

Final Report
on the
Mathematical Sciences Research Institute
Undergraduate Program (MSRI-UP)
supported by
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Annual Report 2012-13

MSRI-UP: Mathematical Sciences Research Institute Undergraduate Program.

In 2012, the MSRI-UP had 18 students participating in research on Enumerative Combinatorics led by Dr. Matthias Beck from San Francisco State University. Dr. Beck was assisted by a postdoctoral researcher, Michael Young (Iowa State) and two graduate students: (1) Amanda Ruiz (Binghamton) and (2) Ana Berrizbeitia (UT Austin). The MSRI-UP has five directors who manage the program in the long-term: Duane Cooper (Morehouse), Ricardo Cortez (Tulane), Herbert Medina (Loyola Marymount), Ivelisse Rubio (UPR Rio Piedras), and Suzanne Weekes (RPI). R. Cortez served as the on-site (lead) director in 2012.

Recruitment and selection of students

As has been done in previous years, the directors designed fliers and email announcements to be distributed massively to mathematics departments around the country. In particular, the announcements were sent to all MSRI member institutions as well as a large number of Historically Black Colleges and Universities (HBCU's) and Hispanic Serving Institutions (HSI's). The MSRI web site also had the program listed. A list of mentors known to the team of directors as faculty who regularly recommend students to summer research programs were also included in the mailing list. The MSRI created a website for the program with all the necessary information, including the on-line application form. The current version of the website can be found at: <http://www.msri.org/up/>.

The application process opened on December 1, 2011 and closed in early March 2012. We received over 180 applications, which was the largest number in the six-year history of MSRI-UP. In consultation with Dr. Beck, the team of directors looked through the applications and ranked them based on a set of criteria that included the student's preparation for the research topic; gender, ethnic and geographic diversity; and anticipated plans to attend graduate school since the objective of the program is to increase the number of graduate degrees in the mathematical sciences, especially among the U.S. minority communities.

The final list of student participants and their institutions was:

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| 1. Alyssa Cuyjet | Trinity College |
| 2. <u>Jessica De Silva</u> | Cal State University, Stanislaus |
| 3. Erika Meza | Loyola Marymount University |
| 4. <u>Claudia Rodriguez</u> | Arizona State University |
| 5. <u>Molly Stubblefield</u> | Western Oregon University |
| 6. <u>Michael Dairyko</u> | Pomona College |
| 7. Joseph Pruitt | Cal State University, Long Beach |
| 8. Jordan Clark | Morehouse College |
| 9. <u>Gabriel Dorfsman-Hopkins</u> | Dartmouth College |
| 10. Stefan Klajbor | U of Puerto Rico, Rio Piedras |
| 11. <u>Bryan Nevarez</u> | CUNY Queens College |
| 12. Gordon Kirby | Stanford University |
| 13. <u>Schuyler Veeneman</u> | San Francisco State University |
| 14. Alana Shine | Pomona College |
| 15. Taina Jean-Louis | Amherst College |
| 16. Chelsie Norton | Valdosta State University |
| 17. <u>Joseph Crawford</u> | Morehouse College |
| 18. <u>Daniel Blado</u> | California Institute of Technology |

The underlined names denote students who are currently applying to graduate programs. Most of the remaining ones are not seniors yet. In terms of diversity, there were 8 women and 10 men, 8 African American, 6 Latinos, 1 Asian American and 3 Caucasian.



The summer research program

During the summer, students participate in a 1-2-week lecture period characterized by intensive group work and assignments, followed by a research phase when they worked in teams to complete research projects. During the lecture period, the MSRI arranged for the students to work in a lecture hall and in other areas of the Institute. The group work was designed so that the groups were constantly changing and each student eventually got to work with many others.

There were six research groups of 3 students each formed based on the students' own suggested interests. The projects that students completed in 2012 were:

1. *Nowhere-Zero Flows on Graphs*, Alyssa Cuyjet, Gordon Kirby and Molly Stubblefield
2. *A Generating Function Approach for Reciprocity Formulae of Dedekind-like Sums*, Jordan Clark, Stefan Klajbor and Chelsie Norton
3. *On Weak Chromatic Polynomials of Mixed Graphs*, Daniel Blado, Joseph Crawford and Taina Jean-Louis
4. *A Bijection from Shi Arrangement Regions to Parking Functions via Mixed Graphs*, Michael Dairyko, Claudia Rodriguez and Schuyler Veeneman
5. *Computing the Chromatic Polynomials of the Six Signed Petersen Graphs*, Erika Meza, Bryan Nevarez and Alana Shine
6. *Interval-Vector Polytopes*, Jessica De Silva, Gabriel Dorfsman-Hopkins and Joseph Pruitt

Revised versions of two of these reports have now been submitted for publication:

The Combinatorics of Interval-vector Polytopes

Matthias Beck, Jessica De Silva, Gabriel Dorfsman-Hopkins, Joseph Pruitt, and Amanda Ruiz
<http://arxiv.org/abs/1211.2039>

On Weak Chromatic Polynomials of Mixed Graphs

Matthias Beck, Daniel Blado, Joseph Crawford, Taina Jean-Louis, and Michael Young
<http://arxiv.org/abs/1210.4634>

Workshops during summer research program

The following workshops were presented during the summer program. All of them were originally proposed as part of the important information that guided the students' work and future plans.

