003; Gregg et al., 2016, 2017), but had not been implemented at the scale needed during the pandemic.

The pandemic also impacted educational equity, resulting in decreased engagement and access to resources, especially for female and URM students, who faced additional challenges with online models (Barber et al., 2021; Jeffers, 2021; Saw et al., 2020; Walsh et al., 2021; Wu and Teets, 2021). These students often serve as caregivers to siblings and elderly family members, and experience higher rates of food insecurity and financial instability (Barber et al., 2021). Therefore, the need for flexible preparatory and transitional programs designed to support and equip URM students to pursue STEM careers and focus on accessibility and retention.

Improvement of Student Preparation for and Representation in STEM Fields. Several summer programs that focus on practical research experiences have succeeded in improving student aspirations to participate in further research, including Ph.D. programs (Burgin et al., 2015; Constan and Spicer, 2015; Pender et al., 2010). When these programs are constructed and executed well, they double the probability that students will plan to pursue a STEM career, compared with students without program exposure (Kitchen et al., 2018). Professional development programs can improve STEM recruitment and retention among URM populations in many ways (Table 1).

After targeted recruiting, innovative strategies that result in authentic student participation are key. Engagement tools that improve student outcomes include scaffolding, gamification, networking, and mentorship. Scaffolding provides a supportive environment where learning is broken up into

Table 1. *Previously published recommendations for recruiting among URM students.*

Recommendations	Arkansas Summer Research Institute (ASRI) Approaches	References
Target recruitment by focusing on institutions and programs that serve URM.	Recruitment from HBCUs, Ark-LSAMP, and McNair Scholars Programs*	Bradley et al. 2021; Caldwell et al. 2021
Represent diverse career paths in the programs so students from a wide variety of backgrounds can envision themselves succeeding.	STEM professional panels and research stories feature many different backgrounds and fields.	Bradley et al., 2021
Include more mentors and other STEM professionals who are themselves from URM groups.	More than half of the presenters are women (while they are only 34% of the STEM workforce) and organizers purposefully seek out URM as mentors.	Sass, 2015
Build a program around a multidisciplinary approach to also appeal to students from nontraditional paths.	Many panelists and presenters come from nontraditional backgrounds and nearly a third of participants are not from strictly STEM fields.	Doerschuk, 2016
Provide customized support for those who are struggling in specific aspects of the curriculum because students perform better when they receive personalized instruction.	Beginner and intermediate options are available for most sessions; R or python can be chosen depending on student fit; curated data sets vary widely from astronomy and business to cancer research. Occasionally, students return to the ASRI for a second year and are able to experience new content by choosing different sessions.	McClure et al., 2010
Provide one-on-one support for students since this approach increases chances of success and contributes to a learner-centered environment.	Every student participates in one-on-one coaching, pear deck engagement, and shares screens during technical sessions; students can sign up for individualized help breakout rooms and get advice about their presentations.	Bransford et al., 2000; Horn and Staker, 2011
Prepare students for new technologies that will be used during the program.	Tech onboarding occurs weeks before the institute and focuses on community introductions, overview of tools, set up of needed software, discussion of expectations, and fielding of technical questions.	Gaida et al., 2021; Watts, 2019

**Historically Black Colleges and Universities: Philander Smith College and University of Arkansas at Pine Bluff; Ark-LSAMP: Arkansas Louis Stokes Alliance for Minority Participation program.*

smaller structured blocks, allowing guided exploration with mentorship to support new skill development. Interestingly, some of the largest effect sizes of scaffolding benefits occur among college and graduate students (Belland, 2017). Many studies also show that gamification is effective in a myriad of educational settings that improve student motivation, engagement, commitment, and understanding (Gari et al., 2018; Manzano-León et al., 2021). Leaderboards have been most motivating as points were more effective than other gamification elements (Gari et al., 2018). Discussions about how best to incorporate gamification into mainstream educational activities are ongoing but proponents continue to report positive outcomes (Cassel et al., 2019; Dicheva et al., 2019, 2022; Swacha, 2021).

Developing a connected learning community among students and professors is also key to recruiting and retaining more STEM students (Dagley et al., 2016). In fact, it is clear that social integration must accompany academic integration to maximize student success in higher education (Tinto, 1975). Sharing challenging experiences and getting advice from fellow students can be transformative and offer specific ways to overcome difficulties while the camaraderie gives students hope. It helps students feel that they are accepted and that their success is important to their mentors, helping students find their identity as scientists and make progress on their STEM journeys (Lisberg and Woods, 2018; Robnett et al., 2018). Mentor advice and opportunities that develop from these relationships are mutually beneficial and especially important and effective as a retention tool for URM populations (Estrada et al., 2018).

The goal of the Arkansas Summer Research Institute (ASRI) is to broaden participation in STEM research while building a diverse peer network of students, professors, and professionals. The ASRI has been successful at both recruiting female and URM students and professors and shifting to a virtual model to serve more students from diverse backgrounds. Our purpose here is to provide information and evidence to the larger STEM education community by showcasing the ASRI's impacts and outcomes. This is in response to a call for summer bridge programs to publish their findings, including 1) descriptions, goals, and outcomes; 2) lessons learned that guide future developments; and 3) details of recruitment, daily activities, staff organization, curricular development, and logistics (Ashley et al., 2017). While most programs are tailored to first-year undergraduate students, the ASRI serves participants ranging from high school students to postdoctoral fellows. Most programs that target URM students serve those students exclusively, while the ASRI serves a combination of URM and non-URM students who work together as both benefit from diversity, inclusion, and equity sessions in addition to the focus on adaptable technical and professional skills. We will describe how the ASRI supports students in general, and more specifically those from URM groups, using various targeted recruitment and retention methods which have resulted in overrepresentation of these populations among participants. The successful outcomes of our innovative approaches are reported as increased URM representation, low student-to-teacher ratios, significantly improved student confidence in specific skills, and outstanding student satisfaction ratings.

METHODS

Participants

Participant Recruitment and Retention with Focus on URM Groups. Since the 2015 pilot, over 300 students from campuses across Arkansas and surrounding states have completed the ASRI. The program continues to grow, with the 2022 cohort of 76 students being the largest yet. In the same year, 42 faculty from eight Arkansas colleges and universities and 13 STEM professionals from the public or private sector led technical sessions, shared advice on panels, and advised students in individual research consultations. All faculty participation is voluntary and most accept a small stipend for their time ($55 per panel, $85 per research consultation, $140 per technical session). Faculty already supported by the funding grant may choose to participate voluntarily without a stipend. The time commitment for most faculty is 1 to 3 hours but can often be 12+ hours for those most involved in teaching coding skills. In total, nearly 140 different STEM professionals and faculty from 14 campuses have participated, often returning in subsequent years.

