



Annual Report 2021-22

NSF Award DMS-1929348
Covering activity between June 1, 2021 and May 31, 2022

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1. Overview

This is the 2021-22 annual report for the Institute for Mathematical and Statistical Innovation, funded by NSF grant DMS-1929348. It covers activities of the Institute which took place between June 1, 2021 and May 31, 2022.

The Institute for Mathematical and Statistical Innovation (IMSI) is a mathematical sciences research institute hosted by the University of Chicago, and operated in partnership with Northwestern University, the University of Illinois at Chicago, and the University of Illinois at Urbana-Champaign.

1.1 Mission

The mission of IMSI is to bring rigorous mathematics and statistics to bear on complex urgent problems of significant scientific and social importance and to spur transformational change in the mathematical sciences and the mathematical sciences community. There are three primary pillars to this mission: scientific activity, a focus on diversity and broadening participation in the mathematical sciences, and a focus on effective communication about mathematical science research to a variety of audiences.

IMSI is committed to first-rate interdisciplinary research in areas of great societal interest and impact where the mathematical sciences have the potential to contribute. It aims to make a difference in ways that are scientifically and socially important. The institute will focus the bulk of its scientific activity during the period of the current grant on six themes: Climate Science, Data and Information, Health and Medical Care, Materials Science, Quantum Computing and Information, and Uncertainty Quantification. These areas embody significant challenges for society at large, and meaningful progress in these areas will in many cases require engagement from researchers and decision makers across a variety of sectors, including academia, national labs, government, and the private sector, and will highlight the important and expanding role played by the mathematical sciences across these sectors.

A crucial factor in addressing these scientific challenges is the diversity of those engaged in research and activity at IMSI. The challenges with which we intend to engage will require perspectives and insight from a number of directions in order to make progress. As suggested above, these insights and perspectives must emerge from interactions among researchers from multiple disciplines and employment sectors. At the same time, there is often a need for research to usefully inform policy and decision making, which requires expanding conversation and engagement beyond the realm of basic research. Moreover, the broad social impacts of these challenges implies that effective engagement with them will often require the participation of a community of researchers who can collectively bring an understanding of how these challenges are experienced across human society as a whole. This points to a need for broad participation in the mathematical sciences.

The third pillar in IMSI's mission is an emphasis on effective communication and, beyond that, effective collaboration and engagement. An important aspect of scientific progress is that the insights it generates must propagate and land with those who can make effective use of them. This often requires communicating and collaborating across differences arising from boundaries between intellectual disciplines, research cultures, employment sectors and roles, career and education stages, positions in society, and more. Scientific research often defaults to a mode of experts speaking to experts who emerge from similar research cultures. IMSI aims to encourage scientific research that does not remain confined to this mode, and to provide ways for researchers in the mathematical sciences to build skills in communicating across differences.

1.2 Review of the Second Year

This year included some important firsts for the Institute, such as its first events with an in-person component, and its first long programs.



The year began with two four-week virtual summer schools, each a precursor to a long program which took place during the academic year. During the fall, IMSI hosted a long program on *Distributed Solutions to Complex Societal Problems*, and a long program on *Decision Making and Uncertainty* in the spring. Each of these programs had seven embedded workshops. Other activities hosted or facilitated by IMSI during this reporting period included four standalone research workshops (one during the summer and three in the winter), a summer internship program for Ph.D. students in mathematics and

statistics programs hosted at the University of Illinois at Urbana-Champaign, summer enrichment programs for Chicago Public School students at the University of Chicago and the University of Illinois at Chicago, the Graduate Research Opportunities for Women (GROW) conference at the University of Illinois at Chicago, a satellite event for the 2021 Blackwell-Tapia Conference, a planning meeting for the Indiana-Chicago Metro Area Math Alliance, and two paraDIGMS conferences.

The process of recruiting IMSI staff continued this year. Bernard Davis, the Director of IT and AV Services, started on July 12, 2021, and has been working to develop the IT and AV infrastructure on which IMSI activities and operation depend. Sadie Witkowski, the Director of Communications and Engagement, started on August 16, 2021. She has been developing communications workshops for researchers in the mathematical sciences, working on social media outreach, and other communications initiatives. Two new program coordinators, Hatticia Reynolds and Rebecca Heffner, were hired as Program Coordinators starting on February 7 and February 14, 2022, respectively. These hires bring IMSI's staffing process to completion for the time being.

IMSI staff started working on site during the summer, and began preparing institute space to host activity. Our first activity with an in-person component was a topical workshop at the end of August 2021.

1.3 Impact of COVID-19

The COVID-19 pandemic had a significant impact on activity during the summer, fall, and winter of the reporting period. Two summer schools were held in a purely virtual format. Through the late summer and fall, in person activity on campus began to be possible, but factors like the ban on travel to the US by international participants through the summer and much of the fall and the Omicron surge at the end of the fall and into the winter created significant obstacles and uncertainty around in-person activity. Through much of the year, on site participant numbers were significantly reduced for most activities compared with expectations, and some activities which had been planned to be hybrid needed to move to a purely virtual format. By the beginning of spring, many of the concerns around COVID-19 had receded significantly, and IMSI was able to host close to a full contingent of visitors for activities connected with its spring long program.

2. Participant Demographics

2.1 List of Activities

IMSI Activities 2021-2022

Title	Dates
Introduction to Mean Field Games and Applications	June 1-25, 2021
Introduction to Decision Making and Uncertainty	June 28 – July 23, 2021
Eliciting Structure in Genomics Data: Bridging the Gap between Theory, Algorithms, Implementations, and Applications	August 30 – September 3, 2021
Distributed Solutions to Complex Societal Problems	September 20 – December 17, 2021
Introduction to Distributed Solutions	October 4-7, 2021
GROW 2021	October 15-17, 2021
Short Courses on Mean Field Approach in Machine Learning and Statistics	October 18-20, 2021
Aggregate Dynamics in Models with Heterogeneous Agents	October 27-29, 2021
paraDIGMS Fall 2021 Conference: Diversity in Graduate Mathematics Education	October 28-31, 2021
Mean Field Models for Interacting Agents	November 1-4, 2021
Applications of Mean Field Games: From Models to Practice	November 16-19, 2021
Blackwell-Tapia Conference Satellite Event*	November 18-20, 2021
Applications to Financial Engineering	December 6-9, 2021
Mathematical Advances in Mean Field Games	December 13-16, 2021
Private AI: Machine Learning on Encrypted Data	February 7-11, 2022
Multiscale Microbial Communities: Dynamical Models, Ecology, and One Health	February 21-24, 2022
The Mathematics of Soft Matter: Structure and Dynamics	February 28 – March 4, 2022
Decision Making and Uncertainty	March 21 – May 27, 2022
Advances in Optimal Decision Making under Uncertainty	March 28 – April 1, 2022
Systemic Risk and Stress Testing	April 4-8, 2022
Confronting Uncertainty in Climate Change	April 13-15, 2022

paraDIGMS Spring 2022 Conference: Diversity in Graduate Mathematical Sciences	April 28 – May 1, 2022
Decision Making under Uncertainty	May 2-6, 2022
Dynamic Assessment Indices	May 9-13, 2022
Applied Optimal Transport	May 16-20, 2022
Machine Learning and Mean-Field Games	May 23-26, 2022

* Registration for the Blackwell-Tapia Conference was managed by MSRI, and will not be reported on here.

2.2 Demographics by Type of Activity

Research Workshops '21-'22 includes all workshops embedded in long programs and all topical workshops.