1. **Friday, June 29:** *LaTeX workshop* by Ricardo Cortez. This was an introduction to using LaTeX for typesetting mathematics, including figures, and creating the bibliography.
2. **Friday, July 06:** *Graduate School workshop* by Colette Patt. This was an informational workshop on applying to graduate school, how to select graduate programs, what life as a graduate student is like, etc.
3. **Friday, July 13:** *Graduate School Funding workshop* by Colette Patt. This workshop described local and global funding opportunities for graduate students, including grants, fellowships, research and teaching assistantships.
4. **Friday, July 20:** *How to give effective oral presentations* by Ricardo Cortez. This talk provided a template and tips and suggestions for preparing an effective presentation using the LaTeX package beamer. The student groups used this package for their final presentations.

Seminars by visitors during summer research program

1. *Rational or Irrational?* Tewodros Amdeberhan, Tulane University
2. *Negative Numbers in Combinatorics: Geometrical and Algebraic Perspectives*, James Propp, University of Massachusetts, Lowell
3. *Shuffling cards and adding numbers*, Persi Diaconis, Stanford University
4. *Using the covering method to compute the p -divisibility of exponential sums and applications to coding theory*, Ivelisse Rubio, University of Puerto Rico, Rio Piedras
5. *Erhart Polynomials, Hilbert Functions and Free Resolutions*, David Eisenbud, University of California at Berkeley

Informal visitors that met with students

1. Mela Hardin, Grad student
2. Anastasia Chavez, Grad student at Berkeley
3. Tamas (Tom) Forgacs, CSU Fresno
4. Phil Kutzko, University of Iowa
5. Federico Ardila, SFSU

Outings and other bonding activities during summer research program

1. Saturday, June 23: Exploring San Francisco and boat trip around Alcatraz.
2. Saturday, June 30: Muir Woods and Stinson Beach.
3. Saturday, July 07: San Francisco Exploratorium.
4. Saturday, July 14: Kayaking on the Bay.
5. Saturday, July 21: Oakland A's baseball home game vs. Yankees.

Evaluation activities

During the six-week research program, the on-site Director met periodically with each student individually and with the students as a group to discuss the program progress and to make adjustments as necessary. In addition, an evaluation questionnaire was created and given to the students to fill out. The questionnaire is found in Appendix A.

Post-research program conference presentations

Five of the six student groups were represented the SACNAS conference in Seattle, WA in October of 2012. Students who did not attend were out of the country at the time studying abroad. Each of the five groups in attendance gave poster presentations at SACNAS and was introduced to the SACNAS community of mentors. The students also benefitted from attending professional development workshops, technical talks, and talking with exhibitors. The majority of the students will also attend the Joint Mathematics Meetings in San Diego in January of 2013.

Appendix A: Evaluation questionnaires filled out by the students

| Number | Question | Type |
|------------|---|---|
| Question 1 | How much did the following aspect of the MSRI-UP program help your learning: The background material presented during the lectures of the first two weeks | Multiple Choice no help; some help; much help; great help |
| Question 2 | How much did the following aspect of the MSRI-UP program help your learning: Reading research articles | Multiple Choice no help; some help; much help; great help |
| Question 3 | How much did the following aspect of the MSRI-UP program help your learning: Talking to Dr. Beck | Multiple Choice no help; some help; much help; great help |
| Question 4 | How much did the following aspect of the MSRI-UP program help your learning: Talking to the Postdoc and Graduate Assistants | Multiple Choice no help; some help; much help; great help |
| Question 5 | Please comment on the instructional activities that you found useful or ones that you wish you had as part of the program | Long Answer Type the answer options here, separated by semi-colons |
| Question 6 | How much did each of the following aspects of the program helped your learning: Dr. Beck's lectures | Multiple Choice no help; some help; much help; great help |
| Question 7 | How much did each of the following aspects of the program helped your learning: Homework problems | Multiple Choice no help; some help; much help; great help |
| Question 8 | How much did each of the following aspects of the program helped your learning: Group problem sessions during the first two weeks | Multiple Choice no help; some help; much help; great help |