Since its inception, the ASRI's main goal has been to broaden participation in STEM for URM groups using focused recruiting. Though the ASRI recruits from a broad range of educational institutions, emphasis is placed on Historically Black Colleges and Universities (HBCUs) including Philander Smith College and the University of Arkansas at Pine Bluff (UAPB). Programs like the Arkansas Louis Stokes Alliance for Minority Participation program (Ark-LSAMP), McNair Scholars, and various offices dedicated to diversity or multicultural students are also prioritized. ASRI advertising emphasizes that this is a free opportunity for students, and all materials acknowledge the supporting grants to mitigate financial concerns for applicants. There is no selection process; all who apply and are eligible (enrolled in a U.S. educational institution) are admitted.

By adopting a multidisciplinary and experiential approach, the ASRI appeals to students from diverse degree programs and learning paths, including traditional and nontraditional students studying life, physical, and computer sciences, and those from a variety of other majors who are interested in data science (Table 2). Our research stories and curated datasets include diverse topics like cancer research and astronomy. Since customized approaches and individualized help improve URM student outcomes in STEM,

Table 2. *Demographic participant data, self-reported by students on their registrations.*

n=166	Total (2020-2022)	Average % (± SD)
Gender		
Female	80	48.2% (± 10.24)
Male	83	50.0% (± 10.15)
Non-binary	2	1.2% (± 1.54)
Prefer not to say	1	0.6% (± 1.20)
Race/Ethnicity*	**(2017-2022)**	
African American/Black	93	33.7% (± 21.45)
Asian	54	19.6% (± 12.45)
Caucasian/White	78	28.3% (± 11.63)
Hispanic	38	13.8% (± 2.82)
Multiple/Other/Undisclosed	13	4.7% (± 4.91)
Disabilities		
Yes	6	3.6% (± 1.81)
Prefer Not to Say	7	4.2% (± 2.47)
No	153	92.2% (± 2.97)
First Generation College Student		
Yes	53	31.9% (± 2.96)
Not Sure	13	7.8% (± 5.12)
No	100	60.2% (± 6.62)
Education Level		
High School students	17	10.2% (±1.15)
Undergraduate students	115	69.3% (±23.82)
Graduate students	33	19.9% (±23.99)
Postdoctoral fellow	1	0.6% (±0.77)
Field / Degree Major**	**(2021-2022)**	
Biology/Medical	27	23% (±9.59)
Chemistry/Biochemistry	6	5% (±2.67)
Computer Science	24	20% (±10.47)
Engineering	26	22% (±12.05)
Mathematics	8	7% (±3.65)
Physics/Astronomy	8	7% (±5.38)
Social Sciences/Business	10	8% (±5.38)
Other/Undecided	9	8% (±12.09)
Prior Research Experience***		
Yes, significant	63	37.3% (± 11.53)
Yes, minimal	13	7.8% (± 7.17)
None or no response	90	54.8% (± 27.97)
Schools (40)****		
UA Fayetteville (UAF)	50	30% (±12.81)
UA Little Rock (UALR)	15	9% (±1.87)
Arkansas Tech (ATU)	13	8% (±7.24)
Arkansas State (ASU)	10	6% (±2.66)
Univ. of Central AR (UCA)	6	4% (±1.33)
Additional Arkansas U.	31	19% (±10.64)
Mississippi State U.	15	9% (±11.55)
Arkansas High Schools	4	2% (±3.70)
Other States and Countries	22	13% (±8.03)

**Data about race/ethnicity is reported for years 2017-2022 (n =276).*

***Data about field and major was collected in years 2021-2022 (n = 118).*

****Significant research experience is defined here as some time spent by the student in an actual research setting, such as working with a research group in a laboratory. Minimal research experience is defined as some basic introduction to research in an academic setting, such as in a classroom or as part of an academic course for their major.*

*****Only schools with 6 or more students participating are individually listed. Additional Arkansas Universities included: Henderson State University, Hendrix College, John Brown University, Northwest Arkansas Community College, Philander Smith College, UA Pine Bluff, National Park College, North Arkansas College, Ouachita Baptist University, Southern Arkansas University, UA Fort Smith, and Harding U. The two represented high schools so far include: Arkansas School for Mathematics, Sciences, and the Arts, and Bentonville High School. Other states and countries were represented by students from: U. of the People, West Bengal State U., Bhairab Ganguly College (West Bengal State U.), Brigham Young U. Idaho, Carleton College, Fayetteville State University (NC), Ignite Professional Studies, Nashua Community College, U. New Hampshire (NHTI-Concord's Community College), Pennsylvania State University, Southern U and A&M College, Tulane U., U. of Chicago, U. of Memphis, U. of New Hampshire, U. of Oklahoma, Vanderbilt U., and Wake Forest U.*

ASRI offers both beginner and intermediate tracks (Tables 3, 4, and 5). There are individual sign-up slots and virtual support rooms to address gaps in preparation and overcome frustrations with complex assignments. These interventions are critical for those students who would have otherwise withdrawn due to the challenging and fast-paced curriculum.

ASRI Participant Demographics. After students signed media and information release forms, survey data and demographic information were collected. Participants were from varied gender, racial/ethnic, and educational backgrounds. They were nearly equally represented by both genders (while women make up only about 34% of STEM workers (National Science Board, 2022)), and underrepresented racial and ethnic groups were overrepresented in our cohorts (Table 2 and Figure 1). Nearly 4% of students reported a disability, one third were first-generation college students, and came from various levels of education (high school, undergraduate, graduate, and postdoctoral participants; with undergraduates making up nearly 70% of the participants). Participants also represented over 40 institutions (23% of students from outside of Arkansas), and many different fields (about a quarter each in biology/medicine, computer science, engineering, and others including some in social sciences). In addition, over half of ASRI participants from 2020-2022 had no prior research experience (Table 2).

Program

Institute Structure. The ASRI is sponsored by Arkansas NSF EPSCoR and hosted in collaboration with the Arkansas School for Mathematics, Sciences, and the Arts (ASMSA). ASRI students learn technical and professional skills in an inclusive and supportive environment that is designed to be rigorous and challenging, while also rewarding and immediately applicable. ASRI students design and complete a research project and deliver a presentation of their work. Beginner and intermediate tracks and breakout sessions allow students to customize their learning experience based on their interests and abilities. Every session is interactive and designed with student engagement and interaction in mind. These approaches improve retention, confidence, and skill development.