The template used for gathering demographic, professional, and educational data on participants changed midway through the first year, after we became aware of NSF specifications for gathering data. As a result, some of our data includes categories not provided for in the NSF specifications. In addition, some participants did not register through the institute website, and thus did not provide data.

Demographics by Activity

Activity		Long Programs '21-'22	Research Workshops '21-'22	Summer Schools '21	GROW '21	paraDIGMS '21-'22
Total Number of Participants (Includes all participants, speakers, and organizers)		56	1335	800	162	449
Gender	Female	16	326	169	148	194
	Male	40	927	563	5	219
	Other	0	1	2	4	15
	Do Not Wish to Provide	0	63	46	0	14
	Unknown	0	18	20	5	7

Activity		Long Programs '21-'22	Research Workshops '21-'22	Summer Schools '21	GROW '21	paraDIGMS '21-'22
Total Number of Participants (Includes all participants, speakers, and organizers)		56	1335	800	162	449
Race*	American Indian or Alaskan Native	0	2	3	2	4
	Asian	13	431	343	59	93
	Black or African American	1	41	16	10	34
	Native Hawaiian or Other Pacific Islander	0	0	0	1	4
	White	35	610	232	82	274
	Do Not Wish to Provide	7	241	187	13	29
	Unknown	1	22	24	5	26

* Participants could select multiple races. Some individuals may be reflected in this chart more than once.

Activity		Long Programs '21-'22	Research Workshops '21-'22	Summer Schools '21	GROW '21	paraDIGMS '21-'22
Total Number of Participants (Includes all participants, speakers, and organizers)		56	1335	800	162	449
Ethnicity	Hispanic or Latino	2	105	65	17	36
	Not Hispanic or Latino	39	919	504	124	221
	Do not wish to provide	8	255	190	13	32
	Unknown	7	56	41	8	160

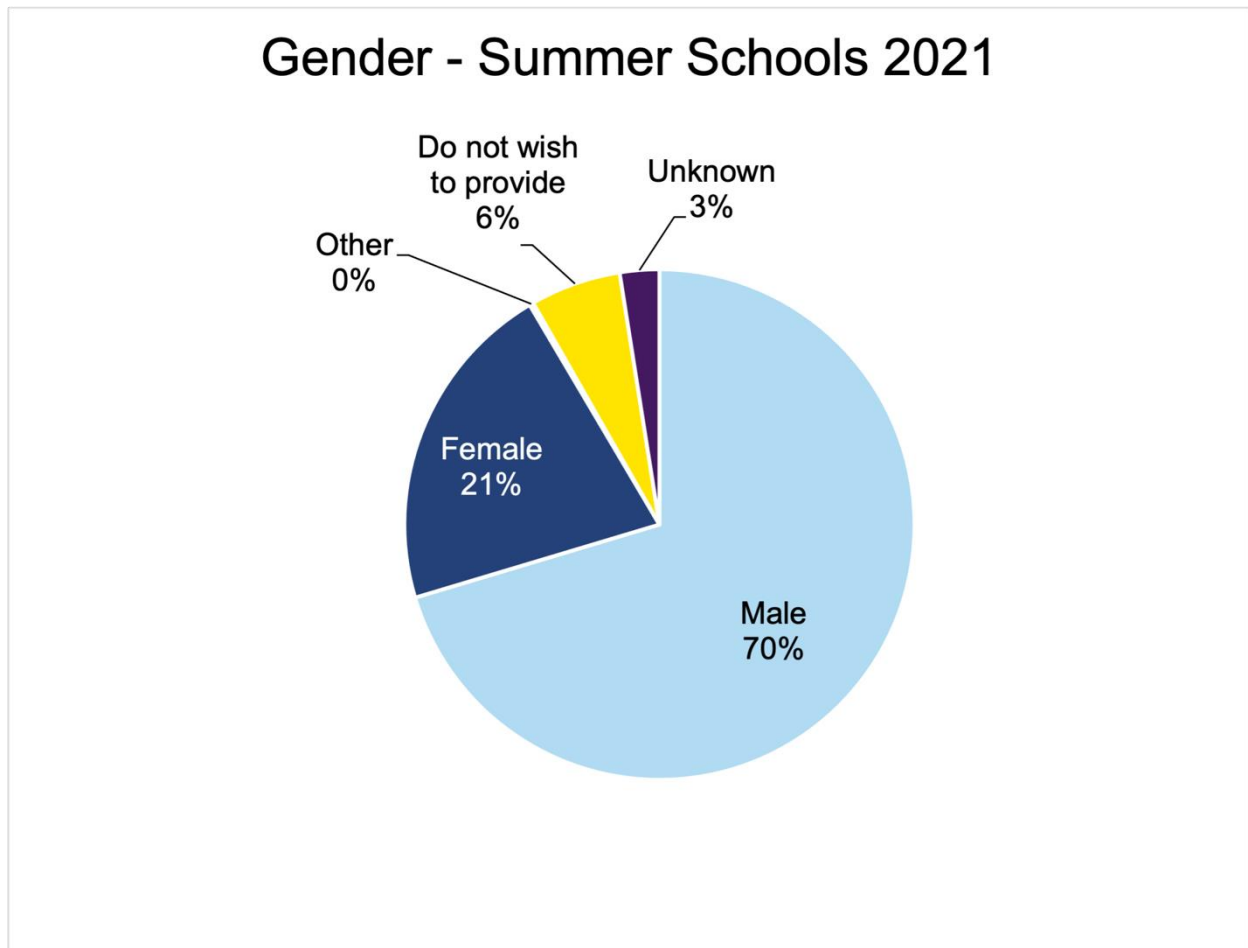
Activity		Long Programs '21-'22	Research Workshops '21-'22	Summer Schools '21	GROW '21	paraDIGMS '21-'22
Total Number of Participants (Includes all participants, speakers, and organizers)		56	1335	800	162	449
Employment/ Educational Status	Faculty Member or Academic Administrator	37	551	201	13	258
	Graduate Student	15	455	424	8	122
	Non-academic Employment	0	125	25	4	13
	Postdoctoral Associate	4	142	105	0	27
	Retired / Not Employed / Self-employed	0	17	7	1	7
	Undergraduate Student	0	24	14	131	9
	High School Student	0	1	1	0	0
	Unknown	0	20	23	5	13

Activity		Long Programs '21-'22	Research Workshops '21-'22	Summer Schools '21
Total Number of Participants (Includes all participants, speakers, and organizers)		56	1335	800
Field(s) of Expertise**	Mathematics	40	716	489
	Statistics	16	254	202
	Physics / Astronomy	0	30	6
	Chemistry	0	39	1
	Materials Science	1	19	4
	Computer Science / Information Science	3	203	99
	Engineering	1	99	52
	Life Sciences	0	42	3
	Medicine	1	14	1
	Geosciences	2	6	2
	Economics	11	199	95
	Social Sciences	0	12	5
	Education or Learning Research	0	1	1
	Other	3	61	30