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| Question 9 | How much did each of the following aspects of the program helped your learning: Research group discussions | Multiple Choice no help; some help; much help; great help |
| Question 10 | Please comment on how these activities helped your learning of enumerative combinatorics | Long Answer Type the answer options here, separated by semi-colons |
| Question 11 | How much did the following material help your learning: Notes or presentations posted by Dr. Beck | Multiple Choice no help; some help; much help; great help |
| Question 12 | How much did the following material help your learning: Library books/articles | Multiple Choice no help; some help; much help; great help |
| Question 13 | How much did the following material help your learning: On-line material using web searches | Multiple Choice no help; some help; much help; great help |
| Question 14 | How much did the following material help your learning: software used (Polymake, Latte, etc.) | Multiple Choice no help; some help; much help; great help |
| Question 15 | How much did the following material help your work: Latex templates for the report and presentation | Multiple Choice no help; some help; much help; great help |
| Question 16 | Please comment on how these materials helped your learning of enumerative combinatorics | Long Answer Type the answer options here, separated by semi-colons |
| Question 17 | How valuable to you was the following: Graduate school workshop | Multiple Choice not valuable; somewhat valuable; very valuable; |

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| | | greatly valuable |
| Question 18 | How valuable to you was the following: Graduate school funding workshop | Multiple Choice not valuable; somewhat valuable; very valuable; greatly valuable |
| Question 19 | How valuable to you was the following: LaTeX workshop | Multiple Choice not valuable; somewhat valuable; very valuable; greatly valuable |
| Question 20 | How valuable to you was the following: Presentations workshop using Beamer | Multiple Choice not valuable; somewhat valuable; very valuable; greatly valuable |
| Question 21 | Please comment on the workshops, including any changes you would propose or possible new workshops | Long Answer Type the answer options here, separated by semi-colons |
| Question 22 | How valuable for learning the program topic do you consider the following activity (elaborate): Interacting with Dr. Beck during the program | Multiple Choice and Long Answer not valuable; somewhat valuable; very valuable; greatly valuable |
| Question 23 | How valuable for learning the program topic do you consider the following activity (elaborate): Interacting with the Postdoc during the program | Multiple Choice and Long Answer not valuable; somewhat valuable; very valuable; greatly valuable |
| Question 24 | How valuable for learning the program topic do you consider the following activity (elaborate): Interacting with the Graduate Assistants during the program | Multiple Choice and Long Answer not valuable; somewhat valuable; very valuable; greatly valuable |

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| Question 25 | How valuable for learning the program topic do you consider the following activity (elaborate): Interacting with peers without the research staff during the program | Multiple Choice and Long Answer not valuable; somewhat valuable; very valuable; greatly valuable |
| Question 26 | As a result of your participation in the MSRI-UP, how much understanding did you gain of enumerative combinatorics? | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 27 | As a result of your participation in the MSRI-UP, how much understanding did you gain of the relationship between combinatorics and other areas of math or science? | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 28 | As a result of your participation in the MSRI-UP, how much understanding did you gain of how the concepts learned at MSRI-UP relate to ideas encountered in traditional courses you have taken? | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 29 | Please comment on how your understanding of combinatorics has changed as a result of MSRI-UP | Long Answer Type the answer options here, separated by semi-colons |
| Question 30 | As a result of your work in MSRI-UP, what gains did you make in the following skill: Finding relevant articles in professional journals or elsewhere | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 31 | As a result of your work in MSRI-UP, what gains did you make in the following skill: Critically reading articles about issues raised in the summer program | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 32 | As a result of your work in MSRI-UP, what gains did you make in the following skill: Recognizing a sound mathematical argument | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 33 | As a result of your work in MSRI-UP, what gains did you make in the following skill: Developing a logical mathematical argument | Multiple Choice no gain; a little gain; good |

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| | | gain; great gain |
| Question 34 | As a result of your work in MSRI-UP, what gains did you make in the following skill: Writing documents in mathematics-appropriate style and format | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 35 | Please comment on what skills you have gained as a result of the MSRI-UP | Long Answer Type the answer options here, separated by semi-colons |
| Question 36 | As a result of your participation in MSRI-UP, what gains did you make in the following: Enthusiasm for combinatorics or graph theory | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 37 | As a result of your participation in MSRI-UP, what gains did you make in the following: Interest in taking or planning to take courses in combinatorics or graph theory | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 38 | As a result of your participation in MSRI-UP, what gains did you make in the following: Understanding the advantages of summer research experiences | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 39 | As a result of your participation in MSRI-UP, what gains did you make in the following: Participating in another undergraduate research experience | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 40 | As a result of your participation in MSRI-UP, what gains did you make in the following: Interest in attending graduate school | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 41 | As a result of your participation in MSRI-UP, what gains did you make in the following: Understanding what funding opportunities exist for graduate school | Multiple Choice no gain; a little gain; good gain; great gain |
| Question 42 | Please comment on how the MSRI-UP has changed your attitude toward combinatorics and toward graduate school | Long Answer Type the answer options |

