

**Final Report**  
**on the**  
**Mathematical Sciences Research Institute**  
**2018 Undergraduate Program (MSRI-UP)**  
**supported by**  
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**2018 Mathematical Sciences Research Institute – Undergraduate Program  
(MSRI-UP)  
Annual Report**

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**2018 Mathematical Sciences Research Institute – Undergraduate Program  
(MSRI-UP)  
Final Report**

**1. Introduction**

The Mathematical Sciences Research Institute Undergraduate Program (MSRI-UP) is a comprehensive program for undergraduates that aims to increase the number of students from underrepresented groups in mathematics graduate programs. MSRI-UP includes summer research opportunities, mentoring, workshops on the graduate school application process, and follow-up support.

The primary objective of the MSRI-UP is to identify talented students, especially those from underrepresented groups, who are interested in mathematics and make available to them meaningful research opportunities, the necessary skills and knowledge to participate in successful collaborations, and a community of academic peers and mentors who can advise, encourage, and support them through a successful graduate program. We achieve this through an intensive six-week summer program of mathematics research and other activities, along with maintenance of relationships with participating students for years beyond the summer program.

The MSRI-UP is coordinated by an experienced team of five directors, consisting in 2018 of Professors Federico Ardila of San Francisco State University, Duane Cooper of Morehouse College, Maria Mercedes Franco of Queensborough Community College (CUNY), Rebecca Garcia of Sam Houston State University, and Suzanne Weekes of Worcester Polytechnic Institute. The directors collaborate continuously and annually rotate direct leadership of the program. The program is supported by the leadership and staff of the Mathematical Sciences Research Institute in Berkeley, site of each summer's six-week program.

The **2018 MSRI-UP** ran from June 16 through July 29 with 18 students studying and researching The Mathematics of Data Science. The summer program was staffed by Lead Director Prof. Maria Mercedes Franco, research leader Prof. David Uminsky of University of San Francisco, postdoctoral fellow Dr. Mario Banuelos of California State University-Fresno, and graduate students Paul Samuel Ignacio of University of Iowa, and Joanna Itzel Navarro of University of California-Los Angeles.

During the previous 11 summers (2007-2017), 187 students conducted 63 small group research projects in Computational Mathematics, Experimental Mathematics, Coding Theory, Elliptic Curves and Applications, Mathematical Finance, Enumerative Combinatorics, Algebraic Combinatorics, Arithmetic Aspects of Elementary Functions, Geometric Combinatorics Motivated by the Social Sciences, Sandpile Groups, and Solving Systems of Polynomial Equations. Most MSRI-UP participants who have graduated college proceeded to enter graduate programs in the mathematical sciences. In 2019, the MSRI-UP will continue with 18 new undergraduates conducting research projects in Combinatorics and Discrete Mathematics, led by Professor Pamela E. Harris of Williams College.

## 2. Funding Information

The funding available to administer the 2018 MSRI-UP is summarized as follows:

- |                                    |                           |
|------------------------------------|---------------------------|
| 1. The National Science Foundation | \$138,376.59 <sup>1</sup> |
| 2. The Alfred P. Sloan Foundation  | \$138,912.17 <sup>2</sup> |
| 3. The National Security Agency    | \$23,399.95 <sup>3</sup>  |

In addition, the MSRI provided much additional support by allowing MSRI-UP to use classrooms, offices, and computers; by facilitating transportation; and providing administrative assistance.

## 3. Recruitment, Application and Admissions Procedures

The directors began recruiting for the 2018 MSRI-UP at the MAA MathFest in Chicago, IL in July 2017, the NAM MATHFest in Brooklyn, NY in September-October 2017 and at the annual national conference of the Society of Chicanos/Hispanics and Native Americans in Science (SACNAS) and its preconference, Modern Math Workshops, in Salt Lake City, UT in October 2017. The directors distributed fliers and talked to dozens of students and faculty about the program. The MSRI-UP home page also provided information about the program and the application process and the program is advertised through the AMS calendar and MSRI's mailing lists. Recruitment of students also occurred that fall at the Math Alliance's Field of Dreams conference and then in January 2018 at the Joint Mathematics Meetings.

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<sup>1</sup> NSF grant award #: DMS-1659138

<sup>2</sup> Alfred P. Sloan grant award #: G-2017-9876

<sup>3</sup> NSA grant award #: H98230-18-1-0008

The online application, which resided on the mathprograms.org site, consisted of four items: a completed student application form, transcripts, a statement of interest, and a letter of recommendation. The 2018 MSRI-UP received 434 applications.

Directors Ardila, Cooper, Franco, Garcia, and Weekes, reviewed each application and evaluated it using four criteria: 1) the student's grades in mathematics courses; 2) the student's mathematical background; 3) the statement of interest; and 4) the letter of recommendation. Based on these criteria, directors gave each applicant a score between 0 and 10. The scores were averaged, and this score served as the initial measure for evaluating each applicant. The directors then proceeded to discuss individual applications and eventually reached a consensus on the students invited to join the program.

#### **4. Summary of Participant Demographics**

Table 1 details some demographic information of the eighteen MSRI-UP students of the 2018 program. The student participants were diverse in terms of their intended majors as well as by the types and geographic regions of their undergraduate institutions. The cohort composition was 50-50 in terms of gender. This is the first cohort, since the founding of the program, where 100% of the participants came from URM groups. Also a first, African Americans made up 50% of the cohort. There were five African American males, the largest number we have had per cohort (previously reached in 2012) and four African American females, also the largest number we have had per cohort (previously reached in 2013 and 2010). Achieving this type of diversity and gender balance is important for creating the academic and research environment that characterizes MSRI-UP and for achieving one of the program objectives.

#### **5. Housing and Lodging for the Students**

The students were housed in Stern Residence Hall at the University of California, Berkeley. On weekdays, lunch was served at MSRI. The lunches at MSRI were shared with graduate students, and faculty participating in other MSRI summer programs. This allowed students to meet mathematicians at different stages of professional development. The students and the program's graduate students had breakfast and dinner at the dining facilities in the residence hall. Sharing meals with their MSRI-UP peers promoted mathematical discussions and enhanced the collaborative and intellectual environment of MSRI-UP.

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**Table 1**  
**2018 Mathematical Sciences Research Institute (MSRI-UP)**  
**Student Data**

| <b>Undergraduate Institution, State</b>             | <b>Gender</b>                   |
|---|---------------------------------|
| California State Polytechnic University, Pomona, CA | Male: 9                         |
| California State University, Channel Islands, CA    | Female: 9                       |
| California State University, Fullerton, CA          |                                 |
| California State University, Monterey Bay, CA       |                                 |
| Central Washington University, WA                   |                                 |
| Georgia Institute of Technology, GA                 | <b>Major</b><br>Applied Math: 2 |
| Georgia State University, Perimeter College, GA     | Computer Science: 2             |
| Hampton University, VA                              | Elect. Engineering & CS: 1      |
| Harvey Mudd College, CA                             | Mathematics & CS: 3             |
| Macalester College, MN                              | Mathematics: 9                  |
| Morehouse College, GA                               | Mathematics Education: 1        |
| Pomona College (x2), CA                             |                                 |
| Stetson University, FL                              |                                 |
| University of Maryland, Baltimore County, MD        | <b>Race/Ethnicity</b>           |
| University of Mississippi, MS                       | African American: 9             |
| University of Puerto Rico, Rio Piedras, PR          | Latino/Hispanic: 8              |
| University of Rochester, NY                         | Native American: 1              |

*Among the 17 institutions listed above, there are 2 HBCUs, 1 Community College, and 10 Public. 15 campuses are considered midsize/large and are located in suburbs/cities and 2 campuses are located in towns considered distant (1) or remote (1). The 17 institutions spread across 9 states and Puerto Rico.*

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## **6. Pre-Research Mini-Courses**

During the first two weeks of MSRI-UP, students participated in mini-courses consisting of lectures, workshops, and problem-solving sessions. Professor Uminsky and the program staff familiarized students with the motivation and fundamental concepts of The Mathematics of Data

Science — including elements of linear algebra, statistics, and topological data analysis — and also the main techniques that they would need to work on their research topics. The pre-research phase was conducted in the Baker Boardroom, an excellent classroom-type facility at MSRI. Appendix A of this report gives the program schedule with the structure of the six weeks of the program.

Students worked on homework assignments on site at the MSRI during the day, and in the residence hall during the evenings. The postdoctoral and graduate student assistants were constantly present as an available resource. Small study groups were formed and shuffled so that each student had the opportunity to work with all of the other 17 students, and so that the students and the program staff could identify partnerships that collaborated well or poorly.

## **7. Research Projects, Technical Reports, Posters, and MSRI Student Presentations**

The focus of the six-week summer component of MSRI-UP is undergraduate research. From the third week until the end of the program, each student worked exclusively on an undergraduate research project in the field of data science that was carefully designed by the program staff led by the research leader, Prof. Uminsky.

At the end of the second week of the program, students received descriptions of the possible research projects. The students were requested to rank their top project choices, to state their teammate preferences, and to provide any additional information that they believed would be helpful to the program staff when defining the research teams. The research staff then composed the six research teams, satisfying student preferences as much as possible while paying attention to interpersonal dynamics revealed in the previous two weeks.

During the research phase of MSRI-UP, students worked in the offices assigned to them at MSRI. Professor Uminsky oversaw all the work of all six groups. Postdoctoral fellow, Dr. Mario Banuelos, and the two graduate assistants, Paul Samuel Ignacio and Joanna Itzel Navarro, each held supervisory roles with two research teams. The undergraduates summarized their daily progress to the research mentors, and each team met their mentors separately at MSRI or at the dorms. During the program, MSRI-UP participants were introduced to some of the techniques that are used while conducting successful research in the mathematical sciences. For instance, students learned to work on an open problem, generate conjectures, partial results, and proofs. They also learned to work as part of a research team, develop an effective faculty advisor-student

relationship, use computer software as tools, use the internet as a resource, prepare and deliver poster and oral presentations, write a mathematics paper (technical report), and use LaTeX, including the Beamer package for presentations. The program also included informal sessions for students to learn about and discuss the personal aspects of being a researcher: confidence, resilience, stereotype threat, and issues of inclusion and equity.

The students' research work resulted in three outcomes. Each group

1. wrote a technical report in LaTeX where they explained the context of their research problem and outlined their main results,
2. made a poster in LaTeX, which they presented at national conferences such as the Field of Dreams, SACNAS, and the Joint Mathematics Meetings,
3. gave an oral presentation on the final Friday of the program to their mentors and peers as well as to MSRI staff and guests.

The program of final research presentations is included as Appendix B to this report. Appendix C gives the abstracts for each of the 6 research projects. The technical reports are available upon request. The recorded presentations are available in MSRI's archive of video lectures; they can be accessed at [http://www.msri.org/msri\\_ups/882#schedule](http://www.msri.org/msri_ups/882#schedule). Three of these groups and their mentors have continued the research and are working on manuscript preparation.

## **8. Evaluation of Student Work**

Close interaction with students allowed the program staff to give individuals feedback on their work throughout the program. During the pre-research phase, homework assignments were reviewed by the program staff and the students were given written and oral feedback individually. During the research phase, each of the six research teams gave oral presentations to the program staff daily. At the end of the presentations, teams received feedback on the substance and style of their deliveries. The research advisors gave students written feedback on drafts of their technical reports.

Professor Franco met with the research staff daily and held formal one-on-one meetings with students every two weeks. These meetings provided Prof. Franco with the opportunity to identify and address participants' needs and address any concerns about individuals or teams that may have been identified by the research staff. The type and frequency of communications with both research staff and students allowed Prof. Franco to ensure that the program was providing a rigorous and

supportive environment for every student and that the needs of the postdoctoral fellow and graduate students were also being met.

## **9. Colloquium Series**

The 2018 MSRI-UP hosted six mathematicians for a colloquium series: Dr. Terrence Blackman (Medgar Evers College-CUNY), Dr. Rebecca Garcia (Sam Houston State University, MSRI-UP Program Director), Dr. Edray Goins (Pomona College – MSRI-UP Research Leader 2010), Dr. Johnny Guzman (Brown University), Dr. Yannet Interian (University of San Francisco), and Dr. Antonio Montalban (University of California, Berkeley).

The colloquium series stimulated the mathematical interests of the students and gave them a glimpse of current research in varied fields of the mathematical sciences. In addition to this, the speakers provided the students with additional role models and expanded their network of mentors. In particular, each speaker was asked to share stories about their mathematical journey and any advice that they would like to share with the students. The speakers' schedules were arranged to maximize opportunities for them to engage the undergraduates in informal conversation, and many students took advantage of those additional opportunities to listen, ask, and learn.

## **10. Graduate School Workshop and Professional Panels**

There was a formal workshop on 'Graduate School and Fellowships,' facilitated by Dr. Colette Patt (Assistant Dean of Mathematical & Physical Sciences at UC Berkeley).

We held three professional panels where mathematicians talked about their experiences in school and their professional trajectories, and fielded questions from the undergraduate students.

The MSRI-UP Alumni/Graduate Students Panel featured eight graduate students, half of whom are past MSRI-UP participants. The MSRI-UP alumni and current graduate students on the panel were Mr. Caleb Bugg (UC Berkeley, PhD program in Industrial Engineering & Operations Research), Mr. Gabriel Elvin (UC Riverside, PhD program in Mathematics), Ms. Viviana Marquez (University of San Francisco, MS program in Data Science), and Mr. Andres Rodriguez (who was about to defend his dissertation in the MA program in Mathematics at San Francisco State University and was headed to UC San Diego to start his PhD in Mathematics). In addition, this panel featured Ms. Delani Molitor (UCLA, PhD program in Mathematics), Mr. John Urschel (MIT, PhD program in Mathematics), and Drs. Anna Ma (had finished a PhD in Computation

Science at Claremont Graduate University and was headed to a postdoctoral position in Mathematics at UC San Diego) and Aisha Wilson (had finished a PhD in Statistics at UC Berkeley and was headed to a postdoctoral position at Microsoft New England – MSRI-UP Grad School Panelist 2015).

The Women in Math Panel & Diversity Fishbowl featured Dr. Candice Renee Price (University of San Diego – MSRI-UP postdoctoral fellow 2013 and graduate research assistant 2008 and 2009), Dr. Nakeya Denise Williams (United States Military Academy), Dr. Shelby Wilson (Morehouse College), and Dr. Emilia Huerta-Sanchez (UC Merced). Program director Maria Mercedes Franco served as moderator for the Fishbowl.

The Career Panel featured Russell Avdek (Data Engineering Lead, Sonder Inc.), Blake Hunter (Data Scientist, Microsoft), Calandria Moore (Data Scientist, Department of Defense), Deanna Needell (Professor of Mathematics, UCLA), and David Uminsky (Associate Professor and Director of MS in Data Science, University of San Francisco – MSRI-UP Research Leader 2018 and Lunch Guest 2017).

## **11. Additional Workshops & Guests**

The research staff offered workshops on Python and R, the state-of-the-art programming languages oriented toward data science. During the pre-research weeks of the program, problem solving sessions and homework assignments included problems designed to strengthen students' coding skills in both languages. Students' assignments and, later on, research projects involved working on platforms like Anaconda, Jupyter Notebooks, or GitHub to support coding tasks and version control, iGraph for network analysis, and Overleaf, the online environment that supports Latex, to work on their technical reports and Beamer presentations.

The Lead Director, Prof. Maria Mercedes Franco, provided a 'Responsible Conduct of Research' workshop. In addition, she offered formal and informal trainings on public speaking and oral presentation skills during the research phase of the program. On the last week of the program, in particular, each research team delivered its final oral presentation to Prof. Franco for a last round of feedback on the substance and style of their deliveries.

The program also held *Lunch Discussions* where we all sat together over our lunch hour to have informal discussion with a mathematician who told us about her/his career path and who

fielded questions from the students, including the visitors mentioned above plus other guests such as MSRI-UP Program Directors Federico Ardila and Rebecca Garcia.

Among the guests, speakers, and panelists that were part of 2018 MSRI-UP, nine have been involved in MSRI-UP as past participants, members of the program staff, or guests. This synergy between current students, alumni/graduate students, and faculty in various stages of their careers play a central role in providing vertically integrated mentorship at all levels. This also fosters a feeling in the students that they are part of a larger professional network, the MSRI-UP family, and that much that the directors' hope for them is, indeed, achievable.

## **12. Recreational/Cultural Activities**

In addition to all the academic activities described above, MSRI-UP students were treated to several recreational activities. These carefully planned recreational and cultural activities were essential to MSRI-UP's success, as they helped to build the MSRI-UP mentored community, as all staff participated in the activities with the students. This gave everyone the opportunity to put mathematics aside for a few hours to connect with each other on a more personal level. Professors Maria Mercedes Franco and David Uminsky and Dr. Mario Banuelos brought their families along on several of these excursions. It was important for the MSRI-UP students to see the other dimensions of the lives of the faculty.

The 2018 MSRI-UP Saturday field trips went to Golden Gate Park and Land's End; Muir Woods and Stinson Beach; San Francisco's Ferry Building and Cable Car Tour; Exploratorium, Filbert Steps and Coit Tower; and Berkeley's Botanical Garden. The group also had a 4th of July picnic at Cordornices Park in Berkeley.

The group also went on two short tours: a 2-hour tour of Meyer Sound (Berkeley) and a 1.5-hour tour of Pixar (Emeryville). These tours were scheduled during weekdays and while they served as an opportunity for everyone to take a break from work, they were also informative and added to ongoing conversations between students and program staff about the type and quality of internships and careers in academia, government, and industry.

## **13. Program Evaluation During MSRI-UP**

Informal formative evaluation in the program started the first day of the program through conversations with students and program staff. Professor Maria Mercedes Franco met daily with

the program staff and regularly with individual staff members and students, conducting extensive discussions with Professor Uminsky to learn about and share opinions regarding the research component. During the meetings with staff and students, the Lead Director had the opportunity to listen to specific concerns, and to provide individual mentoring to the students. The graduate students' close interaction with the students enabled them to gather informal feedback that also led to adjustments to improve the program.

The program staff had regular weekly meetings to discuss the progress of each group and each individual. They also held several impromptu lunch or other daytime meetings when issues arose that would benefit from immediate discussion and resolution.

#### **14. End-of-Program Evaluation**

MSRI-UP students were asked to complete a short pre-program experience survey and a comprehensive, post-program experience survey. Both surveys were available online. The post-program experience survey has formative evaluation questions designed for soliciting feedback in order to improve future institutes and summative-evaluation questions to measure the effectiveness of MSRI-UP in accomplishing the program objectives. The quantitative results of the pre- and post-program surveys are provided in Appendices D and E, respectively.

Post-program conversations between the MSRI-UP staff and the directors indicated that the staff felt that the institute was successful in accomplishing its objectives.

#### **15. Post-Summer Conferences**

MSRI-UP has a substantial post-summer component. There is funding for students to attend academic conferences to present their research. In addition, each year the onsite director keeps students informed of conference opportunities and funding sources for attending such conferences.

All 6 research projects were presented at the 2019 Joint Mathematics Meetings (JMM) in Baltimore, MD in January 2019. Of the 17 students who were able to attend the conference, 13 presented at the MAA Student Poster Session. In addition, 2 students delivered oral presentations –one at the MAA General Contributed Paper Session on Linear Algebra and the other one at the AMS Special Session on Algebraic, Discrete, Topological, and Stochastic Approaches to Modeling in Mathematical Biology I.

Similarly, all 6 research projects were presented at the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) National Conference in San Antonio, TX in October, 2018. Of the 17 students who were able to attend the conference, 16 presented posters. All 17 students attended the Modern Math Workshop that preceded the conference.

A few students also attended the National Association of Mathematicians' MATHFest Conference, hosted by Spellman College in Atlanta, GA in September 2018. Two students presented posters at the MATHFest Student Poster Session. Overall, all students have had the opportunity to attend and (co)present at, at least, one national conference.

Esteban Escobar and Heyley Gatewood received two of only four "Undergraduate Student Poster Presentation Awards in Mathematics" at SACNAS –these two were the only awards given in the subcategory of Applied Mathematics. At the JMM, four "Outstanding Poster Presentation Awards" from the MAA Student Poster Session were awarded to MSRI-UP students: single presenters Esteban Escobar and Cameron Hooper (each under the Applied Mathematics category); co-presenters Heyley Gatewood, Samuel Hood, and Jonathan Scott (Computational Mathematics); and co-presenters Nathalie Huerta, Skylyn Irby, and Cristal Quiñones (Probability and Statistics). In all, four out of the six research projects have been recognized with awards.

The undergraduate research poster presentations of Esteban Escobar and Rosa Garza were among a handful of research projects selected for Congressman Jerry McNemey's stop at the MAA Student Poster Session at JMM.

## **16. Evidence Suggesting Long-Term Success of Program**

In the 12 years of MSRI-UP, 69 research projects have been completed by 205 students (85.9% from underrepresented minority groups). Of the 181 MSRI-UP alumni who have completed their undergraduate degrees, 156 students (86.2%) continued to graduate programs. Of these 156 students, 87 enrolled in Master's programs and 115 enrolled in Ph.D. programs, most of these students are still enrolled in graduate programs. They have completed 51 Master's degrees and 27 Ph.D. degrees.

The twenty-seven PhD recipients are Drs. Talea Mayo, Natalie Durgin, Luis de la Torre, and Gina-Maria Pomann from MSRI-UP 2007; Drs. Ana Berrizbeitia, Natasha Cayco, Nathan Kallus, Gerard Koffi, Alexander Moll, Laine Noble, Ivan Ojeda, Marcos Ortiz, Loraine Torres-

Castro, and Bobby Wilson from MSRI-UP 2008; Drs. April Harry, Caitlyn Parmelee, and Leyda Almodóvar from MSRI-UP 2009; Drs. Alexander Barrios, Alexander Diaz, Megan Ly, and Markus Vasquez from MSRI-UP 2010; Drs. Andrea Arauza, Dan Eckhardt, Raymond Perkins, and Kendra Pleasant from MSRI-UP 2011; and Drs. Jessica De Silva and Michael Dairyko from MSRI-UP 2012.