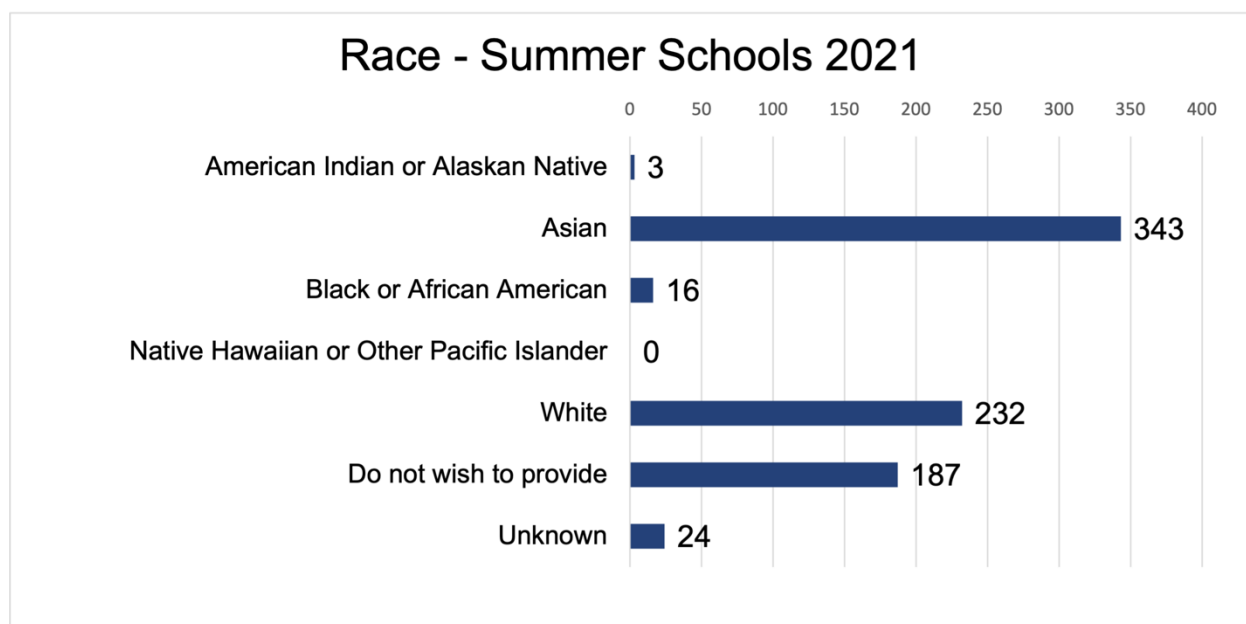
** Participants were able to indicate more than one field of expertise. Those that selected multiple fields of expertise are represented in the totals more than once.

2.3 Demographics for Summer Schools

Summer Schools 2021 - Participants by Gender



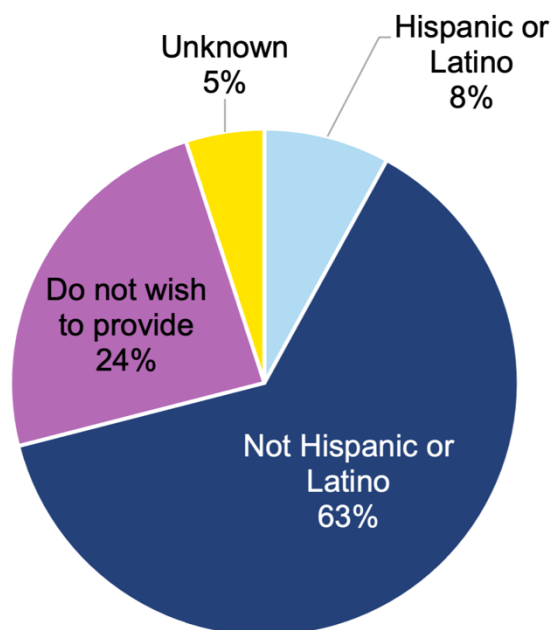
Summer Schools 2021 - Participants by Race



Note: Participants could select multiple races. Some individuals may be reflected in this chart more than once.

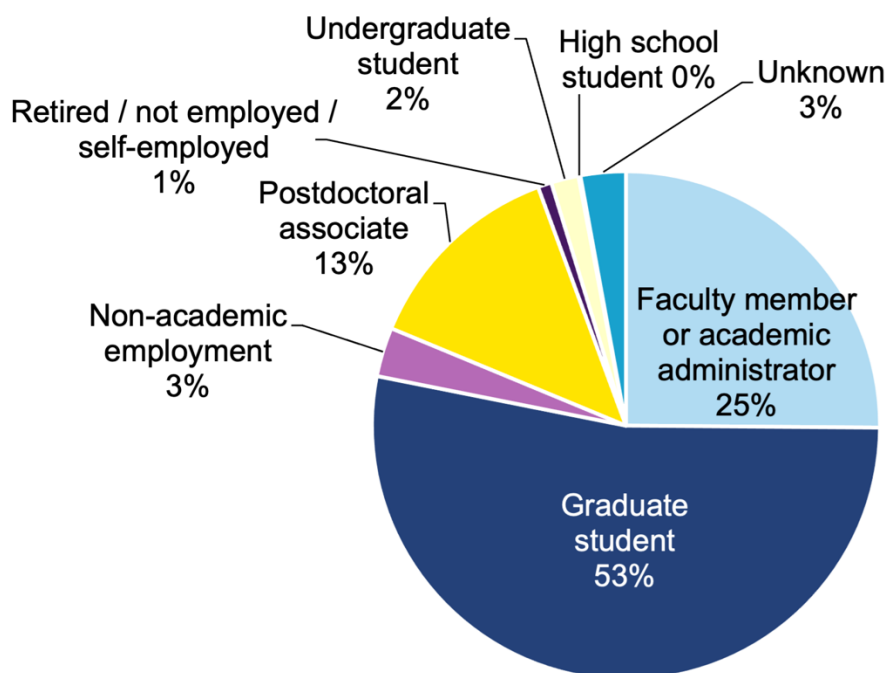
Summer Schools 2021 - Participants by Ethnicity