Initial Model for In-Person Instruction (2015-2019). The ASRI was first piloted in 2015 with funding from the Arkansas EPSCoR ASSET II Initiative and was intended to serve as professional development training for students working in EPSCoR-supported labs. It soon became clear that other students would benefit from this opportunity, especially those at campuses with limited resources to support student research. From 2015-2019, the program was hosted on the ASMSA campus in Hot Springs, Arkansas. STEM undergraduates were recruited to attend the one-week experien-

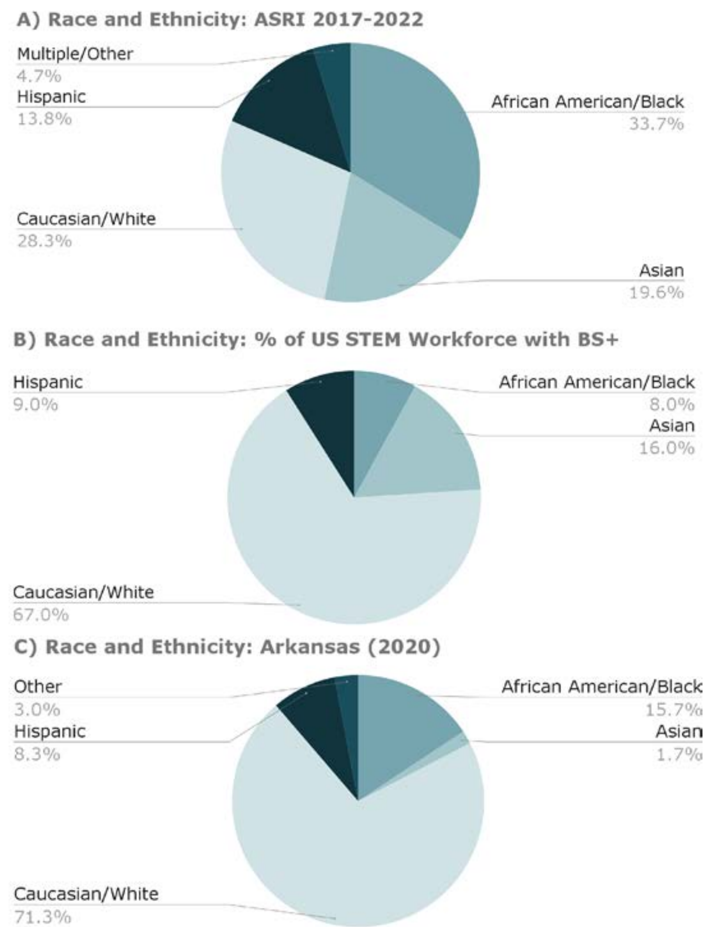

Figure 1. A) ASRI participants' (N = 276) race and ethnicity for the five ASRI's held from 2017 to 2022. B) STEM workforce (BS or higher) participants' race and ethnicity in the US in 2019 (National Science Board 2022). C) Arkansas population's race and ethnicity proportions (U.S. Census Bureau, 2020). There is a statistically significant increase (p = 0.014, $t(5)$ = 3.705) in the URM populations (African American and Hispanic) at the ASRIs (A) compared to those in STEM fields (B) using a one-sample t-test. Overall racial and ethnic breakdown of the US population includes: African American/Black=13.6%, Asian = 6.1%, Caucasian/White = 59.3%, Hispanic = 18.9% (U.S. Census Bureau, 2020): https://www.census.gov/quickfacts/fact/table/US/PST045221.

tial research training. The percentage of URM participants ranged from 56% in 2016 to 85% in 2018.

Courses included lab techniques like polymerase chain reaction as well as résumé building and job interview practice. Students were taught how to conduct a literature review and effectively interpret scientific journal content; skills they applied immediately to develop a presentation of either a selected journal article or their own research data which they shared with fellow attendees. Some students reported that the ASRI was the first time they ever presented research. Students also completed Collaborative Institutional Training Initiative (CITI) Responsible Conduct of Research training. In 2018, the ASRI was expanded to two identical week-long sessions to accommodate two student cohorts per year. Two simultaneous curricular paths were developed, one for life sciences and one for physical sciences, but students were able to move between paths to tailor their experience. New courses were offered to update the curriculum, like 3D printing, protein quantification, electron microscopy, and research commercialization.

Pivot to Virtual Instruction (2020-On). The COVID-19 pandemic resulted in campus closings that posed a challenge for us to develop an interactive and engaging virtual program. We explored innovative tools and developed flexible expectations, revisited learning outcomes, and leveraged new technologies (such as Labster for lab skill instruction, Flipgrid for introductions, and Zoom for virtual instruction) to meet an updated set of student-oriented goals. The ASRI was expanded to two weeks for one cohort to increase time for project development and included a balance of synchronous online sessions and asynchronous assignments. The pivot to an online format came with unexpected benefits, including fewer equipment and dormitory space limitations. More presenters were available to participate because they did not have to travel or arrange hotel stays. Remote instruction also reduced cost. Funds previously used for meals, lodging, and travel expenses could now be saved or redirected. Many attendees noted that the virtual format enabled their attendance because they were able to keep summer jobs and internships and continue to care for family members while participating in the ASRI. This increased the number of students and faculty participating each year.

Communication, preparation, access, and attention to engagement were also key to hosting a successful online program. A pre-survey ensured participants had reliable internet and computer access. Zoom orientation sessions for students and presenters made everyone comfortable with the virtual platforms. During the ASRI, sessions were recorded and provided to participants, virtual office hours allowed for individual help, daily evaluations highlighted student concerns, and daily breakout rooms facilitated small group meetings over specific skills and topics. A gamification strategy incentivized participation online, which galvanized students to better engagement, promoted student learning beyond expectations, and resulted in a more successful (Figure 2) and satisfied (Figure 4) cohort of students.

Shift to Data Science with Student-Driven Research Projects (2021-Present). Originally, the ASRI's focus was on general STEM research preparation, including wet lab skills. In 2021, this focus shifted to data science due to the change in funding and the two-week duration continued. This required additional curriculum to support an effective, individualized approach to training students in data analytics and programming integrated into the established research schedule (Table 3). We developed a schedule with sessions

Table 3. *Comparison of General STEM focus (2015-2020) and Data Science focus (2021-22), with examples of different session categories.*