Given that most students are juniors during the program, the first cohort of MSRI-UP students would have been enrolling in graduate school around 2008-09 and the first MSRI-UP alumni to earn a Ph.D. did so in 2013. We used the AMS annual surveys from 2013 to 2016 (the most recent available) to determine that 14 of the 302 Ph.D.s awarded to underrepresented groups by US math departments (including Applied Math and Statistics) during that time went to MSRI-UP alumni—about 5%.

## **17. Conclusion**

Like the eleven summers that preceded it, reviews of the MSRI-UP from its students, staff, and guests have been overwhelmingly positive. The program is certainly perceived as an overall success. As the first generations begin to graduate, the real fruit—that of achieving the program’s primary goal *to increase the number of graduate degrees in the mathematical sciences, especially doctorates, earned by U.S. citizens and permanent residents by cultivating heretofore untapped mathematical talent*—is starting to be realized.

The long-term data that will confirm that the MSRI-UP objectives contribute towards the goal of increasing the number of Latinos/Chicanos, African-American and Native Americans earning graduate degrees in the mathematical sciences will continue to unfold over several years ahead. As described above, currently available data shows that from 2013-2016 MSRI-UP alumni comprised about 5% of new Ph.D. recipients from underrepresented groups and we expect this ratio to increase as MSRI-UP alumni currently enrolled in graduate school complete their studies. The directors are committed to maintaining the relationships developed with each cohort of students in the program in order to monitor and collect data on the MSRI-UP students’ academic progress and, whenever possible, to provide them with additional academic opportunities.

# APPENDIX A

## 2018 MSRI-UP PROGRAM SCHEDULE

2018 MSRI-UP Schedule - Week 1

|  | Monday<br>June 18  | Tuesday<br>June 19                                     | Wednesday<br>June 20                                   | Thursday<br>June 21                                     | Friday<br>June 22                                      | Saturday<br>June 23                                    |
|--|--|--|--|---|--|--|
| 8:15 & 8:45 Charter Bus from Evans Hall/Hearst Mining Circle | 8:15 & 8:45 Charter Bus from Evans Hall/Hearst Mining Circle | 8:40 or 9:10 "H Line" Shuttle from Evans Hall          | 8:40 or 9:10 "H Line" Shuttle from Evans Hall          | 8:40 or 9:10 "H Line" Shuttle from Evans Hall           | 8:40 or 9:10 "H Line" Shuttle from Evans Hall          |  |
| 9:00-9:30  | 9:15-10:00 Welcome, IDs, photos, keys, bus passes            |  |  |   |  | Golden Gate Park - Cal Academy of Science - Land's End |
| 9:30-10:00   |  |  |  |   |  |  |
| 10:00-10:30  |  |  |  |   |  |  |
| 10:30-11:00  | 10:15-12:00 Linear Algebra for Data Science Lecture 1        | 9:30 - 12:00 Linear Algebra for Data Science Lecture 2 | 9:30 - 12:00 Linear Algebra for Data Science Lecture 3 | 9:30 - 12:00 Linear Algebra for Data Science Lecture 4  | 9:30 - 12:00 Linear Algebra for Data Science Lecture 5 |  |
| 11:00-11:30  |  |  |  |   |  |  |
| 11:30-12:00  |  |  |  |   |  |  |
| 12:00-12:30  | Lunch  | Lunch  | Lunch  | Lunch   | Lunch  |  |
| 12:30-1:00   |  |  |  |   |  |  |
| 1:00-1:30  |  | 1:00 - 1:15 LinkedIn/MSRI                              |  | Library Orientation Group 1 1:00-1:40 Group 2 1:40-2:20 | 1:00 - 2:00 Week 1 Re-Cap                              |  |
| 1:30-2:00  | 1:00 - 3:00 Python Workshop 1                                | 1:15 - 3:00 R Workshop 1                               | 1:00 - 3:00 Python Workshop 2                          | <b>Problem Solving Session 4</b>                        |  |  |
| 2:00-2:30  |  |  |  |   |  |  |
| 2:30-3:00  |  |  |  |   |  |  |
| 3:00-3:30  | Tea  | Tea  | Tea  | Tea   | Colloquium Antonio Montalbano UC Berkeley              |  |
| 3:30-4:00  | Problem Solving Session 1                                    | Problem Solving Session 2                              | Problem Solving Session 3                              | 3:30 - 5:00 R Workshop 2                                | Tea  |  |
| 4:00-4:30  |  |  |  |   | Problem Solving Session 5                              |  |
| 4:30-5:00  |  |  |  |   |  |  |
| 5:00-5:30  | Shuttle to Mining Circle 4:55, 5:25, 5:55, 6:25              | Shuttle to Mining Circle 4:55, 5:25, 5:55, 6:25        | Shuttle to Mining Circle 4:55, 5:25, 5:55, 6:25        | Shuttle to Mining Circle 4:55, 5:25, 5:55, 6:25         | Shuttle to Mining Circle 4:55, 5:25, 5:55, 6:25        |  |
| 5:30-6:00  |  |  |  |   |  |  |

2018 MSRI-UP Schedule - Week 2

|             | Monday<br>June 25  | Tuesday<br>June 26                                  | Wednesday<br>June 27   | Thursday<br>June 28                                | Friday<br>June 29   | Saturday<br>June 30           |
|-------------|--|---|--|--|---|-------------------------------|
| 9:00-9:30   | 8:40 or 9:10 "H Line"<br>Shuttle from Evans Hall             | 8:40 or 9:10 "H Line"<br>Shuttle from Evans Hall    |  | 8:40 or 9:10 "H Line"<br>Shuttle from Evans Hall   | 8:40 or 9:10 "H Line"<br>Shuttle from Evans Hall                    |                               |
| 9:30-10:00  | 9:30 - 12:00<br>Linear Algebra for Data<br>Science Lecture 6 | 9:30 - 12:00<br>Clustering Lecture                  | 9:00am - 11:30am<br>Tour of Meyer Sound                                      | 9:30 - 12:00<br>Statistical Learning<br>Lecture    | 9:30 - 10:30<br>Research Projects Q&A<br>"Preferences" due at 10:45 | Muir Woods - Stinson<br>Beach |
| 10:00-10:30 |  |   |  |  |   |                               |
| 10:30-11:00 |  |   |  |  |   |                               |
| 11:00-11:30 |  |   |  |  |   |                               |
| 11:30-12:00 |  |   |  |  |   |                               |
| 12:00-12:30 | Lunch  | Lunch   | Lunch  | Lunch  | Lunch   |                               |
| 12:30-1:00  |  |   |  |  |   |                               |
| 1:00-1:30   | 1:00 - 2:30pm<br>Women in Math Panel<br>& Diversity Fishbowl | 1:00 - 3:00<br>Topological Data Analysis<br>Lecture | 1:00 - 3:00<br>Fourier Transform &<br>Algebraic Signal<br>Processing Lecture | 1:00 - 2:00 Computational<br>Statistics Lecture    | Research Assignments  | Muir Woods - Stinson<br>Beach |
| 1:30-2:00   |  |   |  |  |   |                               |
| 2:00-2:30   |  |   |  |  |   |                               |
| 2:30-3:00   |  |   |  |  |   |                               |
| 3:00-3:30   | Tea  | Tea   | Tea  | Tea  | Colloquium<br>Johnny Guzman<br>Brown University                     |                               |
| 3:30-4:00   | 3:00 - 5:00<br>Networks Analysis<br>with iGraph Workshop     | Intro to GitHub                                     | Problem Solving Session<br>7   | Introduction to Research<br>Projects               | Tea   |                               |
| 4:00-4:30   |  | Problem Solving Session<br>6                        |  |  | RCR Workshop  |                               |
| 4:30-5:00   |  |   |  |  |   |                               |
| 5:00-5:30   | Shuttle to Mining Circle<br>4:55, 5:25, 5:55, 6:25           | Shuttle to Mining Circle<br>4:55, 5:25, 5:55, 6:25  | Shuttle to Mining Circle<br>4:55, 5:25, 5:55, 6:25                           | Shuttle to Mining Circle<br>4:55, 5:25, 5:55, 6:25 | Shuttle to Mining Circle<br>4:55, 5:25, 5:55, 6:25                  |                               |
| 5:30-6:00   |  |   |  |  |   |                               |

2018 MSRI-UP Schedule - Week 3

|             | Monday<br>July 2                          | Tuesday<br>July 3   | Wednesday<br>July 4 | Thursday<br>July 5                        | Friday<br>July 6  | Saturday<br>July 7           |
|-------------|---|---|---------------------|---|---|------------------------------|
| 9:00-9:30   | 8:40 "H Line" Shuttle                     | 8:40 "H Line" Shuttle   |                     | 8:40 "H Line" Shuttle                     | 8:40 "H Line" Shuttle                                   |                              |
| 9:30-10:00  | Expectations for Research Teams           | 9:00-11:00<br>20 min team daily update<br>blackboard presentations to MSRI-UP staff.<br><i>In rotation with Team Meetings</i> |                     | 9:00-11:00<br>20 min team daily update    | 9:00-11:00<br>20 min team daily update                  |                              |
| 10:00-10:30 | Team Meetings                             |   |                     | Team Meetings                             | Team Meetings   |                              |
| 10:30-11:00 |   |   |                     |   |   |                              |
| 11:00-11:30 |   |   |                     |   |   |                              |
| 11:30-12:00 |   |   |                     |   |   |                              |
| 12:00-12:30 | Lunch                                     | Lunch   |                     | Lunch                                     | Lunch   |                              |
| 12:30-1:00  |   |   |                     |   |   |                              |
| 1:00-1:30   | Team Meetings                             | Team Meetings   |                     | Team Meetings                             | Team Meetings   |                              |
| 1:30-2:00   |   |   |                     |   |   |                              |
| 2:00-2:30   |   |   |                     |   |   |                              |
| 2:30-3:00   |   | Colloquium<br>Estrey Goins<br>Pomona College  |                     |   | Colloquium<br>Terrence Blackman<br>Medgar Evers College |                              |
| 3:00-3:30   | Tea                                       | Tea   |                     | Tea                                       | Tea   |                              |
| 3:30-4:00   | Team Meetings                             | Team Meetings   |                     | Team Meetings                             | Team Meetings   |                              |
| 4:00-4:30   |   |   |                     |   |   |                              |
| 4:30-5:00   |   |   |                     |   |   |                              |
| 5:00-5:30   | Reconvening in Baker Room                 | Reconvening in Baker Room   |                     | Reconvening in Baker Room                 | Reconvening in Baker Room                               |                              |
| 5:30-6:00   | Shuttle to Mining Circle 5:25, 5:55, 6:25 | Shuttle to Mining Circle 5:25, 5:55, 6:25   |                     | Shuttle to Mining Circle 5:25, 5:55, 6:25 | Shuttle to Mining Circle 5:25, 5:55, 6:25               |                              |
|             |   |   |                     |   |   | Ferry to SF - Cable Car Tour |

2018 MSRI-UP Schedule - Week 4

|             | Monday<br>July 9   | Tuesday<br>July 10                           | Wednesday<br>July 11  | Thursday<br>July 12                          | Friday<br>July 13   | Saturday<br>July 14                        |
|-------------|--|--|---|--|---|--|
| 9:00-9:30   | 8:40 "H Line" Shuttle  | 8:40 "H Line" Shuttle                        | 8:40 "H Line" Shuttle   | 8:40 "H Line" Shuttle                        | 8:40 "H Line" Shuttle   | Exploratorium - Filbert Steps - Coit Tower |
| 9:30-10:00  | Student formal Beamer Presentations  | Team Meetings                                | 9:00-11:00<br>20 min team daily update  | Team Meetings                                | 9:00-11:00<br>20 min team daily update                                |  |
| 10:00-10:30 | 9:10-9:30 9:40-10:00<br>10:10-10:30 10:40-11:00<br>11:10-11:30 11:40-12:00 | Team Meetings                                | Team Meetings   | Team Meetings                                | Team Meetings   |  |
| 10:30-11:00 | Lunch  | Lunch  | Lunch   | Lunch  | Lunch   |  |
| 11:00-11:30 | Team Meetings  | Team Meetings                                | 1:00 - 3:30pm<br>Workshop<br>Graduate School and<br>Fellowships - Colette Patt<br>UC Berkeley | 1:00 - 2:00<br>Calandra T. Moore, NSA        | Colloquium<br>Yannet Interian<br>U. of San Francisco                  |  |
| 11:30-12:00 | Tea  | Tea - Vincent Della Pietra                   | Tea   | Tea  | Tea   |  |
| 12:00-12:30 | Team Meetings  | Team Meetings                                | Team Meetings   | Team Meetings                                | 3:30 - 5:00<br>Tour of Pixar<br>1200 Park Ave<br>Emeryville, CA 94608 |  |
| 12:30-1:00  | Reconvening in Baker room  | Reconvening in Baker room                    | Reconvening in Baker room   | Reconvening in Baker room                    |   |  |
| 1:00-1:30   | Shuttle to Mining Circle<br>5:25, 5:55, 6:25                               | Shuttle to Mining Circle<br>5:25, 5:55, 6:25 | Shuttle to Mining Circle<br>5:25, 5:55, 6:25  | Shuttle to Mining Circle<br>5:25, 5:55, 6:25 |   |  |
| 1:30-2:00   |  |  |   |  |   |  |
| 2:00-2:30   |  |  |   |  |   |  |
| 2:30-3:00   |  |  |   |  |   |  |
| 3:00-3:30   |  |  |   |  |   |  |
| 3:30-4:00   |  |  |   |  |   |  |
| 4:00-4:30   |  |  |   |  |   |  |
| 4:30-5:00   |  |  |   |  |   |  |
| 5:00-5:30   |  |  |   |  |   |  |
| 5:30-6:00   |  |  |   |  |   |  |

2018 MSRI-UP Schedule - Week 5

|             | Monday<br>July 16  | Tuesday<br>July 17                           | Wednesday<br>July 18                         | Thursday<br>July 19                          | Friday<br>July 20                                   | Saturday<br>July 21       |
|-------------|--|--|--|--|---|---------------------------|
| 9:00-9:30   | 8:40 "H Line" Shuttle                                      | 8:40 "H Line" Shuttle                        | 8:40 "H Line" Shuttle                        | 8:40 "H Line" Shuttle                        | 8:40 "H Line" Shuttle                               | Berkeley Botanical Garden |
| 9:30-10:00  | Student formal Beamer Presentations                        | Team Meetings                                | 9:00-11:00<br>20 min team daily update       | Team Meetings                                | 9:00-10:45<br>17 min team daily update              |                           |
| 10:00-10:30 | Team Meetings  | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                       |                           |
| 10:30-11:00 | Team Meetings  | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                       |                           |
| 11:00-11:30 | 10:45 - 12:00<br>Jeremy Stober, Apple<br>Simons Auditorium | Lunch  | Lunch  | Lunch  | 10:45 - 12:00<br>Career Panel<br>Simons Auditorium  |                           |
| 11:30-12:00 | Lunch  | Lunch  | Lunch  | Lunch  | Lunch   |                           |
| 12:00-12:30 | Lunch  | Lunch  | Lunch  | Lunch  | Lunch   |                           |
| 12:30-1:00  | Lunch  | Lunch  | Lunch  | Lunch  | Lunch   |                           |
| 1:00-1:30   | Student formal Beamer Presentations                        | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                       |                           |
| 1:30-2:00   | Team Meetings  | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                       |                           |
| 2:00-2:30   | Team Meetings  | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                       |                           |
| 2:30-3:00   | Tea  | Tea  | Tea  | Tea  | Colloquium<br>Rebecca Garcia<br>Sam Houston State U |                           |
| 3:00-3:30   | Tea  | Tea  | Tea  | Tea  | Tea   |                           |
| 3:30-4:00   | Team Meetings  | Team Meetings                                | Graduate Student/Alumni Panel                | Team Meetings                                | Team Meetings                                       |                           |
| 4:00-4:30   | Team Meetings  | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                       |                           |
| 4:30-5:00   | Team Meetings  | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                       |                           |
| 5:00-5:30   | Reconvening in Baker room                                  | Reconvening in Baker room                    | Reconvening in Baker room                    | Reconvening in Baker room                    | Reconvening in Baker room                           |                           |
| 5:30-6:00   | Shuttle to Mining Circle<br>5:25, 5:55, 6:25               | Shuttle to Mining Circle<br>5:25, 5:55, 6:25 | Shuttle to Mining Circle<br>5:25, 5:55, 6:25 | Shuttle to Mining Circle<br>5:25, 5:55, 6:25 | Shuttle to Mining Circle<br>5:25, 5:55, 6:25        |                           |

2018 MSRI-UP Schedule - Week 6

|             | Monday<br>July 23                            | Tuesday<br>July 24                           | Wednesday<br>July 25                         | Thursday<br>July 26                          | Friday<br>July 27   |
|-------------|--|--|--|--|---|
| 9:00-9:30   | 8:40 "H Line" Shuttle   |
| 9:30-10:00  | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                | Final Presentations<br>MSRI-UP 2018<br>9:30 - 10:05<br>10:15 - 10:50<br>11:00 - 11:35 |
| 10:00-10:30 | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                |   |
| 10:30-11:00 | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                |   |
| 11:00-11:30 | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                |   |
| 11:30-12:00 | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                |   |
| 12:00-12:30 | Lunch  | Lunch  | Lunch  | Lunch  | Lunch   |
| 12:30-1:00  | Lunch  | Lunch  | Lunch  | Lunch  | Lunch   |
| 1:00-1:30   | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                | Final Presentations<br>MSRI-UP 2018<br>1:00 - 1:30<br>1:45 - 2:20<br>2:30 - 3:05      |
| 1:30-2:00   | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                |   |
| 2:00-2:30   | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                |   |
| 2:30-3:00   | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                |   |
| 3:00-3:30   | Tea  | Tea  | Tea  | Tea  | Tea   |
| 3:30-4:00   | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                |   |
| 4:00-4:30   | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                |   |
| 4:30-5:00   | Team Meetings                                | Team Meetings                                | Team Meetings                                | Team Meetings                                | Final Products/Evaluation   |
| 5:00-5:30   | Reconvening in Baker Room                    |   |
| 5:30-6:00   | Shuttle to Mining Circle 5:25,<br>5:55, 6:25 | 6:00 PM<br>Closing Dinner<br>Kingston 11<br>2270 Telegraph Ave.<br>Oakland, CA 94612  |

## APPENDIX B



### MSRI-UP 2018 The Mathematics of Data Science Final Research Presentations

Friday, 27 July 2018  
Edward D. Baker Boardroom

- 9:20-9:30     **Opening Remarks** - David Uminsky
- 9:30-10:05   **Hemoglobin Response to Higher Order Gene Interactions -A Spectral Analysis Approach**  
Rosa Garza, Lillian Gonzalez, Sylvia Nwakanma
- 10:15-10:50   **A Quantitative Analysis of Exclusionary Discipline Inequities in California K-12 Schools**  
Nathalie Huerta, Skylyn Irby, Cristal Quiñones
- 11:00-11:35   **Classification of Short ECG Readings via Topological Time Series Analysis**  
Christopher Dunstan, Esteban Escobar, Luke Trujillo
- 11:45-1:00    **Lunch**
- 1:00-1:35     **An Eigenbasis Algorithm for Johnson Graphs**  
Jackson Abascal, Amadou Bah, Olivia Vasquez
- 1:45-2:20     **Statistical Analysis and Geographical Clustering of Los Angeles County Arrests**  
Cameron Hooper, Jaron Jackson, Kessiena Ofunrein
- 2:30-3:05     **TActIC: Tanh Activations in Image Classification**  
Heyley Gatewood, Samuel Hood, Jonathan Scott
- 3:05-3:15     **Closing Remarks** - Mercedes Franco
- 3:15-4:00     **Afternoon Tea**



## APPENDIX C

### RESEARCH PROJECT ABSTRACTS

#### **Hemoglobin Response to Higher Order Gene Interactions – A Spectral Analysis Approach**

Rosa Garza (California State University, Monterey Bay), Lillian González Albino (University of Puerto Rico, Rio Piedras), Sylvia Nwakanma (Pomona College)

Mutations pave the way for evolution, which is why with the growing amount of genomics data we need efficient and effective ways to analyze interactions of gene mutations. In this paper, spectral analysis is used to orthogonally decompose a genomic data set and analyze higher order interactions between mutations. This approach offers insight into the effects that certain gene mutations groups have on hemoglobin while accounting for redundant information. A comparison was performed between our methodology and classic multilinear regression models to highlight some of the advantages that our approach has in identifying significant mutation interactions. The results from our research can be extended to analyses of the variations observed in other phenotypes.

## **A Quantitative Analysis of Exclusionary Discipline Inequities in California K-12 Schools**

Nathalie Huerta (California State University, Channel Islands), Skylyn Irby (University of Mississippi), Cristal Quiñones (Pomona College)

Using statistical methods on data from California public schools, we conducted an investigation on the exclusionary discipline practices widely used throughout the nation today. Specifically, using multiple linear regression, odds ratios, and machine learning, we built a classification model that accurately predicts the number of students in a given district that will pursue higher education in University of California and California State University schools. Some variables we consider are race/ethnicity, community and school demographics, and the number of expulsions, suspensions, and dropouts in a given district. Previous studies show that removing students from the traditional learning environment through expulsion or suspension is negatively correlated with academic success. This study goes beyond finding a relationship by predicting a district's student success as defined by the number of graduates eligible to attend a University of California or California State University school. In addition to looking at the relationship between exclusionary discipline and a district's number of students pursuing higher education, we considered the positive correlation of exclusionary discipline and dropout rates.

### **Classification of Short ECG Readings via Topological Time Series Analysis**

Christopher Dunstan (University of Maryland, Baltimore County), Esteban Escobar (California State Polytechnic University, Pomona), Luke Trujillo (Harvey Mudd College)

Atrial Fibrillation is a common heart condition affecting nearly thirty-three million people worldwide. Atrial Fibrillation can lead to erratic heart behavior that can cause blood clots, heart failure, and even death. It is difficult to diagnose due to distortion in the cardiac rhythm caused by spasms. In response, the PhysioNet/Computing in Cardiology launched a challenge in 2017 to design models that can classify electrocardiogram (ECG) readings and accurately detect Atrial Fibrillation. In this paper, we use persistent-homology based features to classify ECGs and accurately detect Atrial Fibrillation.