Ethnicity - Summer Schools 2021

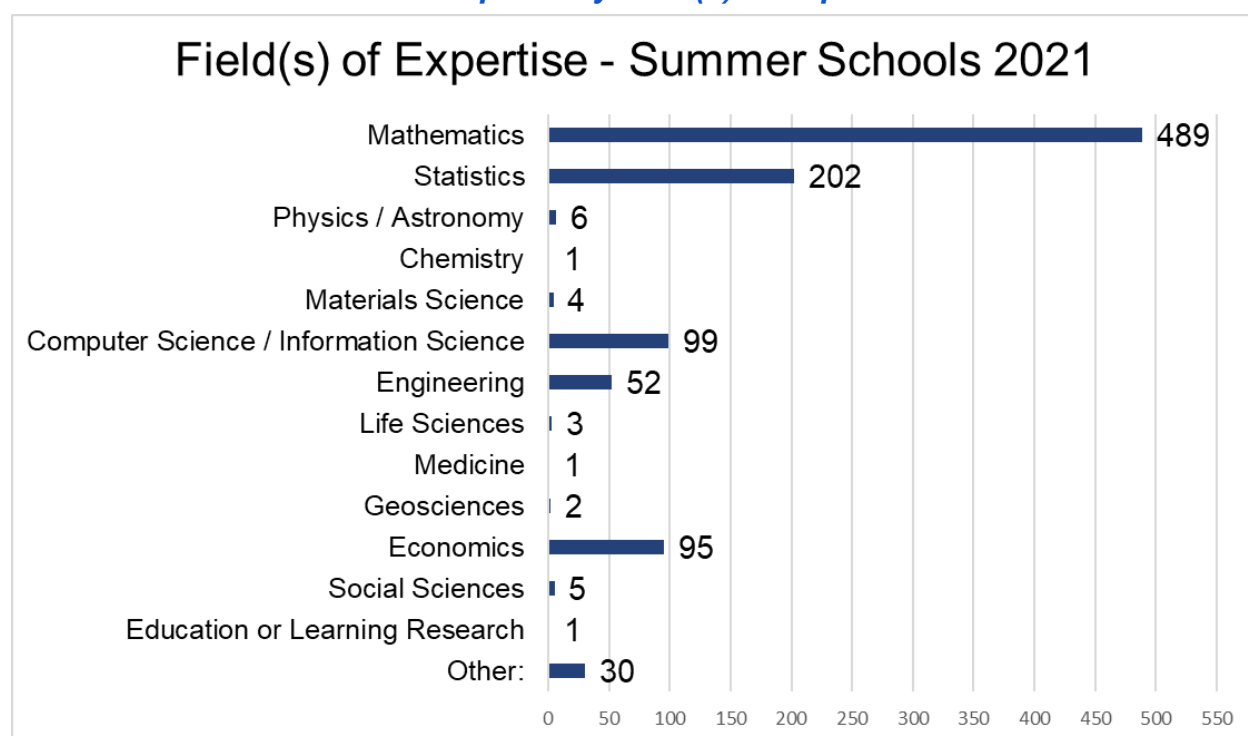


Summer Schools 2021 - Participants by Employment/Educational Status

Employment/Educational Status - Summer Schools 2021

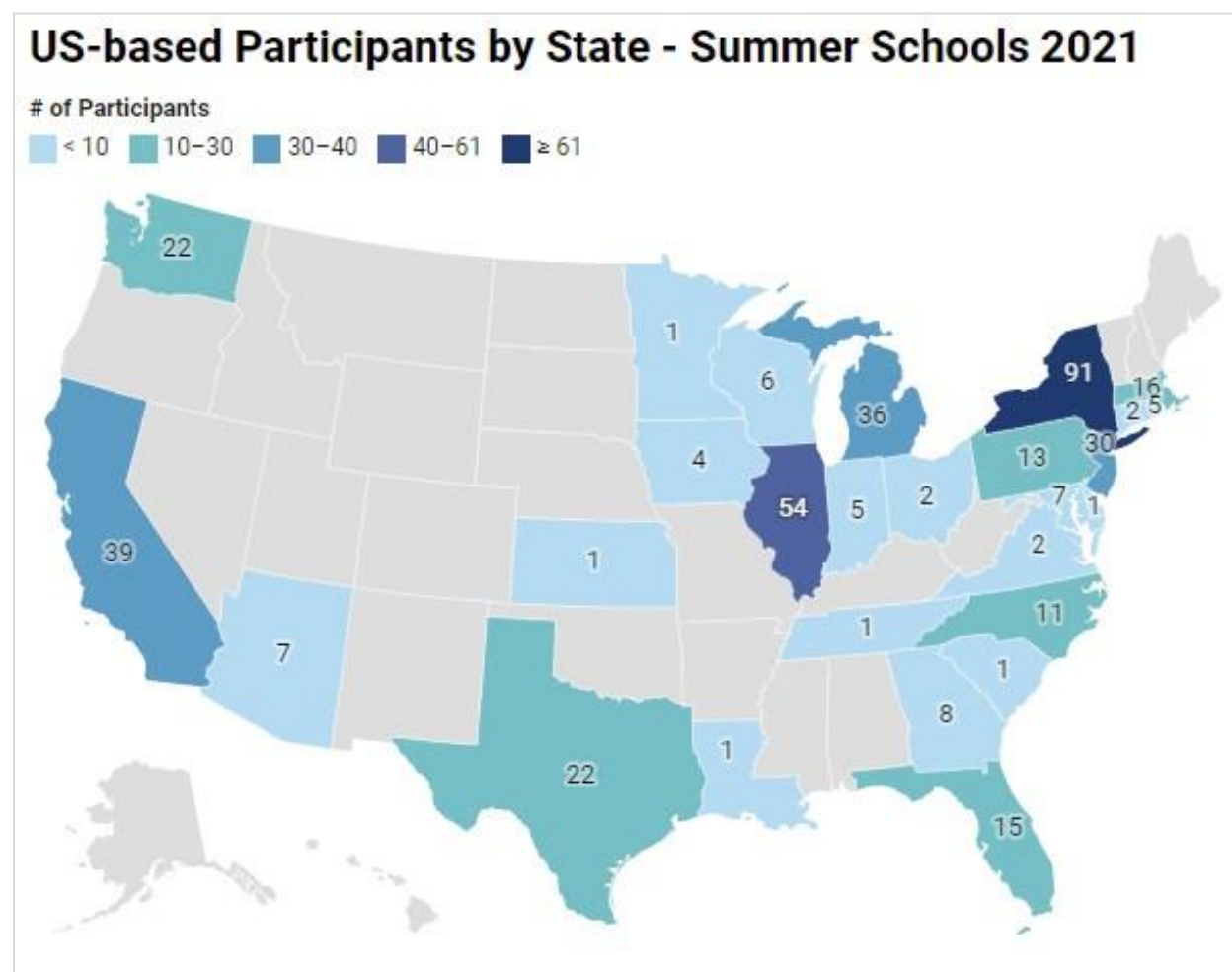


Summer Schools 2021 - Participants by Field(s) of Expertise



Note: Participants were able to indicate more than one field of expertise. Those that selected multiple fields of expertise are represented in the totals more than once.

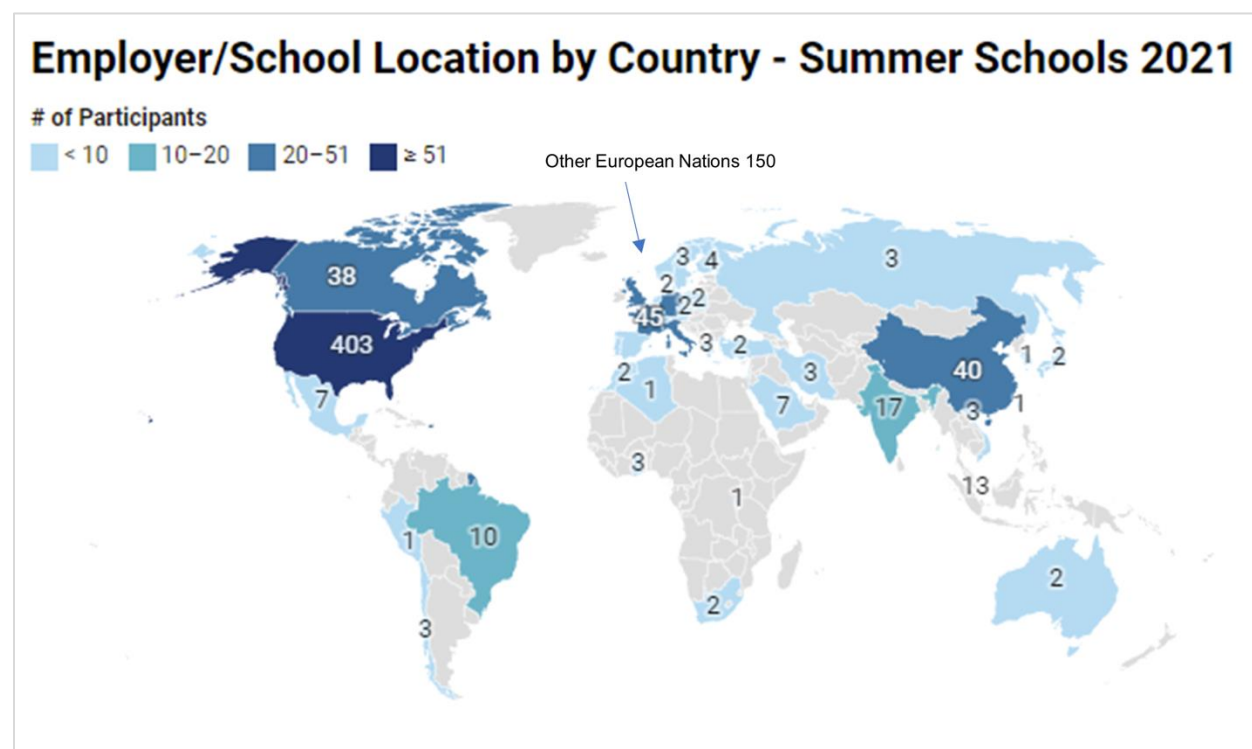
Summer Schools 2021 - Participants by Employer/School Location (United States)