Session Types*	2015-2020 (General STEM Focus)**	2021-2022 (Data Science Focus)	Notes about Sessions
Technical Session Topics and Programs			
MATLAB®	YES	**NO**	In some cases, there were multiple sessions devoted to different aspects of the listed topic. For example, there were five separate sessions addressing different aspects of applications of Python in 2022.
Computer-Aided Design (CAD)	YES	**NO**	
Statistics in Microsoft EXCEL	YES	YES	
Statistics in Google Sheets	YES	YES	
RStudio	YES	YES	
Introduction to Data Science	**NO**	YES	
Data Extraction and Formatting	**NO**	YES	
Cybersecurity	**NO**	YES	
Phylogenetics	**NO**	YES	
Python	**NO**	YES	
Artificial Intelligence	**NO**	YES	
Machine Learning	**NO**	YES	
Laboratory Skills			
3-D Printing	YES	**NO**	These skills are not essential for the new data analytics focus of the ASRI that began in 2021. Students chose between sessions designed for either biological or physical science research. In 2020, laboratory skills were taught using Labster simulations online.
Western Blotting	YES	**NO**	
Polymerase Chain Reaction	YES	**NO**	
Electrophoresis	YES	**NO**	
Protein Quantification	YES	**NO**	
Scanning Electron Microscopy	YES	**NO**	
Green and Sustainable Chemistry	YES	**NO**	
Panels and Research Stories			
Graduate/Medical School Advice	YES	**NO**	Students experienced many diverse voices during these sessions. They heard from at least 19 different professionals across the panels and research stories presented in 2022 from different racial/ethnic backgrounds and with varied experiences.
Entrepreneurship	YES	**NO**	
STEM Careers	YES	YES	
Diversity, Equity, and Inclusion	YES	YES	
Overcoming the Odds in Research	YES	YES	
Research Stories	YES	YES	
Data Science in Today's World	**NO**	YES	
Help Sessions			
Individual Research Consultations	YES	YES	Students had regular access to one-on-one help sessions and office hours. Some were required and built into specific blocks in the schedule, while others were optional lunchtime help sessions.
Individual Résumé Consultations	**NO**	YES	
R Help Breakout Rooms	**NO**	YES	
Python Help Breakout Rooms	**NO**	YES	
Research Skills			
Responsible Conduct in Research	YES	**NO**	Much attention is paid to customization of student experiences; for example, students choose one of several publication options in different fields (Cancer Genetics to Artificial Intelligence). Other sessions such as Statistical Analyses are taught at beginner and intermediate levels.
Research and Data Ethics	**NO**	YES	
Conducting a Literature Review	YES	YES	
Reading Research Publications	YES	YES	
Experimental Design	YES	YES	
Statistical Analyses	YES	YES	
Finding Research Opportunities	YES	YES	
Individual Research Presentations	YES	YES	
Individual Research Project	**NO**	YES	
Science Communication Strategies	**NO**	YES	
Professional Skills			
Practicing Interview Skills	YES	**NO**	These sessions were held while students created or updated their own materials and practiced their skills. They also received individualized help in breakout rooms if requested.
MCAT®/GRE® Prep	YES	**NO**	
Giving a Compelling Presentation	YES	YES	
Making a Résumé/Curriculum Vitae	YES	YES	
Creating an Effective LinkedIn Profile	**NO**	YES	
Technology Utilized in Sessions			
Zoom (breakout rooms, annotation tools, multiple screen sharing)	**NO**	YES	Technologies used were critical for full student engagement, immediate communication, formative assessment, and interactive learning. Access to and practice with these technologies was available before the ASRI.
Pear Deck	**NO**	YES	
Data Repositories	**NO**	YES	
RStudio	**NO**	YES	
Jupyter Notebook for Python	**NO**	YES	
UpSquad	**NO**	YES	

Most listed sessions were offered each year for the given time period. In some cases, new sessions were introduced in later years. For example, representatives from diversity and multicultural offices began contributing to panels in 2018 while "Green and Sustainable Chemistry" and the "Entrepreneurship panel" were both new additions to the schedule in 2019.

**The 2020 ASRI was a transition year. It was the last ASRI to focus on general STEM research preparation and the first online ASRI.*

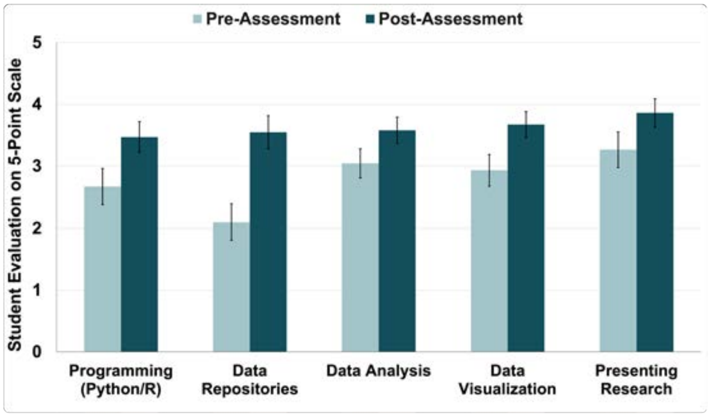

Figure 2. Student experience in multiple skills increased over the course of the 2022 ASRI (N = 64). Increases were statistically significant as described in **Table 6**. The error bars were calculated using twice the standard error of the mean (2SEM, 95% CI). This evaluation form was completed by 84% of the 2022 cohort.

that students selected based on experience and comfort level (Table 5), a detailed program with session abstracts and presenter bios, and an online binder with course resources. Students chose breakout sessions and customized their schedule. We implemented a rule that students had to earn at least 80% of the available points in the gamification scheme and present their research to earn the certificate and a remote slide advancer. Our team curated a raw data repository (with documentation describing each dataset, its data dictionaries, sources, and potential tasks) from sources like Kaggle, the Comprehensive R Archive Network (CRAN), Our World in Data, the Centers for Disease Control (CDC), and the National Institutes of Health (NIH). We reviewed the datasets with students on the first day and they selected one based on their interests and were then mentored through a full data science project.

Innovations. Key creative innovations support the ASRI's goals to recruit, retain, and train female and URM students in an engaging and supportive environment. These innovations are summarized here and expanded upon in sections below (Table 4).

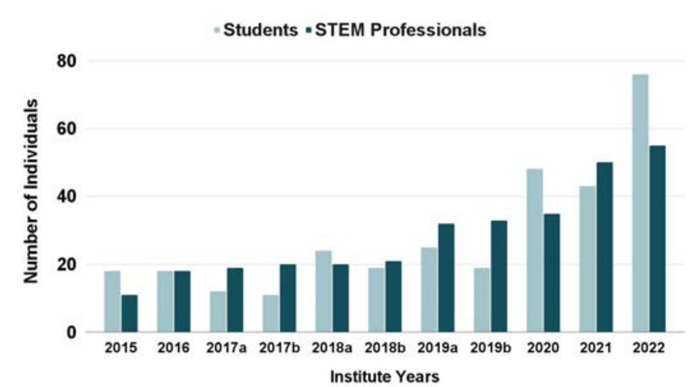

Figure 3. Growth of ASRI with consistently low student to STEM professional ratios. Years 2017-2019 had two separate cohorts of students each summer, denoted with an 'a' or 'b' after the year, hosted on different weeks.

Novel Organizational Approaches. A critical component to the ASRI foundation is the set of meticulously organized resources to orient students and plan their days. The online Daily Schedule is uncluttered and easily accessible. The Student Packet has hyperlinked schedules, session descriptions, and presenter biographies. Recording links are shared for students to access throughout the ASRI. A Google Drive folder serves as a dynamic Student Binder with presentation slides and materials. Links to online resources are organized in a dashboard document, which reduced past frustrations when students were not able to find links quickly.

The ASRI schedule is strategically designed to teach students essential research and data analytics skills to prepare them for professional careers (Table 5). Student learning is scaffolded in interactive lessons in data exploration, literature searches, research paper interpretation, hypothesis formulation, experimental design, statistical tests, analysis in R or Python, data visualization (graphing), and presentation

Table 4. *List of innovations used at the ASRI with a summary of benefits.*

Innovation	Description	Benefits
Schedule Organization	Sessions evolve and are intentionally diversified, scaffolded, and customizable.	Elevates experiential learning.
Skill Development	Essential scientific research and data analytics skills are emphasized with time built in for practice, questions, and independent research.	Improves abilities, independence, and confidence.
Engagement Technologies	Students answer questions simultaneously in real-time during most sessions via Pear Decks or Zoom tools, so their understanding is frequently assessed and interventions are immediately applied.	Enhances participation, identification of gaps in learning, and content comprehension.
Differentiated Teaching	Sessions are customized to meet students at their current level of preparation; participants self-select into beginner or intermediate sessions and join breakout rooms for individualized help.	Improves outcomes and success among students.
Gamification	Students earn points through a variety of activities. A leaderboard, updated nightly, shows earned points. Students with more points have more opportunities to win prizes.	Motivates students to participate, improving excitement, retention, and overall satisfaction.
Independent Research	Participants develop independent research projects based on curated data sets using data analytics techniques they learn in a practical process while being supported by one-on-one coaching.	Improves student abilities and confidence in data analytics and research communication.
Collaboration/ Networking	Students are given multiple opportunities to make valuable professional connections with each other, with faculty mentors, and with industry partners through mixed methods that include one-on-one coaching, panels, breakout rooms, and social media conversations.	Participants envision themselves as important future contributors to STEM fields and take advantage of tangible opportunities.