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| | | here, separated by semi-colons |
| Question 43 | Have you participated in a previous summer research program? | Type the answer options here, separated by semi-colons Yes/No |
| Question 44 | Have you attended a mathematics or science conference before? | Type the answer options here, separated by semi-colons Yes/No |
| Question 45 | Have you given a presentation (oral or poster) at a conference before? | Type the answer options here, separated by semi-colons Yes/No |
| Question 46 | Do you think you will continue to work on your MSRI-UP research project after you return to your home institution? | Type the answer options here, separated by semi-colons Yes/No |
| Question 47 | Have you written or co-written a paper that was published in a research journal? | Type the answer options here, separated by semi-colons Yes/No |
| Question 48 | Do you feel that MSRI-UP has changed your outlook on your academic future? If so, how? | Long Answer Type the answer options here, separated by semi-colons |
| Question 49 | How does your research experience during MSRI-UP compare with your other research experiences? write N/A if not applicable | Long Answer Type the answer options here, separated by semi-colons |
| Question 50 | Please check the answer that most reflects your opinion of the statement: The colloquium talks were successful in giving you a glimpse of other areas of mathematics | Multiple Choice none; a little; a fair amount; a great deal |
| Question 51 | Please check the answer that most reflects your opinion of the statement: After MSRI-UP you want to work on another research project | Multiple Choice none; a little; a fair amount; |

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| | | a great deal |
| Question 52 | Please check the answer that most reflects your opinion of the statement: MSRI-UP helped you become familiar with research protocols/techniques | Multiple Choice none; a little; a fair amount; a great deal |
| Question 53 | Please check the answer that most reflects your opinion of the statement: MSRI-UP has provided you with a rich research experience | Multiple Choice none; a little; a fair amount; a great deal |
| Question 54 | Please check the answer that most reflects your opinion of the statement: MSRI-UP has provided you with desire and motivation to pursue a graduate degree in the mathematical sciences | Multiple Choice none; a little; a fair amount; a great deal |
| Question 55 | Please check the answer that most reflects your opinion of the statement: MSRI-UP has made you aware of strategies to maximize the likelihood of admission into graduate programs best suited to my goals/needs/aspirations | Multiple Choice none; a little; a fair amount; a great deal |
| Question 56 | Please check the answer that most reflects your opinion of the statement: MSRI-UP has made me aware of programs/strategies that will help you secure financial support for graduate school | Multiple Choice none; a little; a fair amount; a great deal |
| Question 57 | Please check the answer that most reflects your opinion of the statement: MSRI-UP has assisted me to begin building a network of faculty mentors and peers that can assist you with future educational and career plans | Multiple Choice none; a little; a fair amount; a great deal |
| Question 58 | How important was it that the program took place at one of the nation's mathematical sciences research institutes? | Multiple Choice not at all; a little; a fair amount; a great deal |

The Mathematical Sciences Research Institute Undergraduate Program (MSRI-UP) is a comprehensive program that has identified undergraduate students with an interest in mathematics and has created a path to take many of them from a math major to graduate school. This is the first predominantly minority research program for undergraduates that takes place at a major mathematics institute, the Mathematical Sciences Research Institute. MSRI-UP students spent time at this internationally renowned research institute, used its library for reference, met and mingled with graduate students participating in Graduate Student Workshops at MSRI during the summer, and met mathematicians passing through the institute.

The objective of 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.

The program began in 2007, although this Project Outcomes Reports summarizes the results of the program from 2008-2011.

- The topics and research leaders of the REU were Experimental Mathematics (Prof. Victor Moll, 2008), Coding Theory (Prof. John Little, 2009), Elliptic Curves (Prof. Edray Goins, 2010), and Mathematical Finance (Prof. Marcel Blais, 2011).
- A total of 69 students (17, 17, 17, 18) participated in the program. All of them were part of a research group that came up with new results, wrote a report and gave oral presentations. There have been 23 reports in total.
- Every research group has presented a poster at the SACNAS national conference; at least 25 students also have presented at the Joint Mathematics Meetings. In addition, many students presented their work or attended additional conferences such as the Field of Dreams Conference, the Nebraska Conference for Undergraduate Women in Mathematics, the Infinite Possibilities Conference, and the Young Mathematicians Conference at Ohio State.
- All students have received long-term mentoring.
- As of June 2012, a total of 37 students (15, 10, 12) are currently in graduate programs. Ten more students, from the 2011 program, will start a graduate program in the fall of 2012 (Five students from 2011 remain undergraduate)
- One of the student group reports has been published in a refereed journal.