Summer Schools 2021 - Participants by Employer/School Location (United States)			
State	Number of Participants	State	Number of Participants
Alabama	0	Montana	0
Alaska	0	Nebraska	0
Arizona	7	Nevada	0
Arkansas	0	New Hampshire	0
California	39	New Jersey	30
Colorado	0	New Mexico	0
Connecticut	2	New York	91
Delaware	1	North Carolina	11

District of Columbia	0	North Dakota	0
Florida	15	Ohio	2
Georgia	8	Oklahoma	0
Hawaii	0	Oregon	0
Idaho	0	Pennsylvania	13
Iowa	4	Rhode Island	5
Illinois	54	South Carolina	1
Indiana	5	South Dakota	0
Kansas	1	Tennessee	1
Kentucky	0	Texas	22
Louisiana	1	Utah	0
Massachusetts	16	Vermont	0
Maryland	7	Virginia	2
Maine	0	Washington	22
Michigan	36	West Virginia	0
Minnesota	1	Wisconsin	6
Mississippi	0	Wyoming	0
Missouri	0		

Summer Schools 2021 - Participants by Employer/School Location (Country)



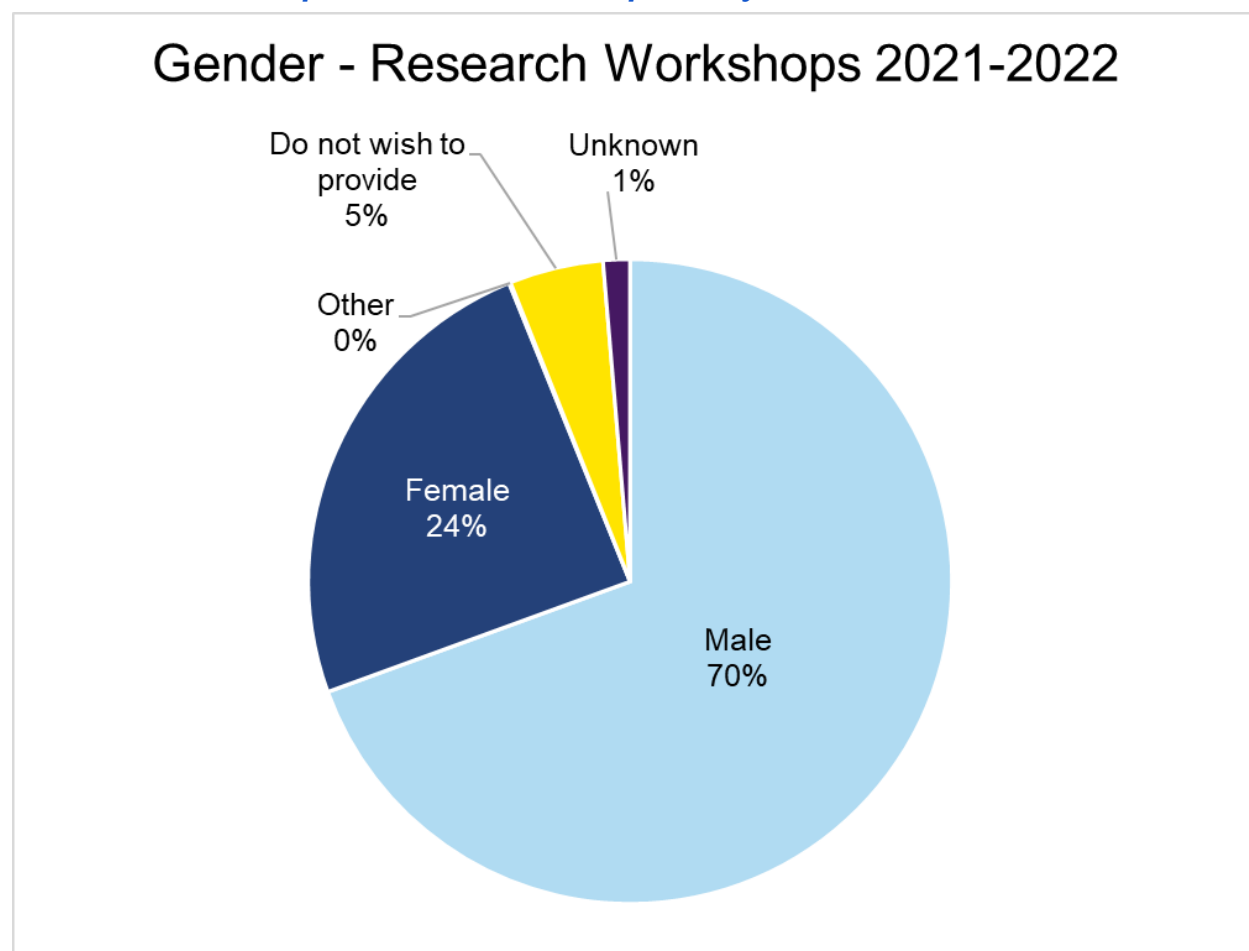
Summer Schools 2021 - Participants by Employer/School Location			
Country	Number of Participants	Country	Number of Participants
Algeria	1	Mexico	7
Australia	2	Morocco	2
Austria	6	Netherlands	4
Brazil	10	Norway	1
Canada	38	Peru	1
Chile	3	Poland	2
China	40	Portugal	3
Czech Republic	2	Russia	3
Denmark	2	Rwanda	1
Finland	4	Saudi Arabia	7
France	45	Singapore	13
Germany	38	South Africa	2

Ghana	3	Spain	3
Greece	3	Sweden	3
Hong Kong	10	Switzerland	8
India	17	Taiwan	1
Iran	3	Turkey	2
Israel	4	United Kingdom	49
Italy	36	United States	403
Japan	2	Vietnam	3
Korea, South	1	Unknown	11
Luxembourg	1		