### **An Eigenbasis Algorithm for Johnson Graphs**

Jackson Abascal (University of Rochester), Amadou Bah (Massachusetts Institute of Technology), Olivia Vasquez (Central Washington University)

Our research seeks to expand on spectral analysis within the context of tournament style competitions. This gives us the ability to numerically quantify interactions between subsets of players by analyzing data in the form of ‘n choose k’ where n represents possible players and k represents the size of each team. We propose a new method of constructing the orthogonal basis vectors for the adjacency matrix of the associated Johnson graph which implements theory from the paper by Yuval Filmus entitled “Orthogonal basis for functions over a slice of the Boolean hypercube” to form faster, more efficient algorithms for computing eigenvectors.

## **Statistical Analysis and Geographical Clustering of Los Angeles County Arrests**

Cameron Hooper (California State University, Fullerton), Jaron Jackson (Georgia Institute of Technology), Kessiena Ofunrein (Hampton University)

The work of the Los Angeles Police Department is something many sociologists and criminologists are intrigued by, but because of a lack of mathematical and statistical skills and clean, unbiased, and available data, their analysis is limited. In this study, we evaluated, interpreted, and analyzed a raw data set directly from the Los Angeles Police Department using advanced mathematical and statistical concepts. Our work entailed visualizing multiple variables using graphs and clustering, which allowed us to build an understanding of who is being arrested in Los Angeles County and how their residence plays a role. We used three clustering methods to aggregate similar neighborhoods based on the types of crime people were arrested for. By understanding the trends of arrests and the distribution of variables in the data set, we conducted a unique analysis. We hope to see this work lead to ways to prevent predictive policing from contributing to disparities and bias towards certain racial/ethnic groups and communities.

## **TActIC: Tanh Activations in Image Classification**

Heyley Gatewood (Stetson University), Samuel Hood (Morehouse College), Jonathan Scott (Macalester College)

Our research is focused on applying deep learning architectures to the classification of images that are corrupted by Poisson noise. Poisson noise is an electronic noise that occurs when the energy levels of the technology producing the image are low, revealing differing variations of pixels within the image itself. Poisson noise is very similar to the noise commonly found in medical imaging, hence it is essential to have powerful methods to improve the imaging quality. In this project, we implement various methods in PyTorch using multiple architectures. For training and testing, we use the original Modified National Institute of Standards and Technology (MNIST) data set and an MNIST data set that is corrupted with Poisson noise. An important part of optimizing performance in a deep learning model is picking an activation function, because activation functions allow deep learning models to approximate functions to complex non-linear data. We not only study the importance of choosing an activation function for this task, but we also designed and carried out many experiments to measure the effectiveness of specific activation functions in multiple architectures. We propose a two-parameter, trainable activation function which we call TAct. We briefly explore the performance of Taylor Series approximations of TAct fitted to the popular activation functions, including Rectified Linear Unit (ReLU), in a convoluted neural network (CNN). Then, we compare TAct to other popular activation functions, including ReLU, and the activation function that has recently claimed to be the most successful, Swish, by testing all of the functions on the original and the corrupted MNIST data sets using a CNN. Our experiments show that our TAct activation function is the best activation function, outperforming all of the most popular activation functions including Swish and ReLU.

## APPENDIX D

### SUMMARY OF PRE-PROGRAM EXPERIENCE SURVEY RESPONSES (N=18)

**Prior to this summer, have you worked on an undergraduate research project in mathematics?**

|     |        |
|-----|--------|
| Yes | 50.00% |
| No  | 50.00% |

**Presently, I am confident I can understand what research in mathematics is about.**

|           |        |
|-----------|--------|
| Not       | 11.11% |
| A little  | 16.67% |
| Somewhat  | 55.56% |
| Highly    | 16.67% |
| Extremely | 0.00%  |

**Presently, I am confident I can understand what the advantages of an undergraduate research experience are.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 5.56%  |
| Somewhat  | 22.22% |
| Highly    | 55.56% |
| Extremely | 16.67% |

**Presently, I am confident I can understand what the job opportunities for mathematics majors are.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 11.11% |
| Somewhat  | 66.67% |
| Highly    | 22.22% |
| Extremely | 0.00%  |

**Presently, I am confident I can understand what the fellowship and graduate study opportunities in mathematics are.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 23.53% |
| Somewhat  | 52.94% |
| Highly    | 23.53% |
| Extremely | 0.00%  |

**Presently, I am confident I can write a technical article.**

|           |        |
|-----------|--------|
| Not       | 16.67% |
| A little  | 27.78% |
| Somewhat  | 50.00% |
| Highly    | 5.56%  |
| Extremely | 0.00%  |

**Presently, I am confident I can design a scientific poster.**

|           |        |
|-----------|--------|
| Not       | 22.22% |
| A little  | 5.56%  |
| Somewhat  | 33.33% |
| Highly    | 38.89% |
| Extremely | 0.00%  |

**Presently, I am confident I can give an oral presentation.**

|           |        |
|-----------|--------|
| Not       | 5.88%  |
| A little  | 29.41% |
| Somewhat  | 35.29% |
| Highly    | 29.41% |
| Extremely | 0.00%  |

**Presently, I am confident I can find data or articles in journals or elsewhere.**

|           |        |
|-----------|--------|
| Not       | 5.56%  |
| A little  | 22.22% |
| Somewhat  | 38.89% |
| Highly    | 22.22% |
| Extremely | 11.11% |

**Presently, I am confident I can use software like Python and R to program or solve some mathematics problems.**

|           |        |
|-----------|--------|
| Not       | 22.22% |
| A little  | 22.22% |
| Somewhat  | 38.89% |
| Highly    | 0.00%  |
| Extremely | 16.67% |

**Presently, I am interested in discussing mathematics with friends or family.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 5.56%  |
| Somewhat  | 16.67% |
| Highly    | 55.56% |
| Extremely | 22.22% |

**Presently, I am interested in reading articles about mathematics in magazines, journals, or the internet.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 11.11% |
| Somewhat  | 27.78% |
| Highly    | 27.78% |
| Extremely | 33.33% |

**Presently, I am interested in taking additional courses in mathematics.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 5.56%  |
| Somewhat  | 11.11% |
| Highly    | 33.33% |
| Extremely | 50.00% |

**Presently, I am interested in attending graduate school in mathematics.**

|           |        |
|-----------|--------|
| Not       | 5.56%  |
| A little  | 11.11% |
| Somewhat  | 16.67% |
| Highly    | 27.78% |
| Extremely | 38.89% |

**Presently, I am interested in having undergraduate research experience beyond this summer.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 5.56%  |
| Somewhat  | 27.78% |
| Highly    | 22.22% |
| Extremely | 44.44% |

## APPENDIX E

### SUMMARY OF POST-PROGRAM EXPERIENCE SURVEY RESPONSES

(N=16)

#### **Usefulness of core and developmental program components**

Please rate the usefulness to you of these program components. We invite you to reflect further on these elements later in this survey.

#### **Pre-research Background Phase (weeks 1-2)**

|                 |        |
|-----------------|--------|
| Not useful      | 0.00%  |
| A little useful | 0.00%  |
| Somewhat useful | 18.75% |
| Useful          | 12.50% |
| Very useful     | 68.75% |

#### **Research Project**

|                 |        |
|-----------------|--------|
| Not useful      | 0.00%  |
| A little useful | 0.00%  |
| Somewhat useful | 0.00%  |
| Useful          | 25.00% |
| Very useful     | 75.00% |

#### **Mathematical Typesetting or Software Skills Workshops (Latex, R, Python, etc.)**

|                 |        |
|-----------------|--------|
| Not useful      | 0.00%  |
| A little useful | 12.50% |
| Somewhat useful | 0.00%  |
| Useful          | 37.50% |
| Very useful     | 50.00% |

#### **Graduate School and Fellowship Workshop**

|                 |        |
|-----------------|--------|
| Not useful      | 0.00%  |
| A little useful | 0.00%  |
| Somewhat useful | 0.00%  |
| Useful          | 37.50% |
| Very useful     | 62.50% |

**Graduate Student/MSRI-UP Alumni Panel**

|                 |        |
|-----------------|--------|
| Not useful      | 0.00%  |
| A little useful | 0.00%  |
| Somewhat useful | 0.00%  |
| Useful          | 31.25% |
| Very useful     | 68.75% |

**Career Panel**

|                 |        |
|-----------------|--------|
| Not useful      | 0.00%  |
| A little useful | 6.25%  |
| Somewhat useful | 6.25%  |
| Useful          | 37.50% |
| Very useful     | 50.00% |

**Women in Math Panel/Diversity Fishbowl**

|                 |        |
|-----------------|--------|
| Not useful      | 12.50% |
| A little useful | 6.25%  |
| Somewhat useful | 0.00%  |
| Useful          | 31.25% |
| Very useful     | 50.00% |

**Weekly Colloquia**

|                 |        |
|-----------------|--------|
| Not useful      | 6.25%  |
| A little useful | 0.00%  |
| Somewhat useful | 37.50% |
| Useful          | 25.00% |
| Very useful     | 31.25% |

**Tours and Saturday/Holiday Activities**

|                 |        |
|-----------------|--------|
| Not useful      | 0.00%  |
| A little useful | 0.00%  |
| Somewhat useful | 6.25%  |
| Useful          | 18.75% |
| Very useful     | 75.00% |

**Prior to MSRI-UP, had you worked on an undergraduate research project in mathematics?**

|     |        |
|-----|--------|
| Yes | 62.50% |
| No  | 37.50% |

**After MSRI-UP, do you want to work on an undergraduate research project in mathematics?**

|     |        |
|-----|--------|
| Yes | 93.75% |
| No  | 6.25%  |

**Presently, I am confident I can understand what research in mathematics is about.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 6.25%  |
| Somewhat  | 31.25% |
| Highly    | 37.50% |
| Extremely | 25.00% |

**Presently, I am confident I can understand what the advantages of an undergraduate research experience are.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 0.00%  |
| Somewhat  | 6.25%  |
| Highly    | 18.75% |
| Extremely | 75.00% |

**Presently, I am confident I can understand what the job opportunities for mathematics majors are.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 0.00%  |
| Somewhat  | 18.75% |
| Highly    | 56.25% |
| Extremely | 25.00% |

**Presently, I am confident I can understand what the fellowship and graduate study opportunities in mathematics are.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 0.00%  |
| Somewhat  | 12.50% |
| Highly    | 50.00% |
| Extremely | 37.50% |

**Presently, I am confident I can write a technical article.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 0.00%  |
| Somewhat  | 12.50% |
| Highly    | 87.50% |
| Extremely | 0.00%  |

**Presently, I am confident I can design a scientific poster.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 0.00%  |
| Somewhat  | 37.50% |
| Highly    | 50.00% |
| Extremely | 12.50% |

**Presently, I am confident I can give an oral presentation.**

|           |        |
|-----------|--------|
| Not       | 6.25%  |
| A little  | 0.00%  |
| Somewhat  | 6.25%  |
| Highly    | 50.00% |
| Extremely | 37.50% |

**Presently, I am confident I can find data or articles in journals or elsewhere.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 0.00%  |
| Somewhat  | 18.75% |
| Highly    | 50.00% |
| Extremely | 31.25% |

**Presently, I am confident I can use software like Mathematica, Excel, Python, R, etc. to program or solve some mathematics problems.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 6.25%  |
| Somewhat  | 12.50% |
| Highly    | 43.75% |
| Extremely | 37.50% |

**Presently, I am interested in discussing mathematics with friends or family.**

|           |        |
|-----------|--------|
| Not       | 6.25%  |
| A little  | 0.00%  |
| Somewhat  | 18.75% |
| Highly    | 37.50% |
| Extremely | 37.50% |

**Presently, I am interested in reading articles about mathematics in magazines, journals, or the internet.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 0.00%  |
| Somewhat  | 18.75% |
| Highly    | 37.50% |
| Extremely | 43.75% |

**Presently, I am interested in taking additional courses in mathematics.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 0.00%  |
| Somewhat  | 12.50% |
| Highly    | 18.75% |
| Extremely | 68.75% |

**Presently, I am interested in attending graduate school in mathematics.**

|           |        |
|-----------|--------|
| Not       | 0.00%  |
| A little  | 6.25%  |
| Somewhat  | 18.75% |
| Highly    | 18.75% |
| Extremely | 56.25% |

**Presently, I am interested in having undergraduate research experience beyond this summer.**

|           |        |
|-----------|--------|
| Not       | 6.25%  |
| A little  | 0.00%  |
| Somewhat  | 18.75% |
| Highly    | 18.75% |
| Extremely | 56.25% |

**What year are you in college? I am a**

|                           |        |
|---------------------------|--------|
| Freshman/rising sophomore | 6.25%  |
| Sophomore/rising junior   | 25.00% |
| Junior/rising senior      | 37.50% |
| Senior                    | 18.75% |
| Other                     | 12.50% |

**How many times have you participated in SUMMER research prior to this summer?**

|                   |        |
|-------------------|--------|
| Never before      | 56.25% |
| 1 summer          | 31.25% |
| 2 summers         | 12.50% |
| 3 or more summers | 0.00%  |

**How important was the stipend or money you were paid in allowing you to do research?**

|                      |        |
|----------------------|--------|
| Not at all important | 6.25%  |
| Slightly important   | 6.25%  |
| Important            | 37.50% |
| Very important       | 50.00% |

**What is your gender?**

|                   |        |
|-------------------|--------|
| Male              | 50.00% |
| Female            | 50.00% |
| Other             | 0.00%  |
| Decline to answer | 0.00%  |

**Compared to your intentions BEFORE doing research, HOW LIKELY ARE YOU NOW to enroll in a Ph.D. program in science, mathematics, or engineering?**

|                       |        |
|-----------------------|--------|
| Not more likely       | 6.25%  |
| A little more likely  | 12.50% |
| Somewhat more likely  | 25.00% |
| Much more likely      | 12.50% |
| Extremely more likely | 43.75% |
| Not applicable        | 0.00%  |

**Compared to your intentions BEFORE doing research, HOW LIKELY ARE YOU NOW to enroll in a masters program in science, mathematics, or engineering?**

|                       |        |
|-----------------------|--------|
| Not more likely       | 18.75% |
| A little more likely  | 6.25%  |
| Somewhat more likely  | 6.25%  |
| Much more likely      | 31.25% |
| Extremely more likely | 12.50% |
| Not applicable        | 25.00% |



## MSRI-UP Evaluation Report

Report created by Karen Peterman Consulting, Co.,  
Jane Robertson Evia, Leanne Jacobson, Keshia Martin, Katherine Ciccarelli, & Karen Peterman



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## Executive Summary

Since 2007, the Mathematical Sciences Research Institute (MSRI) has implemented the MSRI Undergraduate Program (MSRI-UP) to train students who have the potential to enhance the diversity of the mathematical workforce. As described on the program's web site, MSRI-UP "is a comprehensive summer program designed for undergraduate students who have completed two years of university-level mathematics courses and would like to conduct research in the mathematical sciences."

The purpose of this report is to provide a comprehensive analysis of data collected to evaluate the MSRI-UP program over all years of the project to determine the successes of the program to date, and possible areas for continued improvement. The evaluation included a series of exit surveys that were collected by the project team at the end of each summer, tracking data to monitor students' educational and career pathways after the program, an alumni survey, alumni interviews with a stratified sample of alumni survey respondents, and staff interviews.

Key findings from the evaluation included the following:

- MSRI-UP is true to its mission of serving students from underrepresented groups who have interest in pursuing mathematics studies and careers.
- The racial and ethnic diversity of MSRI-UP students and mentors is considered a primary asset of the program to participants and staff alike.
- MSRI-UP is successful at creating a strong community among its participants that includes meaningful connections between peers in the program, and valuable mentorship from staff and faculty.
- Participants reported that MSRI-UP helped improve their ability to apply mathematical skills, their confidence as mathematicians, their technical skills related to math, and their personal capacity to conduct mathematical research. In turn, these changes solidified and expanded participants' educational and career aspirations.
- Years later, alumni confirmed the impact that MSRI-UP had on their burgeoning knowledge and skill as mathematicians. They credited skill gains, increased confidence, and the community as having impact on their growth. They also recalled many specific program components that were quite important to the professional growth they achieved.
- MSRI-UP alumni enroll in graduate-level programs, and complete graduate degrees at higher rates than the national average for all students.

These results indicate that the MSRI-UP program has been an overwhelming success. It has reached populations of students from groups that are underrepresented in mathematics who are eager to become part of the U.S. mathematics workforce. The program components provide participants with unique opportunities that result in meaningful engagement and learning within the context of a strong community that can be relied upon to continue providing support in both the short and longer term.



## Background to This Report

Since 2007, the Mathematical Sciences Research Institute (MSRI) has implemented the MSRI Undergraduate Program (MSRI-UP) to train students who have the potential to enhance the diversity of the mathematical workforce. As described on the program's web site, MSRI-UP "is a comprehensive summer program designed for undergraduate students who have completed two years of university-level mathematics courses and would like to conduct research in the mathematical sciences." The program consists of an intense six-week summer research experience that begins with a week of background training before students begin intensive team-based research projects. Throughout the summer, participants attend colloquia and other professional development workshops and have the chance to connect with mentors, staff, and peers through social activities and weekend excursions.

The project's web page states that "the main objective of the MSRI-UP is to identify talented students, especially those from underrepresented groups, who are interested in mathematics." The program provides students "meaningful research opportunities, the necessary skills and knowledge to participate in successful collaborations, and a community of academic peers and mentors who can advise, encourage and support them through a successful graduate program." Through these experiences, MSRI-UP aims to increase "the number of graduate degrees in the mathematical sciences, especially doctorates, earned by U.S. citizens and permanent residents by cultivating heretofore untapped mathematical talent within the U.S. Black, Hispanic/Latino and Native American communities."

The purpose of this report is to provide a comprehensive analysis of data collected to evaluate the MSRI-UP program over all years of the project to determine the successes of the program to date, and possible areas for continued improvement. Karen Peterman Consulting, Co. was contracted in spring 2019 to conduct a secondary analysis of data that had been collected by the MSRI team since the program's inception to document short-term feedback about the program, and to collect new data that could be used to understand stakeholders' longer-term perspectives of MSRI-UP.

## Method

The evaluation of MSRI-UP included a series of exit surveys that were collected by the project team at the end of each summer, tracking data to monitor students' educational and career pathways after the program, an alumni survey, alumni interviews with a stratified sample of alumni survey respondents, and staff interviews. Each data collection method and sample is explained in detail below.

### Annual Exit Surveys

MSRI-UP collected and analyzed annual exit surveys from students at the end of each summer to gather feedback about the program and student outcomes data. The number of survey items included on each year's survey varied. All had a mix of open-ended and ratings questions. The closed-ended questions included four scales from the Student Assessment for Learning Gains (SALG) instrument were used to measure perceived gains in the following areas: application of skills, personal abilities, skill gains, and overall learning gains.

For the purposes of this report, MSRI shared compiled summary data from the earlier years of the program, and individual responses for students who participated in 2014–2017. A longitudinal analysis



was conducted to identify consistencies and differences in student experiences across time. The quantitative analysis focused on SALG scores; individual-level data were needed to create scores for each of the subscales, and thus this analysis focused on the 2012–2017 cohorts.

### MSRI Database of Participants

Throughout the program, registration data were collected by MSRI to describe student participants. Program staff then continued to update the database. The project team also tracked the educational and career pursuits of alumni after the program. Data were available for a total of 205 MSRI-UP alumni who participated in MSRI-UP between 2007 and 2018. Items included personal characteristics, such as race/ethnicity and gender, as well as items related to their educational and career choices since their participation in MSRI-UP.

### Alumni Survey

Working in collaboration with MSRI, KPC collected survey data from 2007–2018 MSRI-UP alumni in the summer of 2019. The survey was distributed successfully by email to 178 former MSRI-UP program participants via SurveyMonkey; 127 completed the survey for a 71% return rate.

The sample included alumni from each cohort year, as shown in Table 1. The portion of the sample from each cohort ranged from 5% to 13% across cohort years. Representation was greater from the most recent compared to more distant cohorts. The one exception was the 2011 cohort, which represents 11% of the sample.

Fifty-five percent (55%) of the survey respondents identified as male and 42% identified as female. One person (1%) each identified as transgender or preferred not to answer the question. Two respondents did not answer the question. Table 2 provides the distribution of survey respondents by self-identified ethnicity. Latinos and Hispanics were the largest ethnic group to participate in the program (38%), followed by those who identified as Black/Afro-Caribbean/African-American (25%) and multi-ethnic (20%). In total, 88% of survey respondents were from a racial/ethnic group that is underrepresented in mathematics.

Table 1. Alumni from all years completed the survey, with those from most recent cohorts responding at a higher rate.

| Cohort Year | Percentage of Cohort that Completed Surveys | Percentage of Total Surveys Completed |
|-------------|---|---------------------------------------|
| 2007        | 75%   | 7%                                    |
| 2008        | 41%   | 6%                                    |
| 2009        | 53%   | 7%                                    |
| 2010        | 41%   | 6%                                    |
| 2011        | 82%   | 11%                                   |
| 2012        | 39%   | 6%                                    |
| 2013        | 33%   | 5%                                    |
| 2014        | 61%   | 9%                                    |
| 2015        | 76%   | 10%                                   |
| 2016        | 67%   | 9%                                    |
| 2017        | 89%   | 13%                                   |
| 2018        | 89%   | 13%                                   |

Table 2. Survey Participants' Ethnicity

| Ethnicity                                 | Alumni | Percentage |
|---|--------|------------|
| Latino or Hispanic                        | 48     | 38%        |
| Black, Afro-Caribbean or African-American | 32     | 25%        |
| Multiethnic                               | 26     | 20%        |
| Non-Hispanic White or Euro-American       | 10     | 8%         |
| Asian or Asian American                   | 5      | 4%         |
| Chose not to respond                      | 4      | 3%         |
| Native American or Alaskan Native         | 1      | 1%         |

### Alumni Interviews

A total of 12 interviews were completed with MSRI-UP alumni in late summer 2019. A random stratified sample was selected from those who completed the alumni survey, such that one alumnus was randomly selected from each year (2007 to 2018) and invited to participate. All agreed to take part in the interview. The interviews were brief, lasting 20 minutes, on average. The intent of the alumni interviews was to gather former students' experiences, impressions, and feedback about the impact of MSRI-UP. Alumni also had the opportunity to share ideas about ways the program could be improved and the impact of MSRI-UP on the U.S. mathematical workforce. Participants reflected the range of career and educational positions expected, given that all cohorts were included in the sample. Many were currently working as faculty at a college or university (n=6), or in industry or nonprofits (n=4); two were completing an undergraduate or graduate degree (n=2). All were working or studying in a mathematics-related field or mathematics education.