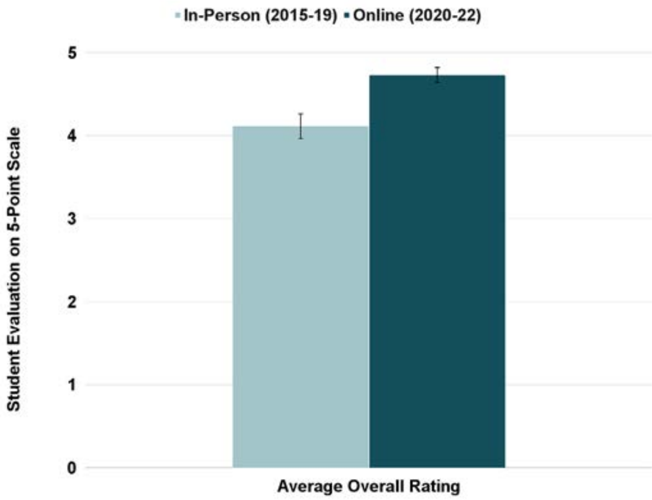

Figure 4. Overall student satisfaction at the end of each ASRI was measured by anonymous student evaluations using a 5-point scale. Student responses to this question from cohorts in the historical in-person model (2015-2019, N = 133) were compared to student responses from cohorts experiencing the new online model (2020-2022, N = 148) focused on data science training. A two-sample, unpaired t-test showed a statistically significant difference between in-person and online models ($t(213.7) = 7.1$, $p < 0.001$), with moderate effect size (Glass's delta, 0.87). Levene's test for equality indicated unequal variance ($F = 22.07$, $p < 0.001$) so degrees of freedom were adjusted from 279 to 214.

skills. Time is built in for questions, instructions, and reiterating of expectations.

Panel discussions have included STEM Careers, Data Science in Today's World, and Diversity, Equity, and Inclusion in STEM. Several faculty present "research stories" that exhibit their diverse backgrounds, career paths, and the reward derived from challenging research endeavors. Students are exposed to diverse voices during these sessions, and presenters are recruited based on students' reported degree programs and demographics. In 2022, more than 19 professionals from diverse racial and ethnic backgrounds, and with varied lived experiences, served as panelists or presented their research stories. These sessions are important and demonstrate that some STEM career paths are not linear and may include unexpected turns, which is often not explicitly discussed in formal educational settings. Students frequently rate these sessions highly in daily evaluations.

Each day includes a 90-minute lunch break, when students can sign up for optional virtual office hours. Each day ends with daily evaluations and "reflection and prep" homework to support the experiential learning process. Evaluations are anonymous, but to ensure high rates of completion, we compare the number of submitted evaluations to the number of active participants in Zoom and encourage students to complete the form. Examples of homework assignments include reviewing a resource for the next day, signing up for a dataset and specific breakouts, reviewing a résumé, sharing experimental design for feedback, and developing the final presentation. We ask students to submit screenshots or post responses on social media, which is monitored and documented each night.

Integrated Engagement Technologies. Various engagement technologies employed during synchronous and asynchronous activities help make the ASRI a success. Among the dozens of different sessions, there are no didactic lectures. Sessions are intentionally interactive and thoughtfully designed to build confidence, encourage engagement, and develop a sense of community. Presenters are trained to use Pear Deck, a digital tool in which students answer formative assessment questions anonymously in real-time; this keeps students engaged and allows misconceptions to be detected and addressed immediately. During technical sessions, presenters use the multiple screen share Zoom feature to troubleshoot and guide each student. Zoom annotation tools are invaluable in showing students what actions to take on their screens. The ASRI community also interacts asynchronously on UpSquad, a custom online community where current and former students, presenters, and organizers connect, communicate, and collaborate. Users create posts, tag individuals, share findings from their research projects, comment on other posts, access session recordings, and stay engaged as a cohort.

Personalized Customization. ASRI participants are from varied backgrounds, with different plans for their futures and with unequal levels of preparation and exposure to data science and research processes. To meet the needs of such diverse students, the ASRI offers beginner and intermediate tracks that students select based on their experience and abilities. For example, during the session "Setting Up Your Environment in R," students in the beginner track are given an overview of the RStudio Desktop environment, how to customize it, and the basic features before being taught how to import data files and proceed with exploratory data analysis. Those in the intermediate track have the necessary background to immediately jump into data exploration and analysis. We allow students to change tracks even during sessions if their original choice is not the right fit, or when they return for a second year.

During sessions, ASRI staff monitor the Zoom chat to ensure that each comment or question receives a response. Each technical session has breakouts during or after the main meeting when students can get individualized help. Breakouts and working groups are also opportunities for students to network with each other and offer constructive feedback. Students can sign up to get personalized advice on résumés, projects and presentations. Individual research consultations have been part of the ASRI since its pilot year and always receive excellent feedback. Research faculty meet one-on-one with students for about 25 minutes, though these conversations can last much longer. They have a highly per-

Table 5. *The two-week 2022 ASRI schedule showing concurrent sessions at beginner and intermediate levels with networking and help sessions, research stories, and panels. Note, some breakout sessions have four options.*

Monday June 6		Tuesday June 7			Wednesday June 8			Thursday June 9			Friday June 10	
9:00	Welcome And Introductions	**8:45**	Log In & Announcements		**8:45**	Log In & Announcements		**8:45**	Log In & Announcements		**8:45**	Log In & Announcements
		9:00	Data Set Sign Up		**9:00**	How to Read a Research Paper	Science Writing & Publication	**9:00**	Introduction to Data & Information Visualization		**9:00**	Finding Research Opportunities
10:00	Technology & Binder Overview		Data Science Project Overview - Full examples in R and Python		**10:30**	Starting Your Presentation - Finding Templates		**10:00**	Panel: Grad School & Postdoc Opportunities		**10:00**	Fundamental Design and UX for Science Communication
11:30	Networking Breakout Rooms	**11:30**	Networking Breakout Rooms		**11:30**	Support Rooms		**11:30**	Support Rooms		**11:30**	Support Rooms
12:00 PM	Lunch + Virtual Office Hours	**12:00 PM**	Lunch + Virtual Office Hours		**12:00 PM**	Lunch + Virtual Office Hours		**12:00 PM**	Lunch + Virtual Office Hours		**12:00 PM**	Lunch + Virtual Office Hours
1:00	Intro to Data Science	**1:00**	Literature Review & EndNote Web (Beginner)	Build your References (Intermediate) with Bibtex and Zotero	**1:00**	Introduction to Statistics and Experimental Design		**1:00**	Setting Up Environment in R (Beginner 1)	Setting Up Environment in Python (Beginner 1)	**1:00**	How to Use LinkedIn Effectively & Professionally
2:30	ASRI Repository Overview				**1:30**	Beginner Techniques in Statistical Analysis	Intermediate Techniques in Statistical Analysis		Starting your Project in R (Int 1)	Starting your Project in Python (Int1)	**2:00**	Building your Resume/ CV (including how to add ASRI)
3:30	Afternoon Break	**2:45**	Afternoon Break		**2:45**	Afternoon Break		**3:15**	Afternoon Break		**3:15**	Afternoon Break
3:45	Technology Installation / Setup	**3:00**	Panel: Data Science in Today's World		**3:30**	Physics Faculty: A Research Story		**3:00**	Beginner Techniques in Visualization	Intermediate Techniques in Visualization	**3:30**	Nonprofit Chief Quality and Informatics Officer: A Research Story
4:30	Wrap Up	**4:30**	Wrap Up		**4:30**	Wrap Up		**4:30**	Wrap Up		**4:30**	Wrap Up