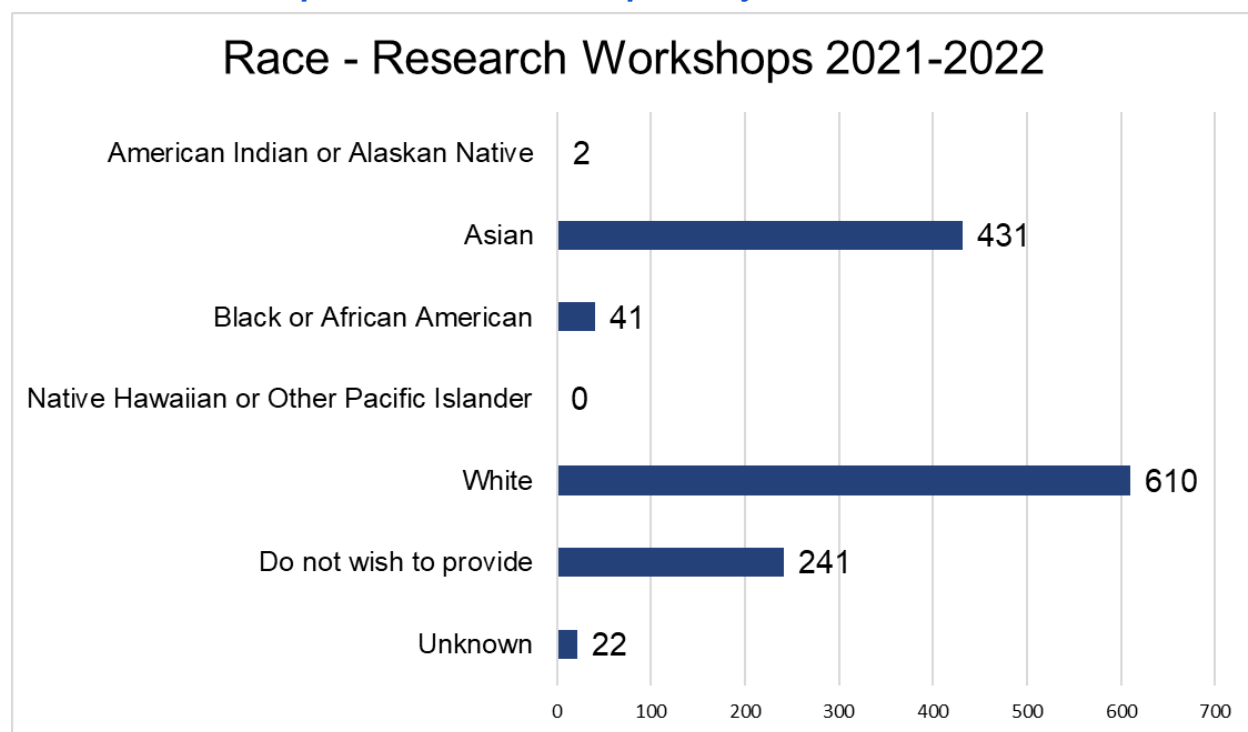
2.4 Demographics for Research Workshops

The following demographic information includes participants, organizers, speakers, facilitators, and panelists. Some individuals may be reflected more than one time if they participated in more than one workshop. This category of activity includes the following events:

- Eliciting Structure in Genomics Data: Bridging the Gap between Theory, Algorithms, Implementations, and Applications
- Introduction to Distributed Solutions
- Short Courses on Mean Field Approach in Machine Learning and Statistics
- Aggregate Dynamics in Models with Heterogeneous Agents
- Mean Field Models for Interacting Agents
- Applications of Mean Field Games: From Models to Practice
- Applications to Financial Engineering
- Mathematical Advances in Mean Field Games
- Private AI: Machine Learning on Encrypted Data
- Multiscale Microbial Communities: Dynamical Models, Ecology, and One Health
- The Mathematics of Soft Matter: Structure and Dynamics
- Advances in Optimal Decision Making under Uncertainty
- Systemic Risk and Stress Testing
- Confronting Uncertainty in Climate Change
- Decision Making under Uncertainty
- Dynamic Assessment Indices
- Applied Optimal Transport
- Machine Learning and Mean-Field Games

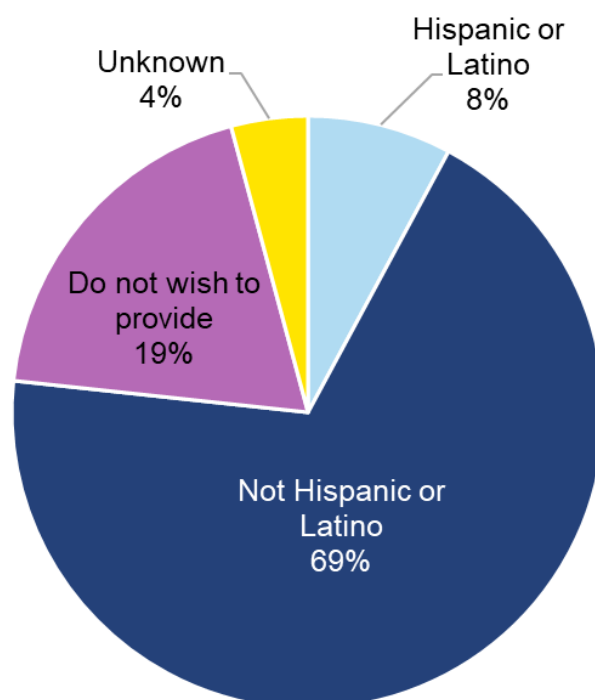


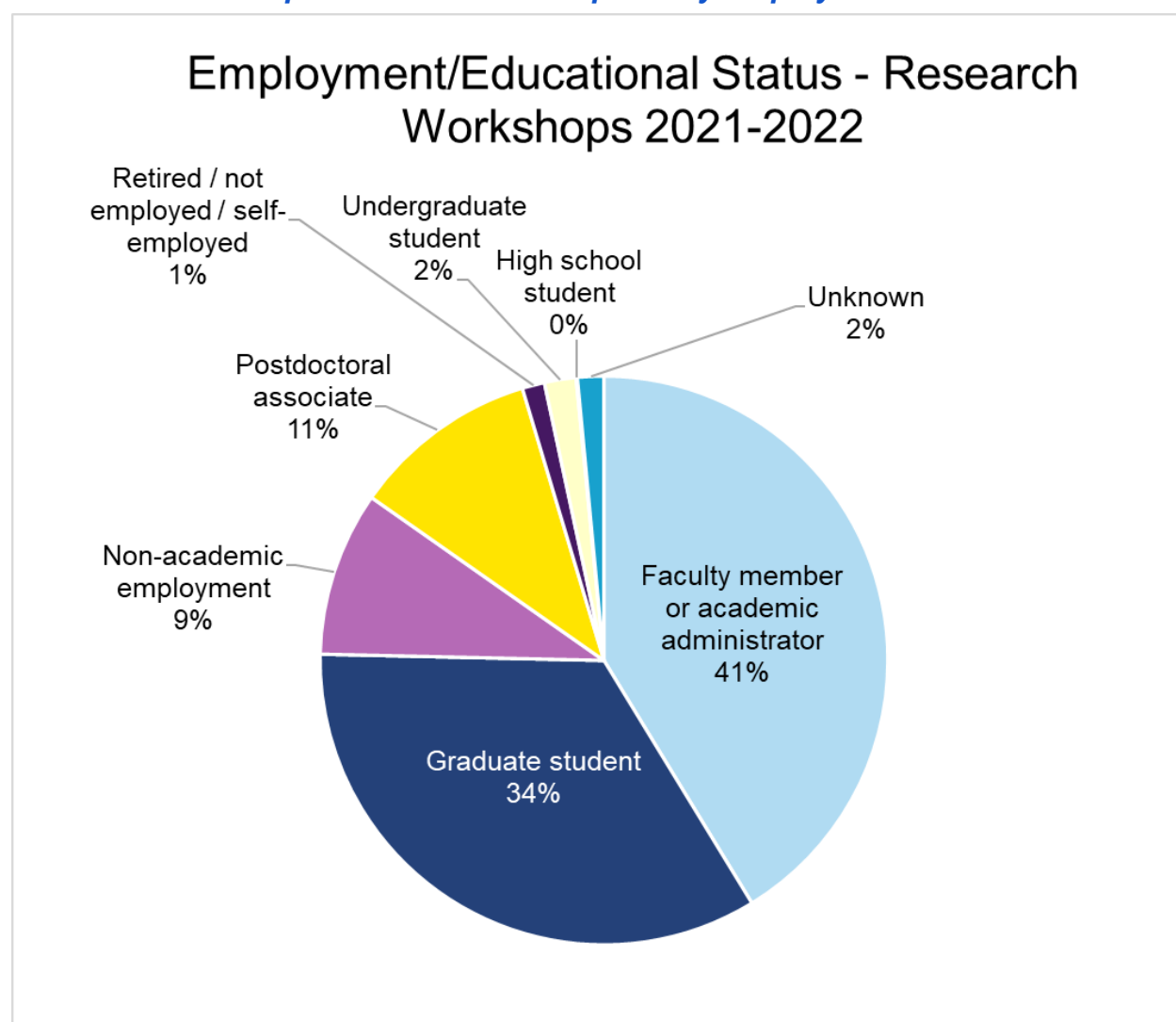
Research Workshops 2021-2022 - Participants by Race