### Staff Interviews

A total of five past and current MSRI-UP staff members were interviewed in early summer 2019. Staff members were selected to reflect the full range of perspectives about and experiences with MSRI-UP, and included graduate students, postdoctoral students, research directors, program directors, and co-founders. The interviews were fairly lengthy, lasting 43 minutes on average. The intent of the staff interviews was to gather impressions and feedback about the impact of MSRI-UP on students, staff, and the U.S. mathematical workforce. Participants also provided suggestions for how the program could be improved.





the demographic data presented above, these results confirm that MSRI-UP was successful at reaching its intended audience.

When asked to reflect, MSRI-UP alumni shared many reasons for wanting to participate in the program (see Table 4). At least half of the alumni checked each of the three checklist options related to future educational and career pursuits in mathematics. In addition, approximately half indicated that a professor or advisor suggested that they apply. Approximately half of those who noted that a professor or advisor recommended the program also indicated that they were interested in the program based on their interests in graduate school and future career goals (47% and 43%, respectively).

A few alumni mentioned other reasons for participating that were not included on the checklist. These included: the program’s prestige, the research experiences offered, the topics covered, the program’s location, the ability to connect with other mathematicians of color, and having something for their curriculum vitae.

Table 3. At the beginning of MSRI-UP, the most common major for participants was Mathematics.

| Pre- MSRI-UP Major/Field of Study | Percentage of Respondents |
|-----------------------------------|---------------------------|
| Mathematics                       | 80%                       |
| Computer Science                  | 9%                        |
| Applied Mathematics               | 8%                        |
| Pure Mathematics                  | 5%                        |
| Mathematics Education             | 3%                        |
| Economics                         | 3%                        |

Table 4. MSRI-UP alumni remembered being interested in the program in relation to their future educational and career goals.

|  | Percentage Agreed |
|--|-------------------|
| Interested in graduate school                                  | 86%               |
| Thinking about future career                                   | 77%               |
| Recommended by a professor or advisor                          | 57%               |
| Interest in a specific field/discipline related to Mathematics | 50%               |
| Interested in meeting peers                                    | 38%               |
| Amount of stipend  | 31%               |
| Interest in a specific field/discipline related to science     | 11%               |
| Interest in a specific mentor                                  | 9%                |
| Other  | 9%                |

MSRI-UP was the first learning experience of its kind for 60% of alumni; this group included 41% for whom MSRI-UP was the only cohort-type mentoring program of their academic career, and 19% who sought another cohort-based mentoring program after their experience with MSRI-UP. Most alumni participated in similar programs before and/or after MSRI-UP. See Figure 2.

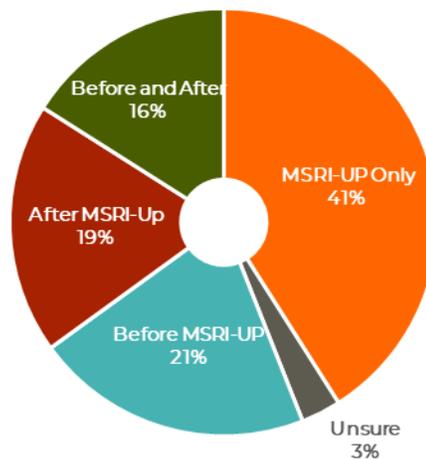
The diversity of MSRI-UP students, mentors, and faculty resulted in an empowering experience for students. The importance of this diversity to the MSRI-UP experience was shared in the exit surveys conducted at the end of each summer, the alumni survey, and in both the alumni and staff interviews. For example, although the exit survey did not ask questions about this topic directly, participants frequently shared that they enjoyed being around other minorities in academia. Assessing responses by year revealed that nearly one-third of participants in 2015 and in 2017 shared ways that the program positively impacted their personal feelings of being a minority in math (29% and 33%, respectively). Responses included:

*The most memorable experiences were working with other black math students. It is an impossibly rare luxury for me to be able to work with black math students or even better, talented black math students.—2015 participant*

*It was unbelievably nice to meet people with the same values and similar backgrounds as me who cared about math but also about bettering our home communities. While my college is a good place to learn math, it's not the greatest at empowering people with less elaborate HS backgrounds/first gen students/underrepresented groups etc. to feel that they're deserving, so this was a welcome change.—2016 participant*

*The diversity of the students and mentors in this program was really inspiring for me...to be affiliated with so many talented people and look forward to keeping our community of underrepresented mathematicians growing.—2017 participant*

Figure 2. MSRI-UP was the first cohort-based training experience for most alumni.



**Key Finding:**

*The racial and ethnic diversity of MSRI-UP students and mentors is considered a primary asset of the program.*

Staff, too, shared their impressions of the importance of creating a program environment that includes racial and ethnic diversity. They perceived the following benefits for students:

*It's a program that's designed for them where they feel comfortable, where they get to meet other people like them, and I think that's extremely unusual for most of our students. It's actually very unusual for them to be mentored by mathematicians of color and so I think that becomes really meaningful.—staff*

*That isn't actually a norm in our community where you have the opportunity to do research with other underrepresented students or people who look like you as a minority in*

*mathematics. So, I think that that opportunity is great that allows these students to work with other students of color, and faculty of color, even.—staff*

*So, they have a wide range in terms of gender, race and ethnicity, and I think it's one of the best in the country when it comes to that.—staff*

*I think just coming together and meeting other students who are underrepresented ethnic minorities in mathematics and meeting faculty members who can be your mentors.—staff*

Two sets of questions on the alumni survey focused on whether and how MSRI-UP alumni had taken steps to support other underrepresented students in their current position. Taking such steps was an area of interest to MSRI staff as a possible unintended consequence of program participation. Most of the respondents stated that they are *strongly* interested in furthering underrepresented minorities in their fields. Fewer, though still a majority, have either made plans or taken steps in this direction (70% of students and 55% of non-students).

Table 5. Many alumni were interested in supporting other underrepresented minorities in their fields. Fewer had taken steps to pursue these interests.

|  | Strongly disagree | Disagree | Neither agree nor disagree | Agree | Strongly agree | Mean |
|--|-------------------|----------|----------------------------|-------|----------------|------|
| Non-Students: I am interested in furthering underrepresented minorities in my field                                  | 2%                | 0%       | 6%                         | 20%   | 72%            | 4.60 |
| Non-Students: I have initiated or plan to initiate programs to help increase underrepresented minorities in my field | 5%                | 11%      | 30%                        | 14%   | 41%            | 3.75 |
| Students: I am interested in furthering underrepresented minorities in my field                                      | 0%                | 0%       | 3%                         | 12%   | 85%            | 4.82 |
| Students: I have initiated or plan to initiate programs to help increase underrepresented minorities in my field     | 3%                | 3%       | 23%                        | 30%   | 40%            | 4.00 |



## Providing Meaningful Research Opportunities

*Short-term reactions to the research project.* All exit surveys contained at least one question about the research project. Questions asked what participants liked and disliked about the research project, how their project compared to others they had worked on, and whether they were satisfied with their research project topic.

The initial surveys (from the years 2008, 2009, and 2013) asked participants to share both what they liked and disliked about their research project. Over half (59%) shared what they liked about their research project; 34% liked the math topics covered in the project the most and 29% said that the process of solving a challenging problem as their favorite part. Comments included:

*Excitement of new ideas—2008 participant*

*I really liked getting to explore new concepts and the feeling when I suddenly grasped a new idea or had new insight into a problem I was working on.—2009 participant*

*Complexity of the problem & simplicity of the conjecture—2013 participant*

A similar portion of participants shared what they disliked about the research project. Lack of time was the theme shared most often (25%), with at least one participant each year noting that there was not enough time in the program to fully complete the research. This theme emerged across multiple questions on the 2008 and 2013 surveys.<sup>1</sup> Others disliked how difficult some of the information was to understand (22%).

*Needing more math background—2008 participant*

*I disliked the fact that we could have used more time, and hence would have been able to get more results.—2009 participant*

*My other REU was 10 weeks long. I would have liked to have more time to work on the research here because by the time I presented my work I was completely familiar with it. For me, it takes me a long time to grasp things and I like to let them sink [in].—2009 participant*

*I dislike the fact that I still don't understand about 25% of what we did.—2009 participant*

*Vagueness at the beginning—2013 participant*

One of the comments above is from a participant who had taken part in other, similar programs in the past. The surveys provided the chance for students who had similar experiences to compare and contrast those with MSRI-UP. Combining all responses, 74% stated that their MSRI-UP experience was positive in comparison to other undergraduate research projects or summer programs they participated in, while 22% were considered neutral. One participant (4%) stated that *this was a bad experience*. The range of responses provided included the following:

---

<sup>1</sup> In 2008 and 2013, participants had the chance to make final comments about their research project. Across both years, 29% of participants responded to this item; 30% of those noted that they would make the program longer.

*MSRI-UP did better job creating collaborative environment—2008 participant*

*This was the best!—2013 participant*

*This one was much more engaging as far as problem solving/formulation goes. The problems were more well-selected as well.—2014 participant*

*This has been, by far, the best research experience I have ever had. I have been involved in 4 different research projects and only now I feel like I know what mathematical research is all about.—2014 participant*

*It [MSRI-UP] was much more structured, and the participants were more diverse. I also felt valued.—2014 participant*

The most common element of the program, mentioned by 26% of participants, was that the MSRI-UP program was more rigorous than others. Most of these participants noted that this was a positive feature of the program. In addition, 17% of the participants reported that MSRI-UP gave them more independence to explore compared to other similar programs. Responses included:

*This research experience has been the shortest (in weeks), but the most challenging. I feel I have reached a new level with regards to solving problems on my own.—2009 participant*

*This was more intense and challenging, but it was exactly what I needed.—2013 participant*

*It has been more rigorous than past research experiences, though with much more rewards.—2014 participant*

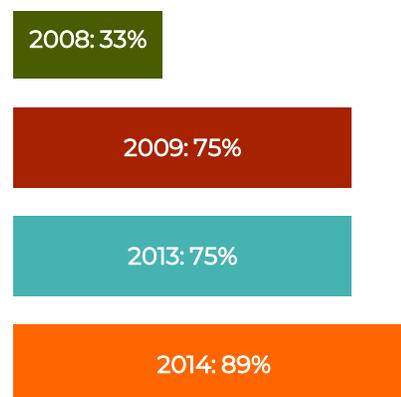
*At MSRI-UP the research was much more student led—we were working on finding some original ideas without the staff holding our hands.—2009 participant*

*MSRI-UP allowed to me to be more independent with my research, which I feel is more accurate with how graduate school will be. Although the homework during the lectures was challenging, it wasn't impossible and I could get to bed at a decent hour. However, I would have either made the lecture portion of the program shorter or extend the program to be a 7 week REU. It would be beneficial to have the extra week because we found ourselves torn about when to stop researching and to start "TeX-ing."—2009 participant*

When examined over time, the percentage of those who shared only positive comments about the research experience in comparison to other programs increased (see Figure 3). This trend may indicate the maturation of the program itself, as ratings were lowest in the earliest year for which we have data, increased sharply, and then stayed high across later years of the program.

This assumption is supported by data from the 2015–2017 surveys. In these years, participants were asked to explain whether they were satisfied with their project topic or if they wished they had requested or been assigned a different topic. In three years almost all participants stated that they were satisfied with their project topic (see Figure 4). The

Figure 3. The majority of MSRI-UP participants share only positive feedback about the research component.



remaining 4% were somewhat satisfied. No one was not satisfied with their project topic. When asked to comment on the rating they selected, participants from the later years of the project shared the following:

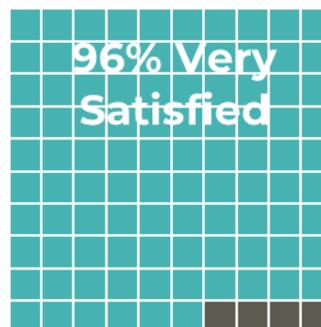
*I enjoyed the project topic very much. Since I enjoy applied mathematics, working with approval voting was exactly what I wanted to do and I can't wait to continue doing research on this topic with my group through Skype.—2015 participant*

*I am very [satisfied] with my project topic. It was my second choice, but now I am extremely happy I was given my second choice. The project ended up being really fun to work on and very interesting.—2016 participant*

*I am very satisfied with my research project. It turned out to be very difficult but I always felt like I could try ideas help crack the problem. It was challenging but not overwhelmingly difficult.—2016 participant*

*I am very satisfied with my project topic and I know that I learned a substantial amount about a field I had never worked in before.—2017 participant*

Figure 4. A vast majority of MSRI-UP participants are *very satisfied* with their research experience.



This satisfaction may be due, in part, to participants' appreciation for working on and solving challenging math problems. Combining the data from all participants across the years, 38% remarked on their appreciation for the challenging math problems. The portion of participants who described this challenge was lower in the data available from earlier years and increased for the first time in 2015 (see Figure 5). From 2015 to date, discussion of the math problems has been a consistent theme for many students at the end of their summer with MSRI-UP. Participants have shared the following perceptions of the math featured in MSRI-UP's research program:

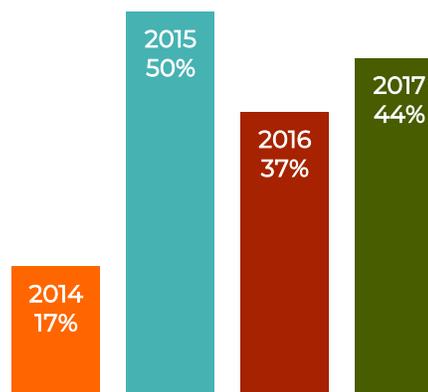
*I really liked getting to explore new concepts and the feeling when I suddenly grasped a new idea or had new insight into a problem I was working on.—2009 participant*

*Complexity of the problem & simplicity of the conjecture—2013 participant*

*Having the opportunity to work on a problem and experience the frustration and joys of research has helped me decide that this is what I want to pursue.—2014 participant*

*My last math research program gave me a problem which I have yet to solve or make any tangible progress on. It was nice to have a chance to see how clever I can be, and how well I can work with others.—2014 participant*

Figure 5. Appreciation for challenging math problems is a common theme



*When we were able to define the group action on the induced Sperner's labeling, I was so happy that I could not stop smiling. It just reminded me how beautiful knowledge is, and how much I enjoy doing mathematics.—2015 participant*

*The most \*mathematically\* valuable and memorable experience was when I realized that the conjecture I was working on for a week was based on false assumptions. The moment when I realized this mistake, I suddenly felt like I understood my problem much better. It felt amazing.—2016 participant*

*The one special moment I will always remember is when we noticed a pattern, formulated a conjecture, and proved it!! Those few days were very exciting!!!—2017 participant*

Short-term feedback about research project teams. MSRI-UP research projects provide the opportunity for students to work in teams. Two questions were added to the exit survey in later years of the project (2015–2017) to gather feedback on project teams. First, participants were asked how satisfied they were with their teammates. Combining responses over the three years, the majority of participants stated that they were *very satisfied* with their project teammates (see Figure 6).

Figure 6. Most students report being very satisfied with their project team.



Participants shared multiple reasons for their high satisfaction ratings; 9% of participants shared that they enjoyed the diverse skills amongst their teammates and another 9% pointed out that they became friends with their teammates.

*Although my project teammates and I have strong personalities and differed in many moments, I really enjoyed working with them. More than project “teammates” I believe that they became my friends.—2015 participant*

*Our diverse backgrounds worked well together in problem-solving.—2017 participant*

Of those who were somewhat satisfied or not satisfied, a small portion (15%) explained that their team did not work well together and cited different teamwork skills that were lacking. This feedback is exemplified in the following comment:

*I do not think that the approach my teammates had towards research fit with mine. Although [sometimes] I like to work on problems on my own, I feel that I am more comfortable in a collaborative setting for projects like this, where there is work that needs to be divided between team members. My teammates were more independent and would become upset whenever I asked them to work more closely. In my opinion, a possible way to avoid this issue would be for*

students to indicate their work style on the sheet where they choose projects and partners.—  
2017 participant

The second question about teamwork asked participants to compare their team research to the work they might have produced if they had worked on the project alone. Most compared their team's work favorably in this context (see Figure 7). When asked to explain their rating, the majority provided only positive comments to describe their team's effort (72%), with 40% stating specifically that their work was better because they were working on a team rather than by themselves. Some participants (28%) highlighted the discussions they had with their teams which were extremely helpful to their work on the research project.

Some participants (11%) made only negative comments about how the team research impacted their progress. The range of feedback received included the following:

*The team research is better than the research I could have done by myself. When the team was stuck on a problem, someone always had an idea to move us forward. If I were by myself, I would not always have ideas to move my research forward and I would have not had as many ideas.—2015 participant*

*I have done a project by myself in the past and think this experience molded me much more as a mathematician. Working with others and talking math with my team really helped me feel accountable and work toward our goals faster than I could have by myself.—2017 participant*

*I love working by myself because I always find myself doing the most work anyway. I think that my teammates made great images and visuals for the presentation, poster, and paper, but we didn't come here to do arts and crafts. So while the visuals are great, I felt like the only one conducting research with output. It felt like they just asked questions (at times not understanding even when asking the same question a plethora of times), created visuals and explained background. – 2017 participant*

Staff too shared perspectives about the importance of MSRI-UP research projects for participants. Figure 8 represents the number of staff who mentioned specific benefits to students during their interview. Having the opportunity to discuss authentic research was one of the two benefits cited most frequently. The remaining benefits will be discussed later in the report. Additional information about staff perceptions of the research opportunities provided by MSRI-UP follow the figure.

Figure 7. Most students shared positive comments about their project team.

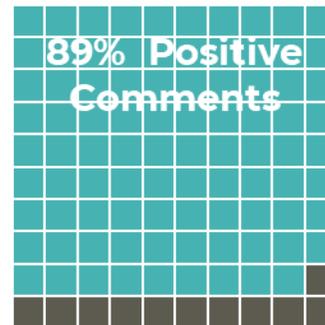
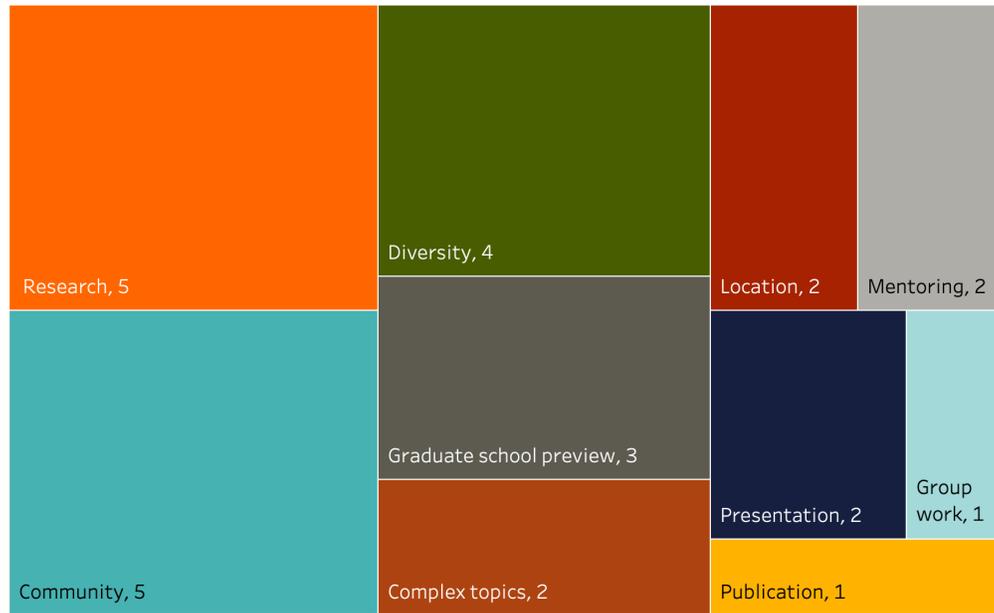




Figure 8. MSRI staff noted several benefits of the program for students. All mentioned the importance of the program’s research projects and community. Four of five also mentioned the importance of the community’s diversity.



MSRI-UP staff mentioned the intense level of research in which students engage during their time in the program, noting that this was new for most participants. This, coupled with the complex and diverse mathematical concepts presented, gave students insight into the rigors of graduate school and encouraged them to consider this as a next step. When asked about some of the greatest benefits of MSRI-UP to students, staff shared the following:

*Exposing them to new, more complex mathematics. Doing like, small group, deep, intensive work with—I think everyone they’ve had, the faculty they’ve had, have always been really fantastic, both researchers and educators. So, getting them exposed to new people who are experts in their field, and then also getting, I think, a really fantastic research experience. MSRI-UP is] not quite a reflection of what you’d experience [in graduate school], but I feel like it’s a pretty good condensed version of that intense work and trying to push out some results and hopefully get something that’s useful to you, either through just your experience and/or through the publication process.—staff*

*One thing I think is great is that it gives them the opportunity to start research pretty early, if possible, in a very supportive environment. I think with the exposure of doing research and meeting a lot of other mathematicians, it helps students see that they could also go on to graduate school.—staff*

*I do think that the faculty the students interact with at MSRI-UP are very significant in terms of the impact they have in going on to grad school. I cannot even start to over-emphasize how significant faculty are.—staff*

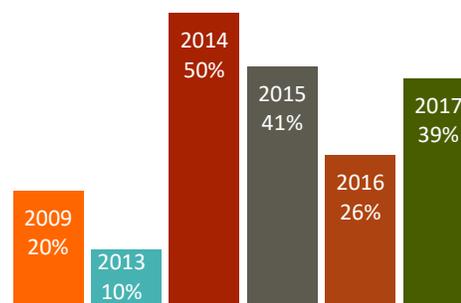
*I mean, I do feel like it's a very successful program at showing students what research looks like, what graduate school might look like, and I think that for many students it's a very decisive experience as far as embarking on that trajectory.—staff*

#### Longer-term perspectives on the research project.

Analysis of participant responses from the exit surveys collected between 2009 through 2017 revealed that, while reflecting on program components and experiences gained, some participants expressed a new confidence in their abilities as mathematicians. These responses were found in reply to a number of questions on the surveys, including those about their research experience, when discussing their future plans, and when identifying their favorite mathematical experience.