Monday June 13			Tuesday June 14			Wednesday June 15			Thursday June 16			Friday June 17	
8:45	Log In & Announcements		**8:45**	Log In & Announcements		**8:45**	Log In & Announcements		**8:45**	Log In & Announcements		**9:00**	Presentations
9:00	Starting your project in R (Beginner #2)	Starting your project in Python (Beginner #2)	**9:00**	Overcoming the Odds- Perseverance in Research		**9:00**	Justice, Equity, Diversity, & Inclusion in STEM		**9:00**	Research Ethics, Data Ethics, & Privacy			
	Exploratory Data Analysis in R (Int #2)	Exploratory Data Analysis in Python (Int #2)	**10:30**	Feature Selection (Beginner)	Feature Selection (Intermediate)	**10:30**	Individual Consultations	Stats & Viz Working Rooms	**10:30**	Working with Missing & Corrupted Data (Beginner)	Imputation & Imbalanced Data (Int)		
11:30	Support Rooms		**11:30**	Support Rooms		**11:30**	Support Rooms		**11:30**	Support Rooms		**11:30**	Lunch + Virtual Office Hours
12:00 PM	Lunch + Virtual Office Hours		**12:00 PM**	Lunch + Virtual Office Hours		**12:00 PM**	Lunch + Virtual Office Hours		**12:00 PM**	Lunch + Virtual Office Hours			
1:00	Giving a Compelling Research Presentation		**1:00**	Intro to Arithmetic & Matrix Operations	Working Group- Intermediate Feature Analysis & Engineering	**1:00**	Individual Consultations	Python Stats & Viz Support	**1:00**	GGplot in R and Python	Visualization with MatplotLib	**1:00 PM**	Presentations
2:00	Designing your Data Science Experiment (Beginner)	Designing your Data Science Experiment (Intermediate)						R Stats & Viz Support	**2:15**	Intro to Cloud Computing	Visualization with Seaborn (Python)	**3:00 PM**	Awards Ceremony
3:15	Afternoon Break		**2:45**	Afternoon Break		**3:15**	Afternoon Break		**3:15**	Afternoon Break			Complete Daily Evaluation & Tweet or post on LinkedIn your favorite session you attended this week, tag #ArkansasSRI
3:30	Data Science Case Study - Gathering Data: Personal Inputs		**3:00**	Panel: STEM Careers		**3:30**	Translational Bioinformatics: A Research Story		**3:00**	Building Your Data Science Portfolio (Github/Project Management)			
4:30	Wrap Up		**4:30**	Wrap Up		**4:30**	Wrap Up		**4:30**	Wrap Up			

sonalized conversation during which faculty offer targeted advice, encouragement, new ideas, and/or an opportunity for the student to practice their presentation. We pair students and faculty based on common research fields and urge faculty to "meet students where they are." Each student gets a fresh perspective on their ideas and progress while benefiting from faculty expertise.

Motivating Gamification. Gamification encourages students to be active participants. They earn points for attending onboarding activities and ASRI sessions, answering Zoom polls, participating in Pear Deck, asking thoughtful questions during sessions, sharing experiences on social media with the hashtag #ArkansasSRI, and submitting screenshots of their work in UpSquad. Awarding points for asking questions has been so effective that the Zoom chat window can become overwhelmed by eager students. Because multiple ASRI organizers are present in Zoom, these questions can be answered in chat or combined and asked of the presenter by a moderator. Presenters are surprised by and praise this level of engagement and return to the ASRI year after year. Such open communication spurs additional conversations and discussions, some of which have even led to students getting internships in the presenters' labs.

Throughout the ASRI, a leaderboard shows the students' earned points. Tallying points requires a significant time investment from the organizers, but this effort is worthwhile as students log in excited to see the leaderboard and win prizes from randomized spins on a virtual wheel. The more points they earn, the more chances they have to win. Interestingly, points earned have also been a good predictor of which students present their research and earn the certificate of completion. Only three students who gave a final presentation in 2022 earned less than 50% of the possible points. Gamification can also promote competitiveness in students which can be directed towards a positive experience. Emphasizing that the depth and breadth of the skills learned are the most important rewards helps students not to overly focus on accounting for every point.

Independent Research Project with Individualized Help. The ASRI implements mixed pedagogy methods and best practices in mentorship to ensure that every student completes a data science research project, delivers a presentation of their findings, and builds a curriculum vitae (CV). The participants are led through data cleaning, exploratory data analysis, experimental design, feature selection, statistical analysis, visualization, and communicating the results. Students sign up for a curated dataset. Intermediate students learn more advanced techniques like deep learning and feature engineering, while beginners perform simpler statistics and visual analysis. Initially, basic examples of full projects are presented in R and Python with prepared code notebooks, and students choose which language they will use. Students with no prior coding experience who struggle in the programming sessions are offered help completing their projects in Google Sheets or Excel rather than risk withdrawal from the ASRI. Additional sessions demonstrate how to develop and deliver a compelling presentation. Students must virtually present their work to peers, with a proctor, to receive evaluations, comments and suggestions from their peers and earn their certificate of completion and receive any prizes they won. Finally, students are led through creating or expanding a personal GitHub repository with their work and adding their ASRI research experience to their CV.

Collaboration and Networking. Opportunities for collaboration and networking are integral parts of a program intentionally designed to prepare students for professional STEM careers with increased chances of success. ASRI students benefit from consultations and office hours, the UpSquad and LinkedIn communities, and student roundtable discussions on rotating topics like research interests, future career plans, examples of adversities overcome in research, or specific components of the ASRI projects. In addition to breakout rooms, panels create opportunities for students to ask questions and make connections with STEM professionals. Panelists discuss how data science is key to numerous fields and give advice for educational and professional paths. Students also interact with faculty members from many institutions, some of whom are open to networking and collaborating with interested students. Since 2015, over 130 STEM professionals and faculty have contributed to the ASRI. Some students receive job and internship offers during sessions and many are bridged into graduate programs.