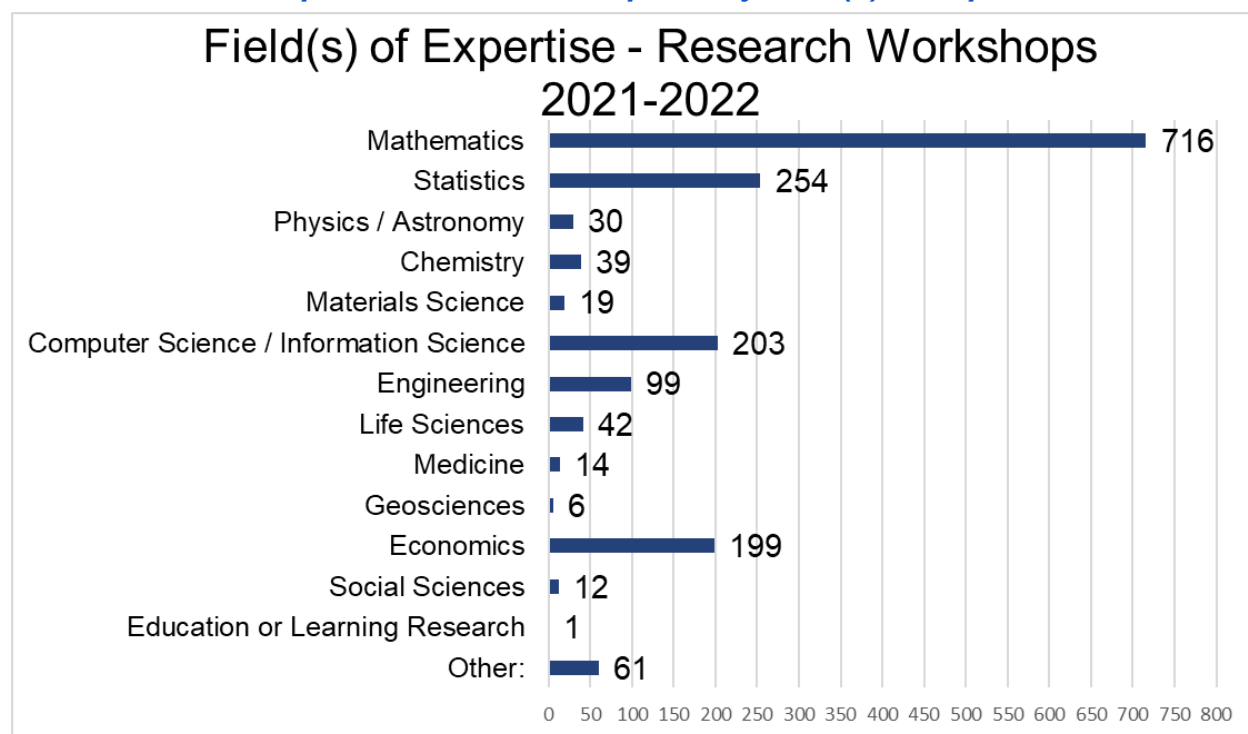
Note: Participants could select multiple races. Some individuals may be reflected in this chart more than once.

Ethnicity - Research Workshops 2021-2022



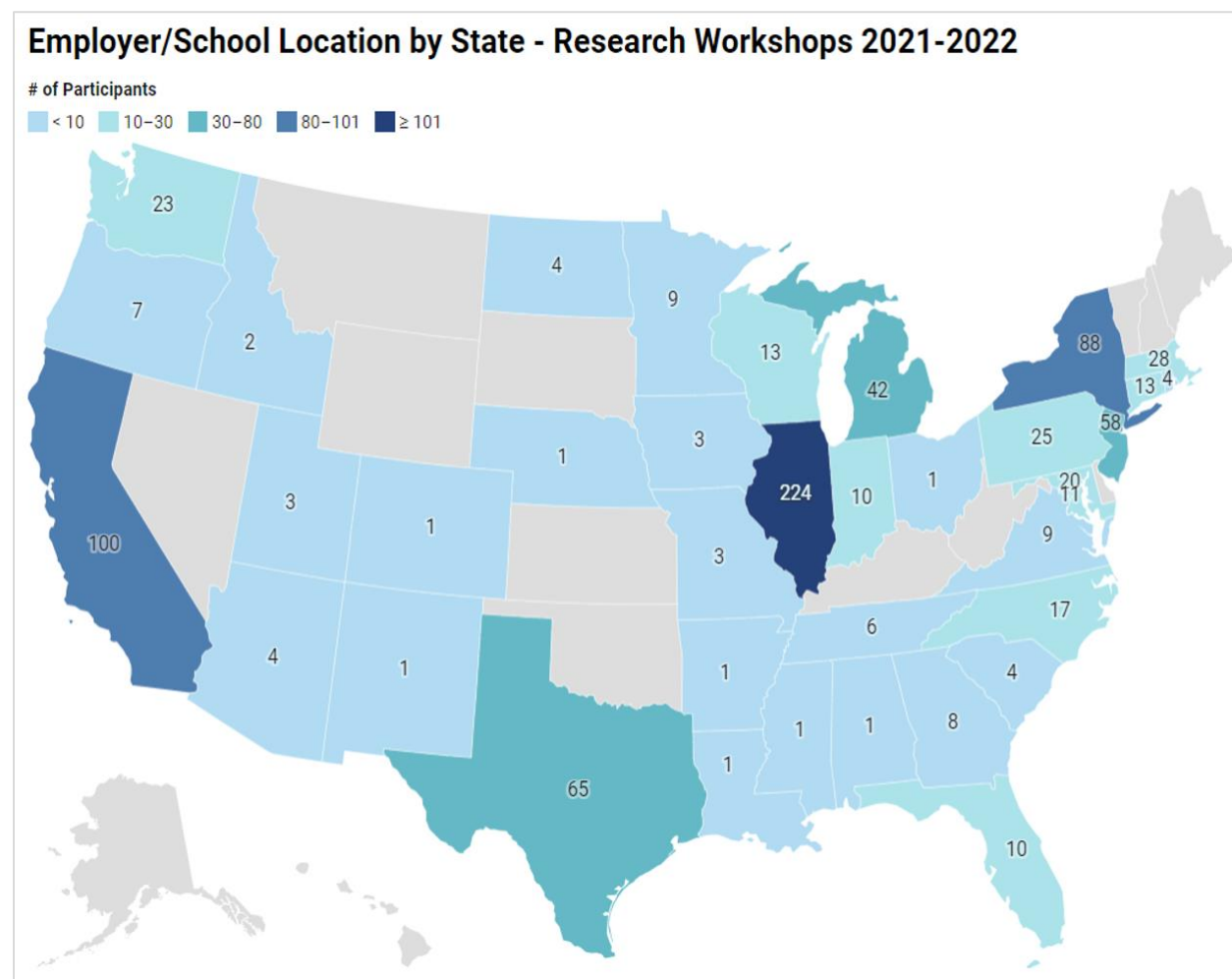


Research Workshops 2021-2022 - Participants by Field(s) of Expertise



Note: Participants were able to indicate more than one field of expertise. Those that selected multiple fields of expertise are represented in the totals more than once.