This boost in confidence varied across years. A few participants shared that their confidence increased in 2009 and 2013 (20% and 10%, respectively). This portion jumped to half of participants in 2014; although rates did not remain at this level, analyses of responses from the subsequent years revealed that the percentage of participants who shared that they felt their confidence had risen remained relatively high (see Figure 9). Participants shared the following at the end of their summer with MSRI-UP:

Figure 9. Increased confidence was a common theme among students at the end of each summer.



*During my last research experience, I have felt nervous on how I may conduct research (as well as how to form my own research questions). I feel that this program has helped make me more comfortable with this however, and I feel more confident in pursuing a PhD.—2014 participant*

*I really enjoyed the talks in the Colloquia, they showed me different sides of mathematics with equal beauty. Their personal background made me understand that at some point, they were just like us, and that if they could do it, I might as well.—2015 participant*

*I'm currently an AB candidate in Applied Math. Grad school was previously something that I thought would be nice, but not something that I thought I deserved/was intelligent enough to pursue. After working in this research environment, I feel much more inclined to try to contribute to math, starting with applying to PhD programs in math. At this point (barring major extenuating circumstances) I will definitely be applying to math PhD programs this upcoming Dec/Jan.—2016 participant*

*It was inspiring to learn about people who have done this program and to see what they are doing now. It certainly helps me believe that I can also go to graduate school and do mathematical research.—2017 participant*

Recall that the results from the alumni survey indicated that students wanted to be part of MSRI-UP based on their intentions to pursue additional studies or careers in mathematics. Even though most aspired to math-related pursuits before they began the program, the exit surveys from 2009 and 2013 indicate that the program solidified and expanded students' plans. The exit surveys in these two years asked participants about their aspirations. Of the 25 participants across both years who responded to

this question, nearly half (48%) shared that the program changed their outlook on their academic future by increasing their interest in pursuing graduate school. Moreover, 36% explained that program participation clarified what they did or did not want to do in their future career. Responses included:

*Yes, I do think MSRI-UP has changed my outlook. After this program, I have been thinking more and more about attending grad school. I am more excited to continue my education and get a job that I know I will love.—2009 participant*

*Absolutely. I now have a better idea of what opportunities are out there and what direction I want to go in. It is a great feeling.—2009 participant*

*Now think want to get a PhD in math more than I thought.—2013 participant*

**Key Finding:**

*The MSRI-UP program overall and the research projects in particular enhanced participants' confidence in their abilities as mathematicians. Their experiences and increased confidence also solidified and expanded their educational and career aspirations.*

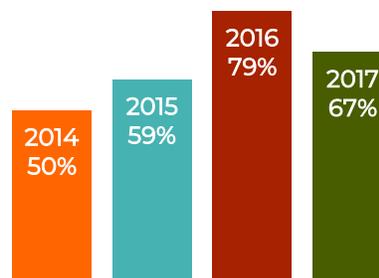
This trend continued in subsequent years. From 2014 through 2017, many noted the impact of MSRI-UP on their outlook for the future. Although rates varied across the four years, at least half of participants each year said that their intention to attend graduate school was influenced by the program (see Figure 10). Responses from these years cited two different ways their plans were affected. Like the responses from 2009 and 2013, some stated that their intent to pursue graduate school was influenced by the program (71% in 2016 and 32% in 2017). Others provided more general statements about MSRI-UP's influence on future plans, without offering specifics (18% in 2016 and 32% in 2017). Responses included:

*I am very excited to continue with my mathematical career. Learning about graduate school and fellowships and different areas of mathematics has really peaked my desire to pursue a doctorate degree in mathematics.—2014 participant*

*The career panel made me very excited. I don't really want to be a professor, but I didn't know about other opportunities. This panel made me very interested in working in the industry.—2016 participant*

*I was going to be applying to applied mathematics master's programs. Now, I am going to be applying to PhD programs in pure mathematics.—2017 participant*

Figure 10. At least half of MSRI-UP participants shared ways that the program influenced their aspirations for the future.



Some participants noted that the changes in their aspirations were related to the increased confidence that they had as the result of MSRI-UP. The percentage of participants that spoke about this impact varied across the years. In 2014, 22% noted that their plans for graduate school were affected by their increased confidence. In 2015, the percentage rose to 29%. Over the next two years, however, rates decreased to 16% in 2016 and to 11% in 2017.



In 2015 and 2016, participants were asked to compare their intentions before doing research to their intentions now that the program was completed. They were also asked to share their likelihood to enroll in a graduate program.

- 73% of 2015 participants and 46% of 2016 participants shared that they were now planning to obtain a more advanced degree after taking part in the MSRI-UP program.
- The remaining participants in both years (27% and 54%, respectively) shared that their plans for a graduate degree had not changed, and that MSRI-UP had increased their resolve to attend graduate school and focus on mathematics.

Participants' reflections on their future aspirations before and after MSRI-UP included the following:

*Before: 4-year degree. Lacked confidence. Now: PhD in pure math. This program was the greatest catalyst.—2015 participant*

*My intended degree is bachelor's in mathematics. Before I just felt that it was the logical thing to do, now I truly believe that grad school is the place I have to be.—2015 participant*

*Before doing research I was THINKING about going for a master's degree. After research I KNOW that I will apply to a PhD program.—2016 participant*

*I'm currently an AB candidate in Applied Math. Grad school was previously something that I thought would be nice, but not something that I thought I deserved/was intelligent enough to pursue. After working in this research environment, I feel much more inclined to try to contribute to math, starting with applying to PhD programs in math. At this point (barring major extenuating circumstances) I will definitely be applying to math PhD programs this upcoming Dec/Jan.—2016 participant*

*I intended on pursuing a PhD degree in pure mathematics, and after having participated in this MSRI research program, I have confirmed this decision to go on to higher education.—2015 participant*

*I already intended to enroll in a PhD program, and now my decision has been affirmed. I am much more determined that I was before this REU.—2016 participant*

*Before this program I was already sure that I wanted to go to graduate school, but I wanted to enroll in a master's program and had little interest in a PhD program. After this summer research program I feel much more confident about my ability.—2016 participant*

By the end of the program, regardless of their original intention, 75% of 2015 and 2016 participants were planning to pursue a PhD in mathematics. The remaining participants (25%) provided generic statements about their intentions such as *attending graduate school*, which may or may not have been specific to math. Participants shared the following range of comments:

*Compared to my previous intent I am much more likely to apply to more competitive graduate school programs than before. I always wanted to apply to a PhD program but never gave serious consideration to applications at top grad school programs. Now I am confident I will try my best to be accepted into one of these programs.—2015 participant*

*Before MSRI-UP, I was on the fence about whether I should go to graduate school. If I had gone before, it would have only been for more non-academic job opportunities. Now, I want to enroll in a PhD program in statistics or applied math.—2015 participant*



*Before this program I was already sure that I wanted to go to graduate school, but I wanted to enroll in a master's program and had little interest in a PhD program. After this summer research program I feel much more confident about my ability to become a mathematician, and I will definitely be applying to PhD programs.—2016 participant*

The sentiments shared by participants at the end of their summer with MSRI-UP were reiterated years later when alumni were interviewed. Alumni mentioned graduate school preparation as one of the key benefits of the program. They noted preparation in several ways, including research and computing experiences and skills, presentation and communication skills, exploration of complex mathematical topics, an understanding of the graduate school experience, and self-confidence to conduct research and consider graduate school as a realistic goal. When discussing graduate school preparation specifically, alumni said:

*I think MSRI does a good job of, one, giving us some sort of structure so we know what direction to head in, but also the freedom to get creative and use our own interests to drive our research.—2018 alumnus*

*It gave me an idea of: Okay, this is something I can do and it's a very realistic goal to go to graduate school and finish a degree, and then get a job afterwards.—2011 alumnus*

*It was a huge help that I learned how to use MATLAB at the time. That meant that afterwards, I knew how to do MATLAB, and also LaTeX. So, for the rest of my undergrad I kept doing things in MATLAB and I kept doing things in LaTeX and that meant that when I got to graduate school I could already type up my homework in LaTeX and I already knew how to use this computational tool.—2011 alumnus*

## Providing Skills and Knowledge

*Assessment of short-term gains.* Upon completion of the program, MSRI-UP participants were asked to report gains in four areas by answering Student Assessment of Learning Goals (SALG) items. Gains were assessed in the following areas: Application, Personal, Skills, and Overall. Several items were used to assess each of these four areas. An average score was then computed for each student in each area. A total of 72 students who participated in MSRI-UP between 2014 and 2017 completed the assessment.

To assess Application gains, students were asked how much their most recent research experience helped them improve analyzing data, problem-solving, and formulating research questions; and understanding various limitations of research methods, mathematical theory, connections among mathematical disciplines, and the relevance of research. The results for students who participated in MSRI-UP between 2014 and 2017 are displayed below. Figure 11 shows the minimum Application scores (i.e., the lowest average Application score), the average Application scores for all respondents, and the maximum Application scores (i.e., the

### *Key Finding:*

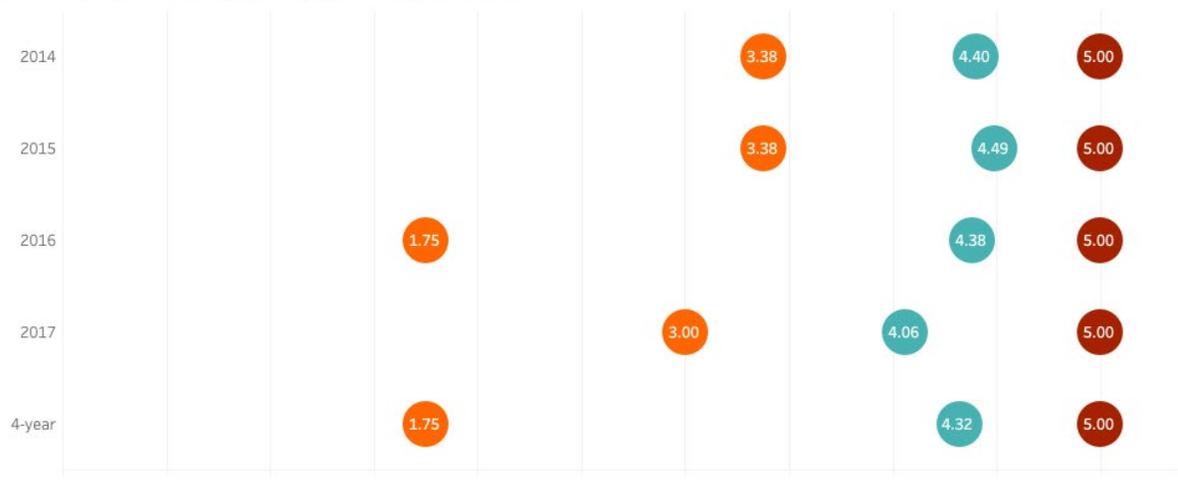
*Participants reported that MSRI-UP helped improve their ability to apply mathematical skills, their confidence as mathematicians, their technical skills related to math, and their personal capacity to conduct mathematical research.*



highest average Application score) reported by year, as well as in aggregate over all four years. Though a range of ratings were provided, average ratings were at the top end of the scale, indicating that students perceived strong gains in this area.

Figure 11. MSRI-UP students provided high ratings to describe gains made in their understanding of how to apply mathematical research skills.

Application: **Minimum**, **Average**, and **Maximum**



Personal gains were measured by: confidence to do research, to contribute to mathematics, and to do well in future math courses; comfort in talking about mathematical concepts and working both collaboratively and independently; and developing patience to conduct research, taking care when conducting research, and understanding what everyday research is like. Figure 12 below displays the minimum Personal scores, the average Personal scores for all respondents, and the maximum Personal scores for each year and for the four years combined. As with the prior results, students used a full range of ratings to describe their personal gains from the program. Average ratings were near the top of the scale, and similar to those provided to rate Application gains.



Figure 12. MSRI-UP students provided high ratings to describe the personal gains related to comfort and confidence in mathematics after the program.

Personal: **Minimum**, **Average**, and **Maximum**



Skills gains assessed included written and oral communication skills, keeping a detailed lab notebook, conducting observations, statistical analysis skills, working with computers and lab instruments, understanding journal articles, conducting searches for information, and time management. Figure 13 below displays the minimum Skills score, the average Skills score for all respondents, and the maximum Skills scores for each year, as well as the four-year average scores. Skills ratings had a narrower range from minimum to maximum compared to the two prior categories rated. The average rating for this group was the lowest of the four, though still near the top of the scale.



Figure 13. MSRI-UP students provided slightly lower ratings to describe their gains in Skills, though average scores were still at the top end of the scale.

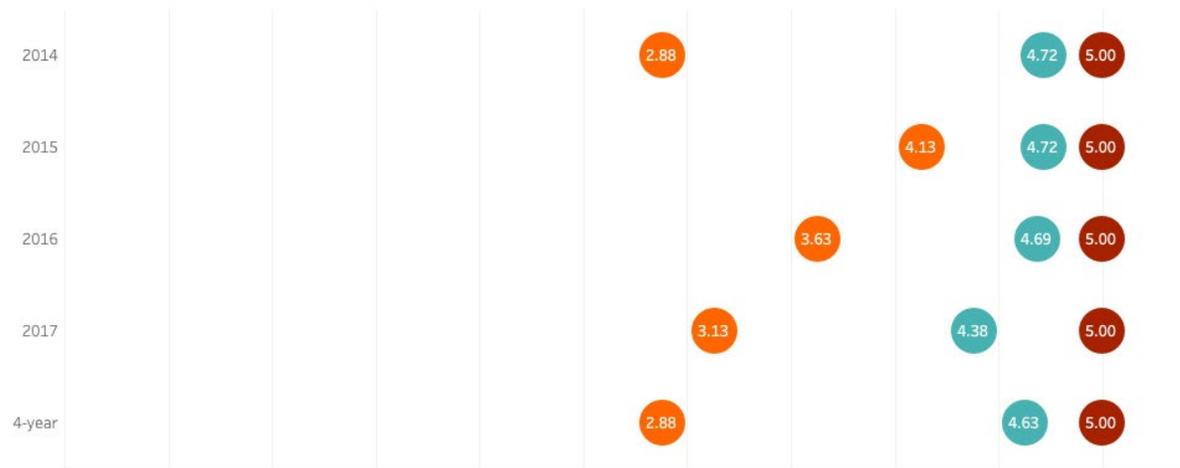
Skills: **Minimum**, **Average**, and **Maximum**



To assess Overall gains, students were asked, during their research experience, how often they: engaged in real-world mathematics research, felt like a mathematician, thought creatively about a project, tried new things on their own, felt responsible for their project, were excited to work extra hours, interacted with mathematicians from outside their home institution, and felt as though they were part of a mathematics community. Figure 14 displays the minimum Overall score, the average Overall score for all respondents, and the maximum Overall scores for each of the four years, as well as the four-year averages. Students scored this category highest overall, and reported the narrowest range of ratings.

Figure 14. Students reported the highest learning gains in relation to Overall questions.

Overall: **Minimum**, **Average**, and **Maximum**





Longer-term perspectives on program outcomes. The alumni survey included a number of items that were designed to capture longer-term reflections of the MSRI-UP program, with a particular focus on outcomes. One overall question was used to gauge former participants' impressions of their experiences. Using a five-point scale from *not at all satisfied* to *extremely satisfied*, alumni shared very positive lasting impressions of the educational opportunities provided by MSRI-UP. Average ratings were between *very satisfied* and *extremely satisfied* (mean rating = 4.63). None of the alumni chose options at the negative end of the scale.

The survey also asked alumni to recall some of their most memorable experiences from MSRI-UP.

Alumni recalled a full range of experiences, including some that focused on knowledge and skill gains from the program; 7% each wrote about the skills they developed, improved confidence in their knowledge as mathematicians, and the social experiences and outings with their cohort and work team. Some also mentioned the new topics they were exposed to and their specific research projects (5% each). Sample recollections from MSRI-UP alumni about knowledge and skill gains included:

**Key Finding:**

*Years later, alumni confirmed the impact that MSRI-UP had on their burgeoning knowledge and skill as mathematicians. They credited skill gains, increased confidence, and the community as having impact on their growth.*

*It introduced me to Stochastic Calculus.—2011 alumnus*

*It was the first time I was really forced to think about a research topic from start to finish and present it in a very thorough and complete way.—2011 Alumni*

*Getting some donuts and/or ice cream with the project partners before starting a night of work.—2012 alumnus*

*The entire process of reading papers, collaborating with peers and mentors, and conducting research. Honestly, the entire experience was extremely impactful.—2015 alumnus*

*Working in a group to successfully come up with and prove a previously-unproved theorem has given me the confidence to continue to pursue a career in research.—2016 alumnus*

## Short-term Feedback about Program Components

Throughout the years, a subset of questions on the exit survey asked participants for specific feedback about program components. The results from these questions are presented briefly in this section, to provide overall reactions to the specific learning opportunities provided by MSRI-UP.

The pre-research background period. The initial exit surveys (2008, 2009, and 2013) asked participants two questions related to the pre-research background phase of the program. Surveys collected from 2015–2017 participants included one question about the background phase.

- In the early years of the program, half of those who responded to this question shared that they liked or would've liked instruction such as *formal instruction, lectures, review of basic topics* and *short lecture for each group on their specific research problems*. Over half of the participants (54%) who mentioned the need for instruction also referenced computational and reporting

tools that they would be using in their project (e.g., Mathematica, LaTeX, Beamer, toric codes, and Magma).

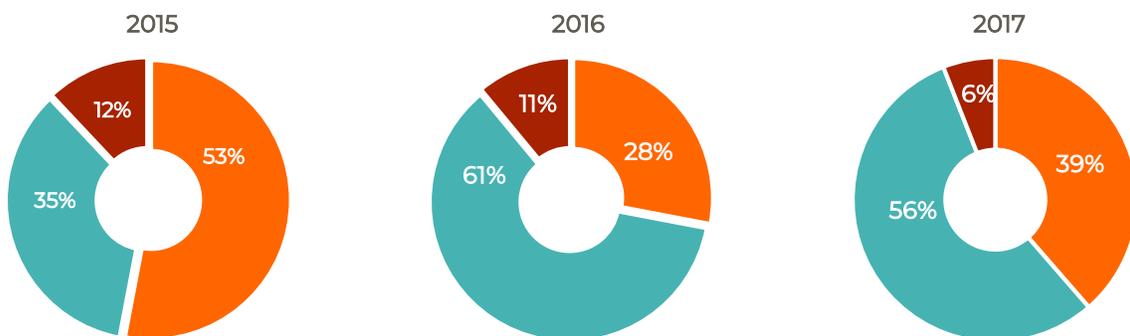
- In the later years, participants were asked if the pre-research background phase of the program was *just right* and to give suggestions that would have made it more effective for participants. Nearly half (47%) of those who responded shared neutral responses that included both positive commentary about the background phase and suggestions that would make it more effective. Moreover, one in four (25%) made only positive comments while a similar portion (28%) made only suggestions for changes.

Further examination of responses from the later years revealed a shift in the amount of positive versus neutral feedback provided over time (see Figure 15). While the question specifically asks for recommendations, most participants in 2015 shared only positive feedback. Neutral comments that included both positive feedback and a recommendation were provided more often in 2016 and 2017. Few participants in any year shared only negative feedback and recommendations. With regards to recommended changes, participants suggested shortening this phase of the program. They also questioned the value of the lecture series.

*Key Finding:*

*Feedback from participants and staff confirms the specific design characteristics of the individual program elements that they found beneficial, and provides suggestions for making these elements even stronger in the future.*

Figure 15. Participants both **praised** and made **recommendations** related to the background phase of the MSRI-UP program.



*Colloquia.* All participants from the 2015–2017 cohorts (100%) described what they liked about the colloquia. Indeed, most (77%) offered only positive commentary about this program component. Participants noted that they particularly enjoyed learning about the personal backgrounds of the presenters; these types of comments were the most common theme, shared by 35% of participants. Comments included:

*Young professionals are the ultimate motivators. These talks were impressive, and the people delivering them even more so. The speakers were happy to engage us. Great experience! Dr. Mayo made a great point to help me realize the importance of my undergraduate experience.—  
2015 participant*

*I really enjoyed the talks in the Colloquia, they showed me different sides of mathematics with equal beauty. Their personal background made me understand that at some point, they were just like us, and that if they could do it, I might as well.—2015 participant*

*These talks were particularly inspiring, because we not only got to learn about cool math, but we got to know the speakers as people. Hearing people's different journeys was really impactful for me.—2017 participant*

The remaining participants (23%) shared both positive and critical feedback about the colloquia. Of this group, some recalled colloquia presentations that were too hard to follow (33%) or were boring (25%). Sample comments from this group included:

*Very informative, but sometimes hard to follow. It was inspiring to see MSRI-UP alumnus achieve their goal of graduating with a PhD.—2015 participant*

*The research talks were often an hour and a half, not including the time presenting their life's path. I enjoyed the part of presenting their career and life choices, however I think shortening the research talks to an hour or less would be less boring and allow more time for research.—2016 participant*

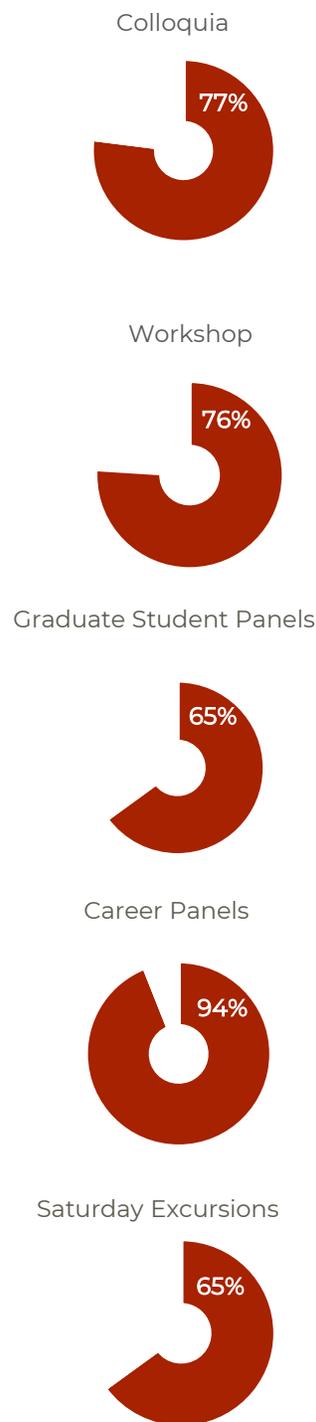
*Most of these colloquia were dope!! I thought Dr. Nicolas' material was a bit boring, but I still thought he had great presentation skills.—2016 participant*

*I enjoyed the majority of the colloquia, I felt that Professor Mercedes Franco's presentation, however, was a bit hard to follow in terms of what her research focused on.—2017 participant*

Graduate school and fellowship workshop. When asked about the graduate school and fellowship workshop, almost all 2015–2017 participants (85%) had only positive impressions to share. The majority (76%) said the workshop was informative. One-third (33%) noted that they felt more confident about being accepted into graduate school after the workshop, and an additional 21% reported that they found the workshop encouraging (21%). Participants said:

*It was nice to get some inside information on what to expect when applying to graduate school and once you get there.—2015 participant*

Figure 16. More than half of the feedback provided to share impressions of each MSRI-UP component was entirely positive.