Before, during and after the ASRI, students are asked to use the hashtag #ArkansasSRI on social media (Twitter, Facebook, and LinkedIn). Communities on Facebook and LinkedIn are maintained by AR EPSCoR where alumni and presenters remain connected. In 2021, we contracted with UpSquad to provide an ASRI online community and primary tool for program administration; it has a familiar social media aesthetic and broad functionality, replacing other previously used platforms. UpSquad works with the ASRI organizers annually to customize the online community and increase functionality.

RESULTS

Increased Participation of Underrepresented Groups. Historically, groups underrepresented in STEM (Black/African Americans, Hispanics/Latinos, Native Americans/Alaska Natives, women, and those with disabilities) have been overrepresented at the ASRI relative to their representation in the STEM workforce (Figure 1B). ASRI cohorts have also included a larger proportion of URM individuals than the Arkansas population as a whole (Figure 1C). This is primarily due to the targeted recruitment and retention strategies described earlier, recruitment materials that include photos and videos from previous cohorts, and specific onboarding and technical support to retain participants with less preparation and fewer resources. This pre-ASRI onboarding ensures access to technical tools and introduces the organizers to improve retention and excite students to be active participants.

Enhanced Skill Development through Scaffolding. Since its inception, the ASRI has used a holistic approach to the curriculum, targeting development of both scientific/techni-

Table 6. *Statistical analysis of each question about skills answered by students on pre- and post-institute surveys in 2022. Results are for one-sided, two-sample, paired t-tests at the 0.05-level of significance (all p values are significant and effect sizes are large).*

Questions	Pre-survey		Post-survey		r	t^*	p	Effect Size (Cohen's d)
	$\bar{x}$	SD	$\bar{x}$	SD				
Please rate your experience with programming (in Python or R)	2.61	1.26	3.47	1.01	0.084	-4.46	<0.001	1.54
Please rate your experience with repositories	2.03	1.21	3.55	1.07	-0.149	-7.02	<0.001	1.73
Please rate your experience with data analysis	3.02	1.03	3.58	0.85	0.062	-3.47	<0.001	1.30
Please rate your experience with data visualization	2.91	1.14	3.67	0.84	0.001	-4.34	<0.001	1.41
Please rate your experience with presenting research	3.23	1.21	3.86	0.92	-0.098	-3.15	0.001	1.59

*$\bar{x}$: mean score; SD: standard deviation; r: correlation between matched pair scores; t: matched pair dependent t-statistic; p: p-value; *Degrees of freedom for all questions were 63.*

cal skills and more general professional skills. Examples of technical skills included gel electrophoresis and 3D printing in earlier cohorts, and programming in Python or R in later cohorts. Other skills, like choosing appropriate statistical tests and learning how to read research papers, have been featured at every ASRI. Professional skills include networking with LinkedIn, communicating scientific findings, building a CV, and persevering in STEM (Table 3). Every session addresses core competencies to encourage student growth. For example, the data analysis competencies addressed include setting up the working environment, importing and cleaning data, conducting exploratory data analysis, practicing basic statistical and matrix operations for beginners, while intermediate students learn to apply feature analysis, selection, and engineering, perform statistical or machine learning analysis, work with missing or imbalanced data, manage code projects (including version history), and build a portfolio on GitHub. Such scaffolding of content enhances skill development, and this improvement was measured using a 5-point scale where 1 = *poor*, 2 = *fair*, 3 = *good*, 4 = *very good*, and 5 = *excellent* on pre- and post-institute surveys. Skills such as experience with programming, data repositories, data analysis, data visualization, and presentation of one's research were assessed. A paired, one-sided two-sample t-test showed that students' confidence in these skills improved significantly ($p < 0.001$, Figure 2 and Table 6) when pre-survey scores ($M = 2.8$, $SD = 1.22$) were compared to those on a post-survey ($M = 3.63$, $SD = 0.95$). This is a 30% improvement in confidence across the five measured skills.

Focus on Mentorship. To provide students with significant individual mentorship, many faculty and STEM professionals volunteer to participate each year so our pool of research mentors has expanded as our student population has grown. In fact, our student to faculty ratio approaches 1:1 each year (Figure 3). In addition to recruiting diverse students, the ASRI also deliberately recruits female and URM presenters. Since the ASRI is not affiliated with any one campus, the research faculty, like the students, are recruited from multiple campuses, increasing mentor diversity. The ASRI also highlights female and URM voices by including multiple panels and diverse research story seminars. For example, over 47% of our presenters were female even though only 34% of STEM jobs are held by women. Female minorities hold only 4.3% of STEM jobs (National Science Board, 2022), whereas 8.7% of the ASRI faculty presenters are female minorities.

Elevated Student Satisfaction. The ASRI is formally evaluated each year by the AR EPSCoR external evaluator who produces a report used to make iterative program improvements. The ASRI evaluation process collects daily anonymous feedback from students to enable changes in real time to continue to improve the program such as when more help time slots were added to lunch breaks based on evaluations. Students are eager to provide this feedback because they are made aware that their opinions are appreciated and lead to improvements each year. Since 2015, a majority of participants have submitted evaluations ($N = 281$, $M = 90.3\%$, $SD = 11.5\%$). Though initially it was surprising to the organizers, the overall student-reported satisfaction increased with the change from an in-person to a virtual program (Figure 4). Using a 5-point scale where 1 = *poor,* 2 = *fair*, 3 = *good*, 4 = *very good*, and 5 = *excellent*, students were asked to anonymously rate their overall ASRI experience. Virtual students from 2020-2022 ($N = 148$) rated their overall program experience higher ($M = 4.73$, $SD = 0.53$) than those from 2015-2019 ($N = 133$) who were in-person ($M = 4.11$, $SD = 0.87$), indicating a 15% increase in satisfaction for the online model. This difference was statistically significant (legend of Figure 4) and may be the result of continued improvement in other aspects of program quality despite the more challenging virtual model. The positive response to a virtual ASRI may have been unexpected, but is welcome and supported the decision to continue the program virtually.