*Dr. Patt made me actually feel like I belonged in a PhD program, so that was pretty amazing!—2016 participant*

*I felt more confident about applying because she really helped me see that getting accepted into grad school is possible.—2015 participant*

Graduate student panels. Nearly all 2015–2017 participants (92%) shared positive remarks when asked their perspectives on the graduate student panels included in the program. Over half (65%) gave only positive comments. Many noted that the highlight of the panel was gaining insight into graduate students' personal experiences (45%). The number of participants that commented on this topic decreased over time, from 59% in 2015 to 42% in 2016 and then to 28% in 2017.

*The graduate student panels were very nice because it gave us a chance to pick the brains of many individuals that were in graduate programs that I would like to be a part of one day. They also said many things that I might not have considered before when looking for the graduate schools that I will apply to.—2015 participant*

*The grad student panel was also very helpful. I enjoyed hearing from people who are currently in a graduate program.—2016 participant*

*They all offered good advice about graduate school.—2017 participant*

Like prior panels, some participants felt that this panel were informative (26%). Participants said:

*The graduate students gave me great information on what it takes to get into graduate and how to succeed while in graduate school.—2015 participant*

*They were both very enlightening on what it means to be a graduate student lifestyle and workload style and how your own personality dictates your experience. Was able to see a larger picture about picking graduate schools. Much good.—2016 participant*

*This panel was very educational for me. Despite my ambitions of going to grad school, I knew very little of what that experience would actually entail before this program. I learned about what the day-to-day life of a grad student is like, their research process, working with an advisor, and so much more. Also, their information about their grad programs (most of which I was unfamiliar with) helped expand my view on what to look for in a program. Their information on fellowships was also really nice.—2017 participant*

*I was surprised with the trajectory of these students. Most of the time when I think of grad students, I think of one with Robert's trajectory who do a 4-year undergrad and then go straight into a grad program in pure mathematics. It was weird to hear from so many master's students and such, who have very alternative paths. Perhaps that's the point of MSRI-UP.—2017 participant*

In all, 25% of participants' comments included both positive and negative perspectives. These included feedback from those who felt that the sessions were not helpful because they *already knew about graduate school* or they could *find on the internet* (14%). A small portion of participants (10%) shared



comments that were entirely negative. Mixed feedback about and criticisms of the grad student panel included the following:

*The most necessary event of a summer undergraduate program. The selections were great, maybe more students from research institutes like RPI. And we should have talked about the GRE subject test more!—2015 participant*

*The first panel discouraged me from going to grad school because they all seemed like all they did was research. It also seemed like self-care was impossible to do. However, the panel with the MSRI-UP alum eased those fears. They all seemed happy and enjoyed what they were doing. It also helped knowing that finding a good school (not the highest ranked) for us is the most important.—2016 participant*

*Perhaps in the future a more “diverse” panel in terms of goals would be better? The grad students seemed to only want to be the best pure mathematicians possible and had pretty serious opinions on a lot of things. It’s cool hearing from them! But they gave me a weird impression that all math grads would be like that, until I remembered that Jacob and Natalie weren’t.—2016 participant*

*Boring. I only support it because this is three students’ first time attending graduate panels. Yet, this is my umpteenth time attending one, and all graduate students say the same thing, to be honest.—2017 participant*

Career panel. Once again, the majority of 2015–2017 participants (94%) had only positive commentary to share about the career panel. The most common positive comment, made by 41% of the participants, focused on the diversity of careers represented on the panel. Another notable portion (31%) shared their appreciation for including careers outside of academia. Participants shared:

*This was a great opportunity! Thank you for allowing us to see all that can be done with a degree in mathematics. It was also very nice that we were given an extended break in order to talk to each panelist one on one as we wanted to.—2015 participant*

*I really enjoyed this panel. I did not know these career opportunities until this and found new paths I would like to explore.—2016 participant*

*The best panel by far. It showed different ranges of careers, both in academia and industry.—2017 participant*

As mentioned in the last comment, some panels included a focus on industry-related careers. These perspectives proved particularly meaningful for some (12%), who shared that the career panel impacted their thoughts about the future. These participants indicated that they were more interested in industry careers after attending the career panel. Participants said:

*The career panel made me very excited. I don’t really want to be a professor, but I didn’t know about other opportunities. This panel made me very interested in working in the industry.—2016 participant*

*I really enjoyed this panel. I feel like in my desire to go to graduate school and become a professor that I narrowed the possibilities of what I could do, but hearing the merits of going into industry, or teaching at a community college, has really opened me up to other possibilities. That’s not to say that my ambitions haven’t changed, but I’ll definitely be more*



*likely to consider those opportunities more seriously in the future, rather than immediately dismissing them.—2017 participant*

Very few participants (6%) shared negative comments about the career panel. Those who offered criticism included:

*I was hoping for a more diverse panel in the sense that there were more participants representing different jobs in industry.—2015 participant*

*I found this panel boring and not very relevant to my goals, as I plan to go into academia and this was focused on careers in tech and industry.—2016 participant*

*They made me fearful of my coding ability, or lack thereof.—2017 participant*

Saturday excursions. When participants were asked about the Saturday excursions, the vast majority (98%) shared positive comments. Two of three participants (67%) shared positive commentary about them and in the three years that the question was asked only one participant (2%) said something negative about them. The remaining 31% shared a positive comment along with a negative comment. The amount of only positive comments decreased over the years from 82% in 2015 to 58% in 2016 and 50% in 2017.

The most common positive comment about the Saturday excursions was that they allowed for community building with the participants and staff; 24% shared this type of feedback in their comments. The second most common theme focused on the importance of having an opportunity for a mental break (14%). The range of positive feedback shared included the following:

*This was the most surprisingly amazing aspect of the trip. I got to engage with peers on a relaxed level. It expedites the bonding process.—2015 participant*

*I am glad I had the experience to enjoy some of the best things California has to offer. I find that the excursions were necessary in order for us to be able to learn to take breaks ever now and then. Most people do not consider taking time for themselves when they are hard at work but this is also necessary in order to promote new insights for creative problem solving.—2015 participant*

*They were all awesome and helped me get out of my shell a little bit—I love the rest of the students here but can unfortunately be a little shy, so these helped a lot.—2016 participant*

*These excursions were amazing! They really took the mind off all the pressure the research adds to a person. Maybe easily one of the most useful things we did during the six weeks.—2016 participant*

*This was one of the best parts of this entire experience. I enjoy forced fun because it is easy to get too caught up in work and trying to get results. I can't pick a favorite excursion because they were all very well thought out.—2017 participant*

*I loved every excursion. It was a nice break from research and a good time to get to know everyone better.—2017 participant*



The length of the Saturday excursions was too long for some participants (12%) Specifically, two 2015 participants mentioned the beach trip was too long and in three 2017 participants believed that the Exploratorium was too long.

*They were all fun except the beach day was too long.—2015 participant*

*These were fun, but very time consuming and tiring. I wish I would have had more time to unwind in my own way—napping, walking around Berkeley alone or in a small group, being aimless and useless and maybe alone for a while. I also wish I could have been more productive on the weekends, but Saturdays felt completely unproductive. I think the Botanical Gardens was my favorite, but all the activities were pretty fun and memorable.—2016 participant*

*Best one was the Muir Woods. The Exploratorium was very long (I think everyone was tired after one hour). Overall good excursions.—2017 participant*

Final short-term feedback. As part of the overall feedback, 2015, 2016, and 2017 participants were asked to share their most valuable or memorable experience during the program. Combining responses over the three years, three themes emerged: learning new information, solving challenging problems, and talking to mathematicians.

Learning new information was the memorable experience shared most often over the three years, by 35% of participants. Examination of response rates across years reveals that learning new information was most memorable for 2017 participants; 61% of participants said learning new information was their most memorable experience.

*I felt that the first two weeks of the program were the most valuable in terms of expanding my knowledge and it was a very fun experience to learn so much in so little time.—2015 participant*

*I learned that I am capable of learning a large amount of mathematics in a short amount of time when necessary, such as during the first two weeks of the program. I also got to experience some of the frustrations of research which I think were a nice preview to what graduate school will probably be like.—2016 participant*

*This was my first exposure to algebraic geometry and I am now very interested in the subject. I was really intimidated by it before coming here, but Maurice's rock star teaching and mentorship gave me a lot of confidence in my own ability to learn.—2017 participant*

*I learned so much math on algebraic geometry, topology, combinatorics. I have never taken a class on any of this and learning all this at MSRI-UP was the most valuable thing for me.—2017 participant*

*Learning how to conduct research. How to go about solving a problem by breaking it into pieces, trying different methods to deal with them, and how to handle setbacks. Also, seeing that even experienced mathematicians struggle with certain problems, really relaxed a lot of pressure I felt in regards to research.—2017 participant*

Working to solve a problem as well as talking with mathematicians were the second most memorable experiences reported by participants (23% each). For those who focused on solving problems, examples were given from both their research project and the background phase of the program. For those who shared memories of talking with a mathematician, discussions with visitors, peers, and advisors were given as examples. Participants' memories included:



*When we were able to define the group action on the induced Sperner's labeling, I was so happy that I could not stop smiling. It just reminded me how beautiful knowledge is, and how much I enjoy doing mathematics.—2015 participant*

*Sloughing through an ugly conjecture that appeared simple but was a pain to show was true. The patience and perseverance gained from that, as well as the insight into research, are invaluable.—2016 participant*

*It was incredibly valuable to talk with so many amazing mathematicians—my peers, my mentors, the guests who came in, the grad students who were there, other mathematicians who were working at MSRI. No particular incident stands out in my mind, but just the amazing experience of exchanging mathematical ideas on a daily basis. Through these people, I learned not only about group theory and sandpiles, but bits and pieces from all areas of mathematics. I loved hearing about what other people have learned, and sharing what I've learned, and asking questions together about things we didn't know anything about.—2016 participant*

*The most memorable experiences for me were the long hours we spend in the office, writing on the chalk board. Arguing with my team was actually quite enjoyable because we all ended the arguments slightly smarter than we were before.—2017 participant*

*The one special moment I will always remember is when we noticed a pattern, formulated a conjecture, and proved it!! Those few days were very exciting!!!—2017 participant*

Participants over the same three years were also asked about their most valuable or memorable experience while in the program that was unrelated to math. Over half of participants (56%) described the sense of community between program participants and staff in response to this question. Indeed, this was the most prevalent response from 2016 and 2017 (75% and 61%, respectively). Memories related to the community included:

*The strong bond we formed during the program and the wonderful support I was given through it all. I think the choice of staff was perfect and I am glad I had the chance to work with so many talented people that also had great personalities.—2015 participant*

*I really enjoy the friendships I built here and especially the close relationship within my advising group (people advised by Jacob). It was unbelievably nice to meet people with the same values and similar backgrounds as me who cared about math but also about bettering our home communities. While my college is a good place to learn math, it's not the greatest at empowering people with less elaborate HS backgrounds/first gen students/underrepresented groups etc. to feel that they're deserving, so this was a welcome change.—2016 participant*

*Getting to know other people like me and building community was the most valuable personal experience at MSRI-UP.—2017 participant*

In 2015, excursions were also identified as a memorable non-mathematical experience for nearly half of participants (47%). However, none in the 2016 cohort and few in 2017 (11%) mentioned excursions as their most memorable experience. Those who did recall excursions shared the following:

*The Saturday excursions. of course, the beach was my favorite one but they all were very enjoyable.—2015 participant*

*My most \*otherwise\* memorable experience was my last day in Berkeley, the karaoke night. I was really struggling holding my tears back, since I was not prepared to say goodbye to all the*



*wonderful young mathematicians, and researchers I have met. I can truly say that this was my best summer ever!—2016 participant*

*I thoroughly enjoyed the park in San Francisco. Laying in the grass and worrying about nothing was very refreshing amidst the hectic work week.—2017 participant*

Opportunities for improvement. Throughout the life of the program, participants were provided with a number of chances to make recommendations for improving the program. In both 2008 and 2013, for example, participants were explicitly asked to share what they disliked about MSRI-UP. Only 25% of the participants across both years responded to this item. Of those, 31% noted that they disliked the intensity of the math work in the program. In addition, of that subgroup who shared what they disliked about the program, a smaller portion of that group (23%) referred to stressful *group dynamics* and *complaining from everyone*. Others referenced the living arrangements (23%), and a lack of sleep (15%).

In 2015 and 2016, participants were asked to share things they wished they had known prior to the start of the program. In 2016, 41% noted that they wished they had been aware of the background knowledge needed (and not needed) for the program. Other comments were about the intensity of the work, living situation, clothing suggestions, and format of the program.

*I would have liked to know how many times we would be presenting our work throughout the program, so that I could've brought the amount of dress clothing that I felt was sufficient.—2016 participant*

*I wish I had known more about the topic I was researching during MSRI-UP. If students could receive some reading material prior arriving, it would be very useful!—2016 participant*

Former MSRI-UP participants were asked to make recommendations for ways that the program might be more useful in the career development of participants as part of the alumni survey. Approximately half (51%) stated that they did not have any recommendations, affirming their positive impressions of the program overall. Those who did share recommendations included 16% who suggested extending the networking and resource options beyond the summer of participation, and 13% who suggested more time be spent on explaining and preparing participants to be successful in non-academic careers. A smaller portion recommended providing more information on being successful in graduate school (4%) and preparing for tests such as the Math GRE (4%). The range of recommendations provided included:

*Continuing education (at an undergrad level) to help students apply for things the Math GRE to help them be better applicants.—2007 alumnus*

*Better ways to reconnect and network with alumni after a few years of grad school.—2008 alumnus*

*Help develop my programming skills more and better prepare for careers outside of academia.—2010 alumnus*

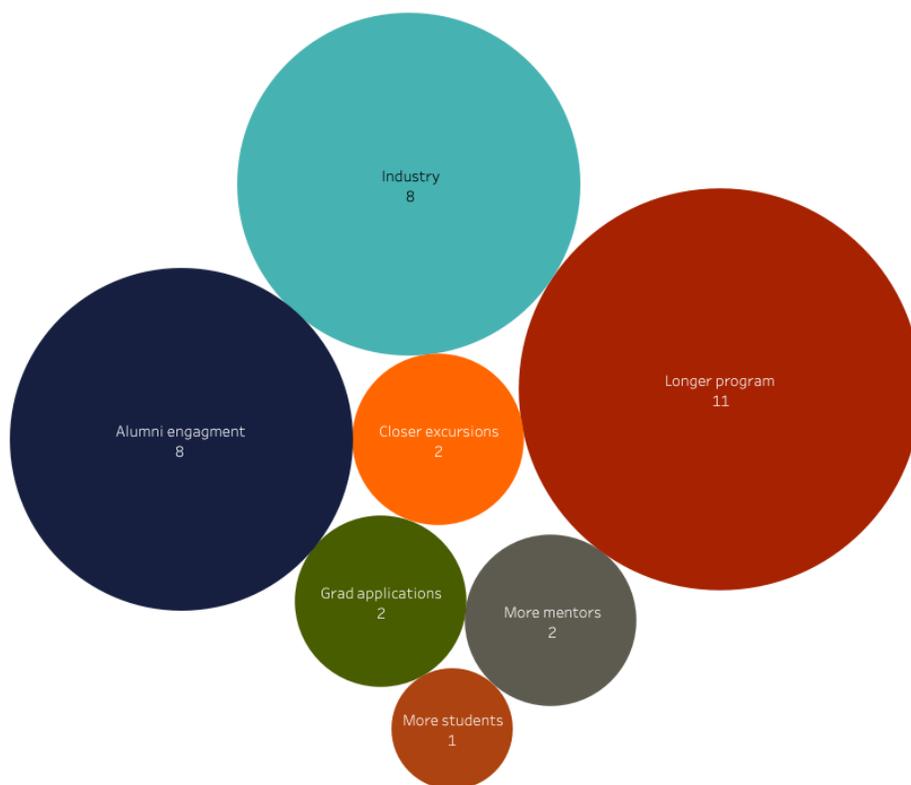
*Maybe a bit more checking up after the program. Especially around the time that one would be applying to graduate school and studying for the GRE.—2011 alumnus*

*Career consulting? There were impromptu sessions, but purposeful career consulting could have been beneficial to provide more direction on options and fit.—2012 alumnus*

*Encouraging more collaboration on related topics between participants, mentors, and visiting scholars, even after the program with events where we could meet. I wouldn't have agreed with it at the time but I could see that would have been a strong way to keep me engaged in the field and working with others on their problems.—2016 alumnus*

Several of these themes emerged again, and with more detail, in the alumni interviews. While the alumni who were interviewed overwhelmingly praised the program, they also noted potential changes and additions that could improve the experience for undergraduates. Figure 17 represents the number of alumni who mentioned each area of improvement.

Figure 17. Eleven of 12 alumni suggested lengthening the MSRI-UP program. Many also suggested enhancing the program's focus on industry-related careers and finding ways to continue engaging with alumni after the program's completion.



One recommendation voiced by several alumni is increasing the length of the program to a typical eight-week REU, a sentiment echoed by MSRI-UP staff (described below). Alumni noted that a longer program would allow for more practice with mathematical writing, academic preparation for students who may be underprepared, and more opportunities to present research findings. Alumni stated:

*I feel like I didn't get as much of an opportunity to practice the actual writing of research.—2018 alumnus*



*Coming in as a novice to people who were Master's in Mathematics, I felt like there were a lot of missed opportunities for explanation on different topics.—2009 alumnus*

*I met the requirements, but I wasn't prepared... so there was a lack of support for someone with minimal knowledge within the mathematics realm.—2009 alumnus*

*I wish there was maybe more space to have those conversations to build that confidence to be okay with the uncertainty of not knowing something. Because now that I'm in education, thinking back it's probably very likely that there were other people who were feeling the same way as me, but we didn't necessarily have the effective pieces to have those discussions.—2014 alumnus*

*[I would have liked to] give earlier and more presentations.—2009 alumnus*

Another recommendation from the alumni interviews, also noted by staff (described below), is to provide formal opportunities for MSRI-UP alumni to engage with one another. While some alumni keep in touch with their peers from the program, several recommended an MSRI-UP reunion and/or newsletter, extended research projects, and presenting together at national conferences.

MSRI-UP alumni believe that the program does a good job preparing them for graduate school and to pursue jobs in academia. However, several alumni wanted to meet mathematicians working in industry to better understand the full breadth of mathematical careers. They noted:

*Giving a full example of all the different career opportunities that one can do with a PhD in mathematics, and this also means diversifying the people that are invited to also include members of the mathematics community that are not in academia but went into industry, and have them talk about their experience.—2010 alumnus*

*I guess in all summer programs, there's this kind of attitude amongst the participants that if you don't get a PhD or you don't go into academia, you kind of failed. So, I don't know if there can be more mentoring about other options so that people don't feel that way.—2007 alumnus*

*So, let's have a business pose a question to students and see how they can answer it. I think it would be nice to have like, an applied side of MSRI-UP as well as the theoretical one, because some students are on the fence about whether or not they want to get a PhD and if not, if a master's will be good enough for them and they want to just go into an industry after the master's, I think having an applied project would benefit that type of person.—2011 alumnus*

Other recommendations from alumni were to have more mentors available to undergraduate participants, and to try to ensure that TAs are interested in mentoring undergraduates. One alumnus stated:

*While I enjoyed the whole program, my actual research project, I felt like the TA that was hired to lead that research program didn't necessarily seem as motivated or perhaps engaged with the material as other TAs. Which made my experience feel kind of different and it felt a bit isolating. Because you know, everyone else was really excited about the research and yet my mentor seemed to be less excited. So, I don't know if there is a way to like—you know, making sure that the TAs they hire are really people who want to do the math and who are going to be not just smart people, but good mentors, and be able to lead a research program and a research team.—2018 alumnus*



Additional recommendations included providing information about the process of applying to graduate school, providing financial assistance to applicants, altering the excursions so they are closer to the MSRI-UP campus, and accepting more students into the program if possible.

As noted above, some of the themes above were also suggested by MSRI-UP staff. Like alumni, staff were extremely positive about the program. When asked, they also noted potential changes that may improve the experience for undergraduates. These include the length of the program (six weeks instead of the typical eight), interaction with other MSRI groups, post-participation interactions and funding, and more or better distribution of information about various topics such as funding to attend conferences, national graduate school funding opportunities, and information about various national societies. Individual staff mentioned the following:

*I often think that our biggest challenge is that the program is short. I think most programs are eight weeks and ours is six weeks, and so that's a concrete challenge...I like the decision, but I think it would be nice if more of our students published their work.—staff*

*One idea that comes to mind would be if there was some time when bringing together the MSRI group with the concurrent programs happening, like if there was some kind of joint activity that they could do, because those people there for that program are going to be most likely graduate students and above. So, that would allow [MSRI-UP students] to be able to mingle with people who in some sense would feel like real mathematicians, you know, that are already part of the community. And so, maybe finding some activity that allowed them to—that wasn't just "Oh, it's tea now. Go out into the woods and see what you find." But really something a little more structured might be nice.—staff*

*I think we can do a better job of having them go on to their graduate programs when they're graduate students and having them come in as researchers later on and really kind of getting them to work more closely with very elite scientists that hang out at MSRI all the time. So, I think that's something that we could do a little bit better is really finding a more meaningful interaction. We do interact to some extent, but it's hard with so little time. But if we could get our students more involved throughout the year and more involved with that kind of stream of things that happen at MSRI, I think that could be very beneficial.—staff*

*I think what would be helpful perhaps—and I don't know if this is a change MSRI has done, but if there's funding for follow-ups. So, if students were really working hard on a project together, I don't know if they'd have the opportunity to meet up again later to continue that work.—staff*

*I think I would prefer that MSRI-UP specifically have a panel on funding for graduate school. So, for example, they always have someone that at least talks about the National Science Foundation Graduate Fellowship. This is something that you actually have in graduate school. But then, there's others out there that I think MSRI-UP doesn't really focus on. So, like, the Ford Foundation...there's National Physical Science Consortium...the GEM Fellowship.—staff*

*I wish that [the students] had known about other conferences. That's, if anything, my one criticism. I know that there was funding available for students to attend, but I don't know how many of the students really took MSRI-UP up on that offer to attend. I feel that they had great opportunity—they learned a lot in how to present, but I wish that they had used those skills to present more at other conferences.—staff*

*Longer-term reflections on opportunities for professional growth.* The alumni survey included a set of questions focused on professional growth opportunities provided by MSRI-UP. The individual items used to rate this topic are presented in Table 6 and demonstrate variability in the importance of MSRI-UP offerings to alumni. Three program components were considered *moderately to extremely important*; more than 90% of alumni chose one of the top two ratings to describe the importance of conducting research, interacting with faculty, and feeling part of the research community. The remaining two items were rated as *slightly to moderately important* to alumni, on average.

**Key Finding:**

*Years later, MSRI-UP alumni remembered many program components as quite important to the professional growth they achieved.*

Table 6. The research opportunities, faculty interactions, and community were all rated as important to alumni. Lower positive ratings were provided to describe longer-term impressions of the importance that guest speakers and non-academic career considerations had on the professional growth of alumni.

|   | Not at all important | Slightly important | Moderately important | Extremely important | Mean |
|---|----------------------|--------------------|----------------------|---------------------|------|
| Conducting research   | 2%                   | 2%                 | 11%                  | 85%                 | 3.79 |
| Interacting with faculty                                      | 2%                   | 5%                 | 27%                  | 67%                 | 3.59 |
| Feeling like you were part of the research community          | 2%                   | 5%                 | 29%                  | 64%                 | 3.55 |
| Meeting guest speakers or other scholars visiting the program | 2%                   | 14%                | 35%                  | 48%                 | 3.29 |
| Considering careers outside academia                          | 14%                  | 27%                | 21%                  | 38%                 | 2.82 |

**Providing a Community of Peers and Mentors**

One of the most common themes throughout the evaluation focused on the successful community fostered by the MSRI-UP program. In 2008 and 2013, for example, many participants focused on community when asked to share the things they particularly liked about the program. Combining responses from both surveys, results revealed that over half (56%) of the participants reflected on an aspect of the MSRI-UP community such as *Tea Time*, *administration*, and *the bond of the group*.

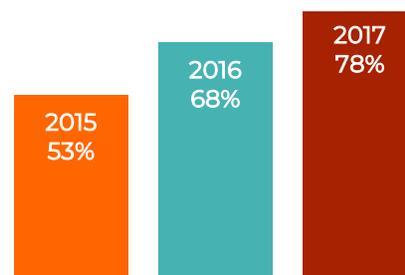
This theme emerged again in various responses shared by the 2015–2017 cohorts. In some cases, participants referenced specific individuals that they enjoyed connecting with, such as guest speakers and their advisors. In others, they cited the positive bonds formed with their peers and staff. Many also mentioned the positive experiences that they had working with their teammates. In all, 67% of participants referenced an aspect of MSRI-UP’s positive community. Indeed, as Figure 18 shows, the portion of participants who mentioned the positive community increased each year. Descriptions of the community included the following:

*I have had so many great times with the other students! I was not sure what to expect with living with 16 other math majors, but I have loved meeting these people and hanging out with them. Also, I liked how welcoming the staff is!—2015 participant*

*I will always remember the relationships I forged with the other students. The students selected for this program truly formed a remarkable group of human beings, and I am tearing up right now thinking about it. Everyone in the program was so intelligent, interesting, thoughtful, mature, and multi-dimensional. I really really hope to keep seeing these people again and again and again throughout my mathematical career.—2016 participant*

*Getting to know other people like me and building community was the [most] valuable personal experience at MSRI-UP.—2017 participant*

Figure 18. Most participants mentioned the importance of community, with increasing frequency across time.



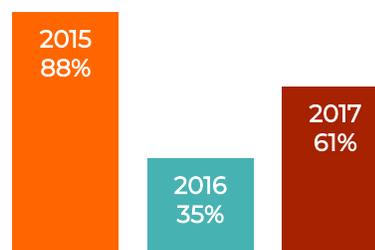
Short-term feedback about mentorship. Beginning in 2015, a question was added to the exit surveys to gather impressions about the mentorship and guidance provided to participants. Over this three-year span, participants were asked to describe the most and least effective ways that they were provided with mentorship and guidance. Nearly two of three participants (62%) shared only positive comments in response to this question.

An analysis of response rates across years revealed differences between years. As Figure 19 shows, more than half of participants in 2015 and 2017 provided entirely positive feedback about the program; this portion was markedly lower in 2016.

When describing the guidance they received from the program, two themes emerged. Most prevalent (29%) was that the guidance helped participants stay on track. Second, shared by 21% of participants, was that the advisement gave them helpful information they needed for their project. Responses included:

*The advisement was most effective in explaining*

Figure 19. Participants provided entirely positive feedback about the mentorship provided by the program in two of three years.





*strategies for how to understand difficult material and how to make good conjectures.—2015 participant*

*The advisement we have received was very effective, it kept us on the track to produce more interesting results.—2016 participant*

Only a few comments were made about guidance that was considered less effective. Unique to the responses from the 2016 survey, 24% mentioned the stress caused by the daily presentations, and the lack of time and benefit from these sessions. A small portion of participants in 2017 shared the latter sentiment (5%). Those who provided mixed reactions about advising from the 2016 and 2017 cohorts wanted additional guidance from their advisor (15%). Mixed feedback and criticisms of the advisement sessions included the following:

**Key Finding:**

***MSRI-UP is successful at creating a strong community among its participants that includes meaningful connections between peers in the program, and valuable mentorship from staff and faculty.***

*The morning meetings were harsh and unnecessary. Time that should have been spent researching was spent working on these presentations so that we wouldn't be ripped apart for not presenting it perfectly.—2016 participant*

*Four to eight hours a day of logistics "advisement and guidance" during an effectively 3 week research project. I don't know if that is considered more efficient or less efficient. The last week was pretty much purely final report and presentation logistics. I didn't even get to meet with any adviser for a one on one or team advisement. The daily presentations should be made every two or preferably three days, especially if the students already have a really good idea on where they are going to go the next day. If they are keeping a daily log you can tell when you should steal their time and when you shouldn't.—2016 participant*

*I enjoyed the guidance and advisement. sometimes I felt like it was "you guys are doing great;" "you guys are so good, you're really improving;" etc. I don't think I have imposter syndrome, but I definitely think I had room to improve but maybe I judge myself too hard.—2017 participant*

Longer-term reflections on the mentorship and guidance provided through MSRI-UP were quite positive. The alumni survey asked former participants to rate the advising they received from the program on a five-point scale from *not at all satisfied* to *extremely satisfied*. Average ratings were near the top of the scale, including that alumni were *very* to *extremely satisfied* with this component of the program (mean rating = 4.54).

*Longer-term perspectives on community and relationships.* The alumni survey also used a series of questions to capture recollections of how alumni felt when they were part of the program. One set of questions asked alumni to reflect on whether and how the program fostered a sense of belonging to the mathematical community. They also answered questions about the role that peers and mentors played in creating a positive learning environment.

Factor and reliability analyses were conducted on the set of items for each topic to determine whether an average score could be used to interpret the results. A Principal Components Factor Analysis with



Varimax Rotation indicated that items related to five of the six topics could be summed in an average score. Average scores for each scale are presented here for each topic; see Appendix A for the results by item.

Table 7 presents the results for the three scales that were created to capture reflections of the program itself. Questions related to each topic focused on how students felt about the program during their time as a participant, using a five-point scale. The results indicated that students endorsed the effectiveness of the program for each topic. Engagement with mentors was rated slightly higher than the other two topics, though all had average ratings between the highest ratings available on the scale.

Table 7. Mean scores across items related to MSRI-UP's community indicate that the relationships formed, and the sense of belonging created were high, with scores near the top of the scale.

| Scale                   | Reliability | Mean |
|-------------------------|-------------|------|
| Community Belonging     | 0.83        | 4.28 |
| Engagement with Peers   | 0.84        | 4.22 |
| Engagement with Mentors | 0.90        | 4.40 |

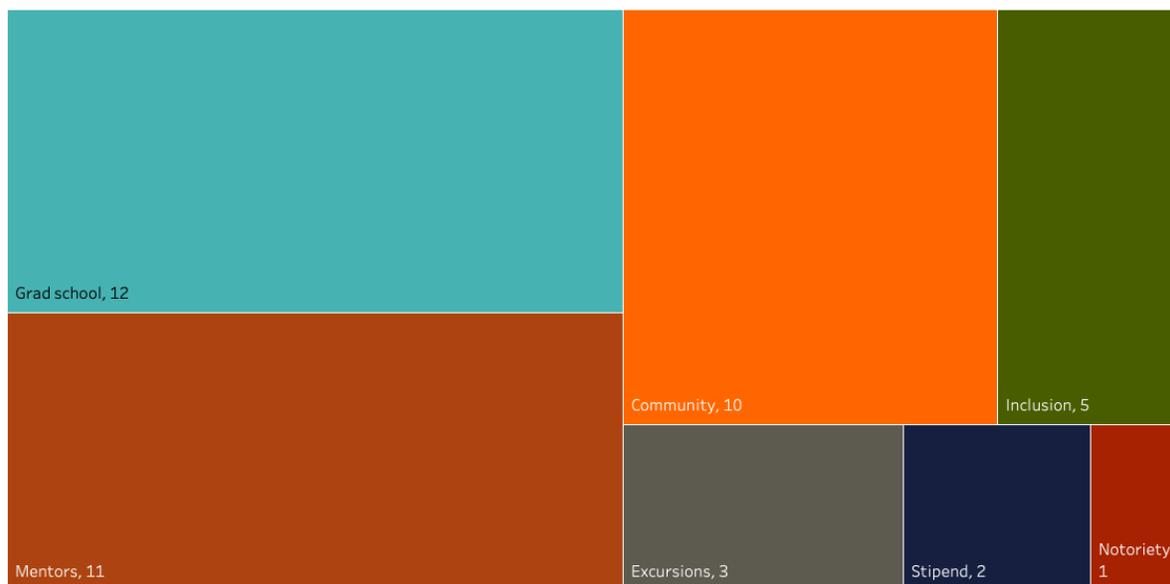
The success of community building was reiterated by alumni when they were asked to reflect on their most memorable experiences in the MSRI-UP program. Three types of comments focused on the community and relationships built throughout the program. Nineteen percent (19%) wrote that MSRI-UP's supportive and inviting community gave them a sense of belonging. A similar portion wrote about the relationships they developed during their time in the program in general (18%), and the guidance provided by their mentors, in particular (17%). See Table 8 for a list of comments related to each topic.

Table 8. Alumni shared a number of positive recollections about community connections, and the personal and professional relationships they developed during the program.

|                                       |   |
|---------------------------------------|---|
| <p><b>Sense of Belonging</b></p>      | <p><i>Working in teams was fantastic. I remember doing a lot of literature review and telling my team members I didn't want to that day and they encouraged me to work with the code instead. They were supportive and it was great to not be confined to one task.—2007 alumnus</i></p> <p><i>The sense of community that I build at MSRI-UP had the greatest impact. I felt like my peers were close friends and I was very comfortable with asking for help from the faculty even well after the program had ended. I had one of the faculty read my research statement when I was applying for tenure-track jobs. The sense of community was wonderful.—2011 alumnus</i></p> <p><i>Being able to have real conversations with other students of my race and connecting over our shared experiences as minorities in the math community was very valuable and healing.—2017 alumnus</i></p> <p><i>Being at MSRI-UP was the first time I was really around mathematicians that were also more than just mathematicians. I felt supported from them academically, socially, and emotionally. The group of students in my cohort are amazing and made me feel realize I need to stop questioning whether I belong in the mathematics community, because I do.—2018 alumnus</i></p>  |
| <p><b>Relationships Developed</b></p> | <p><i>I met my husband at MSRI-UP. We got married six years later. I got my first publication; I picked my grad school based on one of our TAs; I have a relationship still with Dr. Victor Moll who wrote me multiple letters of rec throughout the years; I went back to MSRI-UP as a TA in 2012; I returned once again to MSRI for a summer school in 2016. It literally changed my life in every way.—2008 alumnus</i></p> <p><i>My favorite experiences were reuniting with the group at various conferences, such as SACNAS and the Join Math Meetings.—2011 alumnus</i></p> <p><i>The amazing people that were part of the program, the bonds we shared, the research—it was one of the best experiences I had.—2012 alumnus</i></p> <p><i>The relationship I had with my two project collaborators is really memorable to me and helped shape my idea of the potential of effective collaboration. I appreciate that one of my more outspoken collaborators would always tell my advisor to ask me for my viewpoints on certain parts of our research, since I wasn't great at advocating for myself at the time. Another notable experience was that I developed a close friendship with another student who similarly went from a less-resourced background to an Ivy League for undergrad, and we were able to connect over the experiences of trying to gain the social capital that was often "assumed" by our institutions/departments.—2016 alumnus</i></p> <p><i>The mentors from that program still guide me today. Every lesson I learned is still with me and I now teach to my mentees. It was by far the most valuable experience I had as an undergraduate and without a doubt I would not be where I am today without it.—2007 alumnus</i></p> |
| <p><b>Mentorship and guidance</b></p> | <p><i>The conversation about being a minority woman in math with the director of the program.—2011 alumnus</i></p> <p><i>I particularly remember working on a proof with a mentor and feeling as though we were equals when thinking about how to solve the problem. That moment was powerful because it made me feel respected as a mathematician.—2015 alumnus</i></p> <p><i>Many of my mentors from MSRI-UP have allowed me to feel confident as a researcher and ultimately helped me through my graduate school application process.—2018 alumnus</i></p>  |

Additional examples of the importance of MSRI-UP mentors and community were shared by alumni who were interviewed for the evaluation. Figure 20 represents all themes from the alumni interviews. As noted earlier in this report, the importance of the program in helping them prepare for graduate school was mentioned by all who were interviewed. The next two topics mentioned most often were the importance of MSRI-UP mentors and the sense of community that was formed. These responses are discussed in more detail below the figure.

Figure 20. When asked to describe memorable moments from the program, the topics discussed by alumni most often were those that were directly related to the program’s main objective.



When asked to reflect on their time in the program, almost all MSRI-UP alumni described the sense of community that began with the program. Specifically, alumni mentioned their collaborations with other students and with mentors, meeting visiting speakers and beginning to form professional networks, the exposure to high-impact mathematicians, and connecting with other MSRI-UP alumni since their time in the program. Especially of note is that many of these relationships were with mathematicians from underrepresented groups. Alumni recognized the MSRI-UP program’s focus on diversity and inclusion, noting that this helped form relationships with others like themselves. When asked about the greatest benefits in this area, alumni noted:

*[One of the greatest benefits of MSRI-UP is] the connections that I made while I was in the program, the people that I met that were key at some points in my career.—2009 alumnus*

*One of the TAs gave me an invitation to give a talk [her institution] when I was a graduate student, so that was a phenomenal experience to be able to give a talk as a graduate student.—2010 alumnus*



*It was really impactful to see someone who first of all, is the only Latinx PhD math professor that I know. And seeing her be so vulnerable and sharing so much was the students was really impactful; it made me think of the math community a little bit differently.—2018 alumnus*

*I've met MSRI-UP students from all sorts of years, and the people ahead of me have always been very happy to give me advice or to offer opportunities to me. And certainly, when I meet people who did the program after me, I'm always very excited to offer as much advice and insight as I can.—2011 alumnus*

*I felt that MSRI-UP did a wonderful job of ensuring that [the] students that came in with not as many courses under their belt felt they could also succeed and achieve in understanding.—2010 alumnus*

MSRI-UP alumni found their mentors (i.e., graduate TAs, research directors, and program directors) to be caring and mindful of the challenges and rigor of a program like MSRI-UP. They appreciated the guidance their mentors provided, and continued to provide, regarding their career decisions. Concerning their mentors, alumni stated:

*I felt like I didn't belong in the group at the beginning because I couldn't solve a lot of the questions that were in the homework, so I asked [one of the TAs] about that. I felt insecure because I didn't think I could do the work that other people do, but I was able to catch mistakes, and she said that maybe I would not be the person to prove the theorems but the one to be able to find the mistakes in the proofs. So, that gave me a lot of confidence.—2008 alumnus*

*I just remember feeling really good about the feedback loop. I felt like we would show [the mentor] work and he was very good at looking at it and critiquing it, giving us suggestions but also just understanding where we were coming from, and it felt like a very comfortable conversation to have.—2009 alumnus*

*[My mentor] called me into her office and we just sat and had a talk and she just made me feel less stressed out about things. And I think that has helped me keep a bond with her for a very long time, so she's somebody who I reach out to for help and advice all the time.—2011 alumnus*

*It was evident to me that [the program director was] very invested in all of our futures. I have people who I can go back to and ask questions as I try to navigate industry or academia or what kind of job in academia, what kind of job in industry. – 2018 alumnus*

*[They] really helped me make an informed decision about whether or not I wanted to try and go into academia or not.—2009 alumnus*

These sentiments were reiterated by the MSRI-UP staff who were interviewed for the evaluation. Each staff member also noted the importance of community building—both in the sense of a research community as well as a social community—and how the MSRI-UP program was able to help foster this among the students, staff, and guest speakers. These comments included:

*There's a big sense of community...the students from all different disciplines really become a very nice, integrated community. And I feel like there's also a sense of not only doing really good mathematics, but also kind of giving back to the community. And so, when we see a lot of what the people who have graduated now are doing, many of them are either—they stayed involved in MSRI-UP or they started their own initiatives.—staff*

*I think the two weeks of just full-fledged, 'here's all the information you need', and then sending [students] off into smaller groups to do research is a really good way of creating a research community with the students.—staff*

*One model in particular that I've really liked is they try to bring out the speakers on, let's say, a Friday so that that way the speakers can stay for that Saturday for the field trip and interact with the students even more, and that I thought was really wonderful so you don't have kind of this abbreviated time of just having the person give a talk for sixty minutes and then you never see the person again.—staff*

*And then, we force everybody to bond, the students to bond, by doing a weekend—the Saturday activities together, whether they want to or not. And again, even though you might not feel close to everybody, I think it actually does matter. Those experiences and events stay with you. You're going to the Monterey Bay Aquarium or you did a trolley tour of San Francisco, things like that. That certainly does build that community.—staff*

*I got to go home, but the rest of [the staff and students] stayed in a dorm, so they probably were with each other almost 24 hours a day, besides sleeping. They ate together or they studied together or they traveled together, and the grad TAs were with [the students], too. So, I think that's definitely a unique experience to have that kind of family, almost, type scenario, really working together on everything, trying to solve not necessarily math problems, either, because there's a social dynamic happening, too.—staff*

*I'm pleased when I find out that students from the program are still meeting up and doing things together.—staff*

Given the examples shared above, it is not surprising that alumni chose positive ratings when asked to rate the program's success in helping establish connections to the mathematical community. Using a five-point scale, alumni reported making *considerable* new and useful contacts while participating in the program as undergraduates (see Figure 21). They also reported that the program was *moderately to considerably* successful in helping them keep up to date with what was going on in their field, and they themselves reported moderate success in their attempts to stay connected to the MSRI-UP community.

Figure 21. Alumni considered the program's greatest success in establishing new friendships and collegial relationships.



These results were repeated when alumni were asked to share whether they had remained in touch with MSRI-UP faculty and peers since their time in the program. A pair of questions were asked. First, alumni reported whether they would feel comfortable contacting peers and mentors from their MSRI-UP program. Next, alumni shared whether they had in fact contacted a peer or mentor.

- Comfort with contacting people from the program was rated on a four-point scale from *very uncomfortable* to *very comfortable*. Alumni reported being between *somewhat* and *very*

*comfortable* contacting MSRI-UP peers and mentors, on average (mean ratings = 3.66 and 3.56, respectively).

- The amount of contact with peers and mentors was reported on a four-point scale from *never* to *frequently*. Results indicated that most alumni had contacted at least one person from each category, with 91% reporting that they had contacted a peer from the program and 84% indicating that they had contacted a mentor. Both groups were contacted infrequently, as alumni reported that they attempted to contact people *rarely* to *sometimes*, on average (mean ratings = 2.89 for peers and 2.47 for mentors).

Further analyses found that there were significant differences in alumni comfort levels and amount of contact between peers and mentors. In both cases, respondents were slightly more comfortable and likely to contact their peers than their mentors (Comfort,  $t_{1,125} = 2.06, p = 0.04$ ; Frequency,  $t_{1,124} = 5.37, p < 0.001$ ).

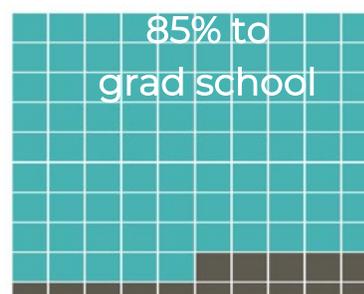
Though these results indicate that alumni are not often in touch with those from MSRI-UP overall, the responses from the alumni interviews did include examples of ways that alumni are still connected to those they met through MSRI-UP. Indeed, of the 12 alumni who were randomly selected for the interviews, almost all were still in touch with at least one of their mentors from the program. In combination, the ratings presented above and the open-ended feedback seem to indicate that alumni have established some long-term personal and professional relationships as the results of the program, and that they would be comfortable leaning on their MSRI-UP network, if needed.