Student Perspectives, Testimonials, and Positive Impacts on Future Endeavors. Anonymous testimonials on student evaluations also show efficacy and impact. For example, participants comment on the warm, welcoming ASRI environment which is particularly noteworthy for an online format. To quote one student: "*Something incredibly memorable was how welcomed and unified this community* *feels. All the presenters/facilitators were so passionate and ready to help.*" Another said that the organizers "*made the place feel friendly and inviting even though there are so many people participating!*" Students noticed efforts to create safety nets for retention, with one student reporting "*Even when I was struggling a lot, [...] I was given help and not left behind*" while another student said, "*I know I have the support of the amazing ladies who are handling such a big cohort!*" URM students also feel represented at the ASRI, with comments like "*I loved how minorities and ethics were involved in this program! They are important topics that need to be acknowledged! As a female minority, it encouraged me to help others who are victims of 'imposter syndrome'.*" This sense of community also helps students feel like they belong in STEM, with one student explaining "*I am truly thankful that I had the opportunity to participate. The confidence boost—knowing that I belong in the science world is truly priceless.*" Another student put it even more succinctly: their ASRI experience resulted in "*Knowing that I* [...] *can do everything I want to do.*"

Another frequent observation in the evaluations is the adaptability of the organizers and customizability of the ASRI experience. One student said this "*is the most adaptive learning platform I have ever experienced. Sessions and activities are customized to individual students' needs.* [The ASRI] *basically created a virtual individual classroom for each participant despite the group environment. The ASRI model is definitely the future of virtual learning!!*" A second student said "*I absolutely love the fact that the facilitators are adaptive and tailor the training to individual needs. That is rare. Thank you!!!*" Another student also noticed that their responses from the daily evaluations were being considered and needed changes were being made in a matter of hours, saying "*I can tell that our suggestions are being implemented, so thank you for listening.*"

Students also use the anonymous evaluations to point out how the ASRI exceeded their expectations. One said that they only came to learn data science, but instead "*learned data science, grad school, research, funding, resumes, presentations, etc.,* [and] *met cool people.*" Students also describe a number of transformative experiences. For example, one said "*The best thing that has come out of ASRI so far is having a 'fire ignited' in me to pursue a Ph.D.*" Another confessed that they had felt "*very unsure if I was 'good enough' to do research, but with a lot of tools online and skills I've learned this week, I think I am going to look for internships or jobs as a research assistant.*" And still another student wrote that they "*felt so empowered when I left, and I know I will remember that feeling in the future.*"

AR EPSCoR keeps track of updates ASRI alumni share on social media, especially on LinkedIn. Many have gone on to graduate school, started jobs in STEM fields and academia, and won awards. After experiencing an ASRI entrepreneurship panel, two students who met at the ASRI, but attended different campuses, formed a team during an unrelated health science entrepreneurship competition and won first place. Another student shared in an evaluation that

> *A new friend of mine from ASRI who also attends* [my university] *got me in contact with the right people so that I can apply and maybe become a TA/tutor for statistics!!! I wanted to do this anyways, but now I have the opportunity to do it AND I'm far more qualified!!*

In addition to positive feedback directly from students, the ASRI's success in providing effective training and mentorship to female and URM students has been noticed by others who have inquired with a desire to replicate our model.

DISCUSSION

Though female and URM participation has slowly increased in STEM fields nationwide, significant gaps persist. Over eight years, the ASRI has been focusing on recruitment and retention of female and URM students to increase their entry into the STEM workforce. One of the unique aspects of the ASRI is its inclusion of URM and non-URM students and faculty working together as one community to learn technical and professional skills within an experiential framework that purposefully addresses diversity, equity, and inclusion throughout. Over 300 students and 130 mentors have collaborated through this model. The results are improved confidence to explore independently, perseverance to complete challenging inquiries, and ability to perform and present research. ASRI alumni feel empowered to seek further opportunities across an extensive network of mentors and professionals to pursue and excel in STEM careers.

Lessons Learned and Future Plans. Throughout the years, the ASRI has focused on increasing the proportion of female and URM participants. It has also been critical to adjust to changing participant needs, which have included various challenges from recruiting the desired populations to resolving transportation and technology needs. The most successful approaches, which resulted in over 50% of our participants being URM students, included recruiting from HBCUs and through diversity offices from Arkansas campuses and beyond. Recruiting through these offices and programs was more difficult during the pandemic, leading to the conclusion that URM participation should not be taken for granted and must remain a committed program goal. To recruit even more URM individuals in the future, the organizers plan to reach out to specific community leaders and individuals invested in providing opportunities for these groups. To retain URM students and encourage them to pursue a STEM career, ASRI organizers recruit diverse presenters (females, those from URM, and from diverse fields) resulting in an impressively low student to faculty ratio that approaches 1:1. Onboarding prior to the start of the ASRI has been so successful in reducing confusion, speeding up technical sessions, and creating engaging content that additional time and even more targeted virtual orientation sessions to support URM students are planned.

Though the initial transition to an online model was forced by the pandemic, this form of delivery was rated higher by students, as overall satisfaction increased from 4.11 to 4.73 on a 5-point scale, and led to a larger audience because it removed space limitations and reduced costs. It also led to better outcomes as observed by more complex independent research projects and a 30% improvement in confidence levels across various research and analysis skills. ASRI achievements provide evidence that data science and research preparation can be taught successfully online as long as innovative strategies and technologies for engagement, customization, and interactive learning are at the core of each session. The adjustment to a virtual platform was not automatic, as many new session types had to replace in-person laboratories and technical experiences. In the future, attention to emerging interactive technologies and virtual tools will continue to be at the forefront of ASRI organization along with continued emphasis on data analytics, statistics, and independent research projects. The critical shift from participants presenting their own preliminary lab research or already published data to analyzing raw data to test their own hypotheses was a tough lesson to learn because the first was too simple and the second too time consuming. A successful compromise developed in 2022 resulted in students choosing a dataset from over a dozen raw sets curated by organizers. The research project component has fostered a sense of pride and confidence in students. Future plans include the extension of the ASRI to two and a half weeks, allowing restructuring of the flow of the technical sessions to better support each stage of the student project development and allow more guided time for student learning and one-on-one help.

Though targeted recruitment of female and URM students, use of engaging technological advancements, and a focus on independent research all contribute to the program's success, its overall organization and networking are also key foundational pieces. In addition to changing types, levels, and timing of program components, even the sessions that occur each year are updated and refined. To avoid unnecessary confusion, the organizers created a dashboard for participants to quickly find what they need. In each subsequent year, differentiation and individual one-on-one help have grown substantially as the ASRI has evolved to become more responsive to student needs. This improvement has been possible because of the consistently low student-to-mentor ratios and the built-in flexibility that includes times set aside for help. Because many participants are non-traditional, the ASRI organizers record and post sessions and include asynchronous components to accommodate varying schedules and student needs. Finally, to keep students engaged, gamification and networking have been built in and continue to be improved every year. The extra incentive of points and a leaderboard motivates students to complete complex assignments and pay attention during sessions. Participants who might have been too intimidated to approach a STEM professional or faculty member in person expressed more comfort in speaking up on Zoom, interacting via chat, or connecting in one-on-one sessions. Many of the described adjustments were made specifically in response to student comments, concerns, and suggestions. The ASRI program is never static: substantial changes are implemented by the organizers each year to accommodate the changing needs of participants which improves content rigor, program success and participant satisfaction.

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Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript.

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ABBREVIATIONS

Ark-LSAMP: Arkansas Louis Stokes Alliance for Minority Participation Program, ASMSA: Arkansas School for Mathematics, Sciences, and the Arts; ASSET: Advancing and Supporting Science, Engineering and Technology; ASRI: Arkansas Summer Research Institute; DART: Data Analytics that are Robust and Trusted; AR EPSCoR: Arkansas Established Program to Stimulate Competitive Research; HBCU: Historically Black Colleges and Universities; NSF: National Science Foundation; RCR: Responsible Conduct of Research; STEM: Science, Technology, Engineering, and Math; URM: underrepresented minorities.

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