## Changing the Face and Culture of the Mathematical Workforce

*Academic and professional careers after MSRI-UP.* As noted, one of MSRI-UP's primary goals is to encourage students from underrepresented groups to attend graduate school. Based on the tracking data available through MSRI-UP's database on alumni, the program has been quite successful in this regard; MSRI staff have recorded 157 of 184 program alumni (85%) who have continued to a graduate program after completing their bachelor's degree. See Figure 22.

MSRI-UP alumni have far exceeded national statistics with regard to enrollment in and completion of graduate degrees (see Figure 23). The National Center for Education Statistics (NCES; <https://nces.ed.gov/datalab/QuickStats/Workspace/Index/54>) reports that 47% of all students who earned a bachelor's degree between 2008 and 2012 enrolled in an additional program after graduation. The list of additional programs includes several different degrees and certificates, including additional bachelor's degree or certificate, associate's degree, post-baccalaureate certificate, master's degree, post-master's certificate, and a variety of doctoral degrees. In comparison, 85% of MSRI-UP alumni continued to a graduate program (i.e., master's or PhD). To date, 89 students have earned a graduate degree (57% of

Figure 22. Most MSRI-UP alumni have continued to graduate school



### *Key Finding:*

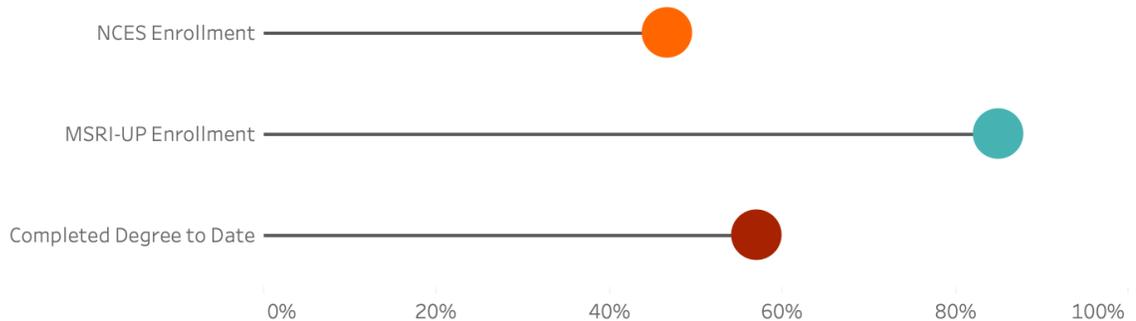
*MSRI-UP alumni enroll in graduate-level programs, and complete graduate degrees at higher rates than the national average for all students.*



those who attended a graduate program) and many more are still working toward a degree (described on page 47). MSRI-UP records indicate that 56 alumni have earned a Master’s degree, 24 have earned a PhD, and nine have earned both a Master’s degree and a PhD to date.

Figure 23. MSRI-UP alumni have far exceeded national statistics with regard to enrollment in and completion of graduate degrees.

### Graduate Program Enrollment and Completion



The alumni survey collected additional information about the type of careers being pursued. Approximately half (51%) were no longer students. As shown in Table 9, the largest group of alumni work in the private sector. Approximately one-third are teaching in some capacity (32%), with most teaching in higher education and a few teaching students at the preschool or K-12 level. Approximately one in ten (13%) are currently unemployed or taking time off. Of the two that specified “other,” one has a position but is waiting for clearance. The other is in the process of going back to graduate school.



Table 9. Almost three-quarters of MSRI-UP alumni who are employed are working in either the private sector or in education.

|  | Percentage |
|--|------------|
| Working in the private sector                        | 39%        |
| Working for a government or non-profit organization  | 13%        |
| Primarily teaching in higher education               | 13%        |
| Unemployed and seeking employment                    | 11%        |
| Balance of teaching and research in higher education | 9%         |
| Primarily research in higher education               | 8%         |
| Something else                                       | 3%         |
| Non-teaching research position                       | 2%         |
| Teaching preschool or K-12 education                 | 2%         |
| Taking time off                                      | 2%         |

The remaining 49% of alumni survey respondents reported that they are students. This group includes 15% who are finishing their bachelor's program, 16% who are currently attending non-doctoral graduate programs, and 69% who are currently doctoral students (See Figure 24 for overall totals and Table 10 for a breakdown by cohort). As shown in Table 10, and as would be expected, those who participated in MSRI-UP in the earlier years were more likely to be part of the workforce, while those who participated most recently were more likely to report that they were students.

Like the alumni who have completed their educations, MSRI-UP alumni who were still in school plan to work in education or the private sector upon completing their terminal degree. That said, alumni who were still in school were more inclined toward faculty positions than those who were already in the workforce. Note that the response options provided to these groups of alumni were different, and so direct comparisons cannot be made.

Figure 24. Most MSRI-UP alumni who are still in school are completing a graduate degree. A few are still working to complete their bachelor's degree.

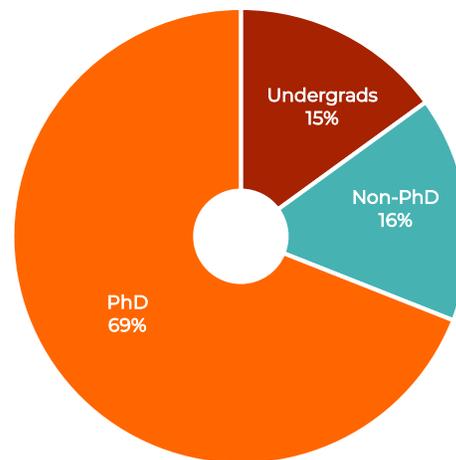


Table 10. Most alumni from earlier cohorts have completed their education, while many from more recent cohorts are still finishing a degree.

| Cohort Year | Completing Bachelor's Degree | Completing Graduate Degree | Schooling Completed |
|-------------|------------------------------|----------------------------|---------------------|
| 2007        | --                           | 33%                        | 67%                 |
| 2008        | --                           | --                         | 100%                |
| 2009        | --                           | --                         | 100%                |
| 2010        | --                           | --                         | 100%                |
| 2011        | --                           | 15%                        | 85%                 |
| 2012        | --                           | --                         | 100%                |
| 2013        | --                           | 100%                       | --                  |
| 2014        | --                           | 91%                        | 9%                  |
| 2015        | --                           | 69%                        | 31%                 |
| 2016        | 8%                           | 42%                        | 42%                 |
| 2017        | 12%                          | 69%                        | 19%                 |
| 2018        | 38%                          | 38%                        | 25%                 |

*Longer-term perspectives about MSRI-UP contributions to professional futures.* Regardless of their current status as a student or member of the workforce, the majority of MSRI-UP alumni reported positive attitudes about their current position. Almost all reported that their field excites them (94%), that they feel comfortable working with peers (92%), and that they were similarly confident working independently (91%). Most also reported that they feel comfortable both inside and out of their professional communities; 70% reported that they felt like they belonged to a community in their field, and 88% were comfortable discussing their work with professionals in other fields.

Importantly, alumni believed that the MSRI-UP program had contributed to their current success. Alumni answered four questions about the extent to which the program has contributed to their current success, in relation to their current student or workforce position. As with some of the results reported previously in this report, factor and reliability analyses were conducted and indicated that average scores for each scale could be used for the purposes of analysis; see Appendix B for the results by item. The results are presented in Table 12. Students who were currently students, and thus closer to their MSRI-UP experiences in their current trajectory, reported the program was more important than those who were currently in the workforce. Even so, alumni in both groups believed that MSRI-UP was very or extremely important to their current success.



Table 12. Both alumni who are completing their educational training and those who are no longer in school reported that MSRI-UP contributed to their current success.

| Scale                       | Population       | Reliability | Mean |
|-----------------------------|------------------|-------------|------|
| Graduate School Preparation | Current Students | 0.78        | 4.50 |
| Career Preparation          | Non-Students     | 0.84        | 3.92 |

Both the alumni and staff interviews asked participants to reflect on the larger influence of the MSRI-UP program. Both groups believed that the program has a positive impact, especially when it comes to diversifying the workforce. Alumni and staff shared the following impressions:

*There are many people that I've met over the years in terms of underrepresented faculty that had their start at MSRI-UP.—2010 alumnus*

*[MSRI-UP is] taking young people at a really pivotal time and saying, 'Here are your options,' and then giving them tools to try to go after whatever option they want.—2011 alumnus*

*I think it does a really good job selecting like, a diverse group who have potential to succeed.—2011 alumnus*

*The program definitely helps people stay in [STEM] careers.—2009 alumnus*

*I know people from our group who have become professors. I know people from our group who have done a lot of stuff in private business. One of them worked for Disney, I think, for a while. I'm not sure. And so, just seeing where we started from, how we've grown and the influence that MSRI can have across multiple fields.—2007 alumnus*

*If you look at the underrepresented minorities these days that are young faculty that are doing really, really well, they almost all trace back to MSRI-UP. So, I think in that sense the students that have come out of the program, the alum, are really doing an incredible job. They're kind of the movers and the shakers in the field these days in the mathematical community.—staff*

*[MSRI-UP has] had some really strong people coming out of the program. And not only just coming out of the program and doing amazing work academic-wise and in the academy, but also just like, changing the face of mathematics, even.—staff*

*MSRI has really talked the talk, but over the years has walked the walk, in terms of diversifying what they're doing.—staff*

Other impacts staff mentioned were related to the people who participate in MSRI-UP. It was mentioned that the MSRI-UP program creates a cycle of people who participate as undergraduates, return as graduate students or post docs, and even serve as faculty in the program. Beyond the cycle of MSRI-UP alumni, the program has begun to reach further, bringing in faculty from underrepresented groups who may not have participated in MSRI-UP before.

*I think that because [the MSRI-UP] students are so well-prepared for graduate school, they're the ones that are now becoming the professors, starting to work with their own students and*



*having the cycle repeat over in terms of preparing other graduate students to go into REUs.—staff*

*When [people] talk about MSRI-UP, that is one of these programs that has built a name for itself and has had people coming through the program and have come up through it, you know. Like students who've returned as TAs who are now faculty. There is a bit of a legacy there. So, I think it has an impact in that way.—staff*

*They've really adopted the younger math generation to come in and take over and that they're continuing to do that again, like roll over and pick up new folks. And so, in my mind, I guess that just means that they're not only producing new faculty, but they're also helping to sort of draw in the faculty that didn't come up through the ranks [at MSRI-UP]. So, it just feels like they're sort of trickling out, even though it feels like it might be slow. But I think that that's a positive effect for sure.—staff*

The MSRI-UP staff praised the program extensively, noting that they grew both personally and as professionals. Several staff noted that they valued the access they had to students from underrepresented minority groups, both during and after the program, which allowed them to strengthen their professional community. They also noted that this access made them feel as though they contributed to diversifying the mathematical workforce.

*Growing my own community and meeting younger mathematicians and being able to watch them progress—that helps a lot too.—staff*

*Being able to mentor [students] after the program was great, too, and stay connected with them as they move on to their different universities or wherever they decide to go afterwards.—staff*

*I teach at a private university of science and technology, engineering... we do not have many underrepresented minority students. Not a lot at all. I get that opportunity to feel that I am contributing to the development of a diverse workforce.—staff*

Staff members discussed ways in which they grew personally, as well. Several mentioned the mentoring aspect of the program, noting that they both learned how to mentor students and received mentoring themselves. They also discussed the benefit of learning about mathematical topics that were outside their areas of expertise.

*Getting to see how you work with students, how you come up with ideas, how you navigate understanding where those ideas lead you, and then how to adjust as you find out if something is working or not, or if you have a new idea, how to pursue that direction.—staff*

*It felt like it was a really nice interactive support group in a way, where we weren't just there being told what to do but we were also being asked what could be done to make things better, and it seemed like our input really mattered.—staff*

*The people who founded this program are really, I would say, some of the leaders in this initiative nationally, and so for me it's been a huge privilege to work with them and see how they work very closely with them. So, you know, I'm used to doing a lot of mentorship, but this is one of the rare places where I actually get to receive mentorship.—staff*

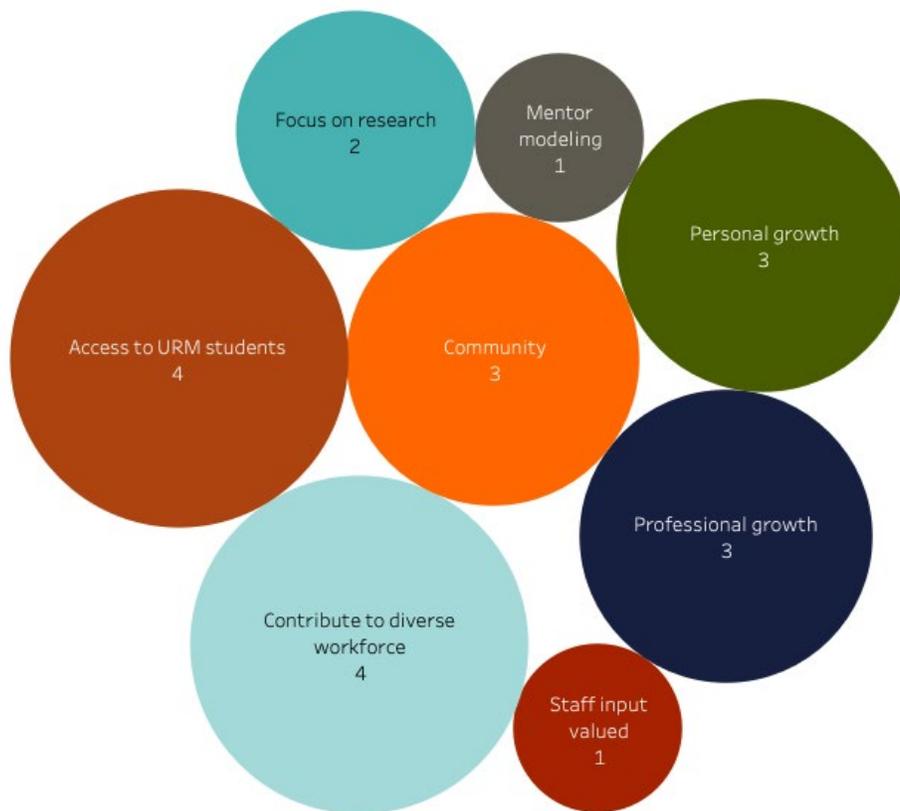
Most of the time the research area isn't your own area. So, you get this opportunity to see new mathematics and expand your understanding of different fields, which is really helpful.—staff

**MSRI-UP staff appreciated the ease of participating in the program, which allowed them to focus on the research and serving the students.**

I liked the fact that the local organizers did all the heavy lifting when it came to choosing the students, organizing the field trips, setting up the classrooms. MSRI itself helped to find housing for us, to arrange for the plane tickets to get in and out. So, as a Research Leader I only had to worry about the research.—staff

It's really the only program I know of in the country where you can get a lot of experience running an REU without having to worry about the logistics of the funding and the choosing of the students and what have you. I don't know of any other REU that comes anywhere close to that.—staff

Figure 25. The image below represents the number of staff who mentioned each of the noted benefits.





## Conclusions

The data presented in this report provide a comprehensive and quite positive evaluation of the MSRI-UP program. The multi-method approach used for the evaluation included a secondary analysis of annual exit surveys and tracking data collected by the MSRI team throughout the program's history, as well as new data that were collected from alumni and staff.

The results indicate that the program has been very successful at reaching its intended audience of students who are from racial and ethnic groups that are underrepresented in mathematics. The MSRI-UP program creates a singular opportunity that generates meaningful and long-lasting experience for participants and staff alike. As stated by one 2009 alumnus, *To this day, MSRI-UP remains one of the few spaces where I have seen a big number of mathematicians of color.*

Both the self-report feedback on the exit surveys and the results from the Student Assessment of Learning Gains provide results to confirm the importance of the research experiences provided by the program, and the knowledge and skills that participants gain through their participation. MSRI-UP staff also noted both the professional and personal impact of the program on participants and on themselves. They believe the program has an overwhelmingly positive impact on undergraduates' skill development. Similarly, they noted that they learned new things during their time at MSRI-UP themselves, in the form of lasting relationships with both students and mentors.

The feedback from MSRI-UP participants at the end of each summer, and feedback from alumni collected as many as 12 years after participation in the program, was extremely positive. In most cases, the majority of participants expressed nothing but praise for each program component included on the survey. Those who did provide recommendations often included both positive feedback and suggestions for making the component stronger in the future.

There were some changes in the feedback provided by participants over time. In many cases, feedback got more positive as the program matured. In other cases, the ratings fluctuated over time. Some of these differences may be the normal fluctuation that would be expected across cohorts of program participants, while others may be related to changes to the program from year to year. It is hoped that the MSRI-UP team can use the results presented here and their own institutional knowledge of how the program changed across years to bring additional meaning to these results.

The combination of learning experiences and community support provided by the program are credited for the success of MSRI-UP alumni who praised the program in the areas of graduate school preparation, community and network building, mentorship, and inclusivity. Several past students were surprised at the amount of influence the program has had throughout their lives. Alumni and staff alike believe the program is successful at meeting its goal of diversifying the U.S. mathematical workforce. These assumptions were confirmed, when measured against national statistics. MSRI-UP participants enroll in and complete graduate degrees at higher rates than the national average for all students. The focus on all students is important, because enrollment and completion rates for those from underrepresented groups have traditionally been lower.

In summary, the MSRI-UP program has been an overwhelming success. It has reached populations of students from groups that are underrepresented in mathematics who are eager to become part of the U.S. mathematics workforce. The program components provide participants with unique opportunities that result in meaningful engagement and learning within the context of a strong community that can be relied upon to continue providing support in both the short and longer term. Though the program is



a resounding success, it is hoped that MSRI-UP staff will review the recommendations from alumni and staff provided in this report to consider how to make the program even more successful it in the future.

## Appendix A

Table A1. Items and Scores Related to Sense of Belonging to a Community During the MSRI-UP Program

*When you were in the undergraduate MSRI-UP program, to what extent did YOU...?*

|  | Not at all | Slightly | Moderately | Considerably | A great deal | Mean |
|--|------------|----------|------------|--------------|--------------|------|
| Feel a sense of belonging to the MSRI-UP community | 2%         | 2%       | 9%         | 22%          | 65%          | 4.49 |
| Identify with your peers in the program            | 1%         | 3%       | 13%        | 32%          | 41%          | 4.30 |
| Identify with your mentors in the program          | 2%         | 3%       | 18%        | 36%          | 41%          | 4.10 |
| Feel like you belonged as a mathematician          | 2%         | 6%       | 13%        | 25%          | 54%          | 4.24 |

Table A2. Items and Scores Related to the Contributions of Peers During the MSRI-UP Program

*When you were in the undergraduate MSRI-UP program, to what extent did your PEERS...?*

|  | Not at all | Slightly | Moderately | Considerably | A great deal | Mean |
|--|------------|----------|------------|--------------|--------------|------|
| Contribute to an enthusiastic/motivational environment   | 0%         | 1%       | 9%         | 25%          | 65%          | 4.55 |
| Become part of the network that you've relied on         | 3%         | 18%      | 19%        | 22%          | 38%          | 3.74 |
| Contribute to your sense of belonging in MSRI-UP         | 0%         | 4%       | 14%        | 21%          | 61%          | 4.39 |
| Contribute to your sense of belonging as a mathematician | 0%         | 9%       | 14%        | 25%          | 52%          | 4.21 |



Table A3. Items and Scores Related to the Contributions of Mentors During the MSRI-UP Program

*When you were in the undergraduate MSRI-UP program, to what extent did your MENTORS...?*

|  | Not at all | Slightly | Moderately | Considerably | A great deal | Mean |
|--|------------|----------|------------|--------------|--------------|------|
| Contribute to an enthusiastic/motivational environment   | 1%         | 2%       | 5%         | 20%          | 72%          | 4.60 |
| Become part of the network that you've relied on         | 5%         | 5%       | 15%        | 22%          | 53%          | 4.14 |
| Contribute to your sense of belonging in MSRI-UP         | 1%         | 2%       | 9%         | 25%          | 64%          | 4.48 |
| Contribute to your sense of belonging as a mathematician | 1%         | 4%       | 12%        | 20%          | 64%          | 4.41 |

Table A4. Student Alumni Perceptions of MSRI-UP Influence on Preparing them for Graduate School

|   | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree | Mean |
|---|-------------------|----------|----------------------------|-------|----------------|------|
| I believe being part of MSRI-UP made me a stronger job applicant when I applied to graduate school              | 0%                | 0%       | 0%                         | 13%   | 87%            | 4.87 |
| I believe being part of MSRI-UP helped me get into a graduate program of my choice                              | 0%                | 2%       | 10%                        | 26%   | 63%            | 4.49 |
| My MSRI-UP experiences prepared me with the skills needed to interact with my graduate school peers effectively | 0%                | 4%       | 9%                         | 36%   | 51%            | 4.34 |
| My MSRI-UP experiences prepared me with the skills to understand what   | 0%                | 4%       | 11%                        | 40%   | 46%            | 4.27 |

is expected of me in my graduate student position

Table A5. Workforce Alumni Perceptions of MSRI-UP Influence on Preparing them for School and Career

|   | Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree | Mean |
|---|-------------------|----------|----------------------------|-------|----------------|------|
| I believe being part of MSRI-UP made me a stronger job applicant when I applied for my first job                                | 3%                | 5%       | 17%                        | 40%   | 35%            | 3.98 |
| I believe being part of MSRI-UP helped me find the job I wanted   | 7%                | 5%       | 33%                        | 33%   | 22%            | 3.59 |
| I believe being part of MSRI-UP helped me get into a graduate program of my choice  | 2%                | 2%       | 14%                        | 25%   | 58%            | 4.35 |
| My MSRI-UP experiences prepared me with the skills needed to interact with my colleagues effectively in my most recent position | 2%                | 2%       | 29%                        | 32%   | 36%            | 3.98 |