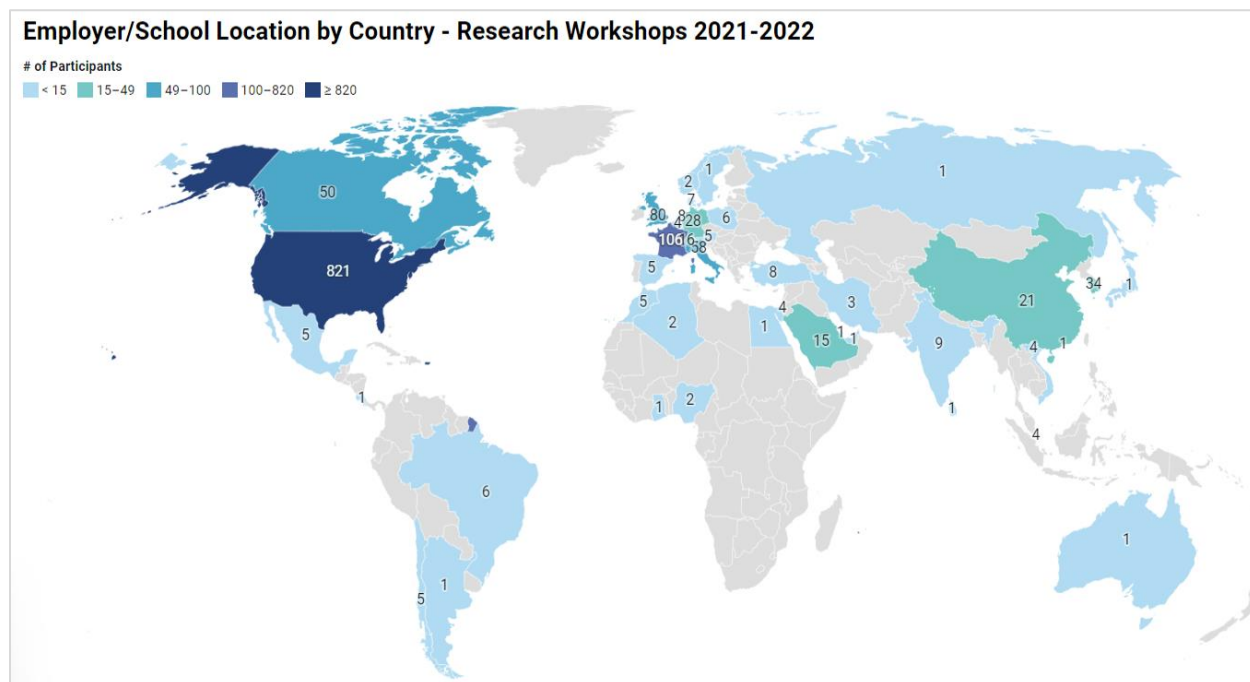
Research Workshops 2021-2022 - Participants by Employer/School Location (United States)



Research Workshops 2021-2022 - Participants by Employer/School Location (United States)			
State	Number of Participants	State	Number of Participants
Alabama	1	Montana	0
Alaska	0	Nebraska	1
Arizona	4	Nevada	0
Arkansas	1	New Hampshire	0
California	100	New Jersey	58
Colorado	1	New Mexico	1
Connecticut	13	New York	88

Delaware	0	North Carolina	17
District of Columbia	11	North Dakota	4
Florida	10	Ohio	1
Georgia	8	Oklahoma	0
Hawaii	0	Oregon	7
Idaho	2	Pennsylvania	25
Iowa	3	Rhode Island	4
Illinois	224	South Carolina	4
Indiana	10	South Dakota	0
Kansas	0	Tennessee	6
Kentucky	0	Texas	65
Louisiana	1	Utah	3
Massachusetts	28	Vermont	0
Maryland	20	Virginia	9
Maine	0	Washington	23
Michigan	42	West Virginia	0
Minnesota	9	Wisconsin	13
Mississippi	1	Wyoming	0
Missouri	3		

Research Workshops 2021-2022 - Participants by Employer/School Location (Country)



Research Workshops 2021-2022 - Participants by Employer/School Location			
Country	Number of Participants	Country	Number of Participants
Algeria	2	Korea, South	34
Argentina	1	Mexico	5
Australia	1	Morocco	5
Austria	5	Netherlands	8
Belgium	4	Nigeria	2
Brazil	6	Norway	2
Canada	50	Poland	6
Chile	5	Qatar	1
China	21	Russia	1
Costa Rica	1	Saudi Arabia	15
Denmark	7	Singapore	4
Egypt	1	Spain	5
France	106	Sri Lanka	1

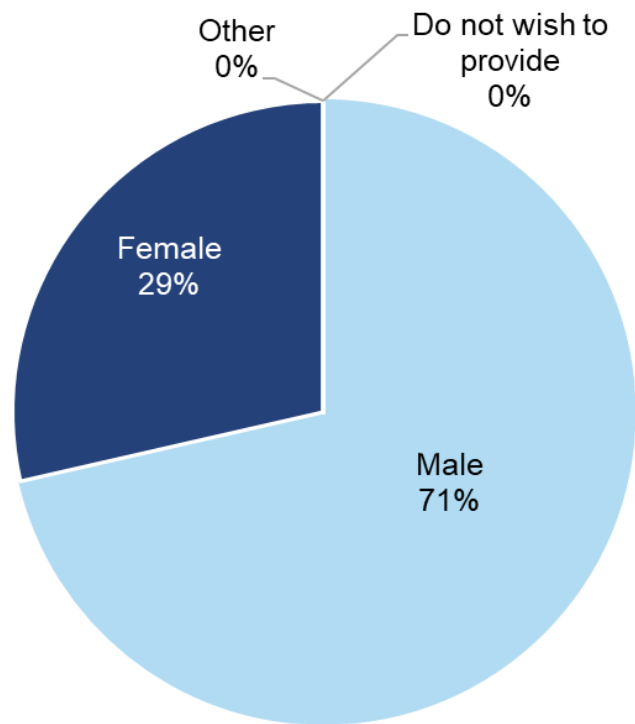
Germany	28	Sweden	1
Ghana	1	Switzerland	16
Hong Kong	1	Turkey	8
India	9	United Arab Emirates	1
Iran	3	United Kingdom	80
Israel	4	United States	821
Italy	58	Vietnam	4
Japan	1		

2.5 Demographics for Fall & Spring Long Programs

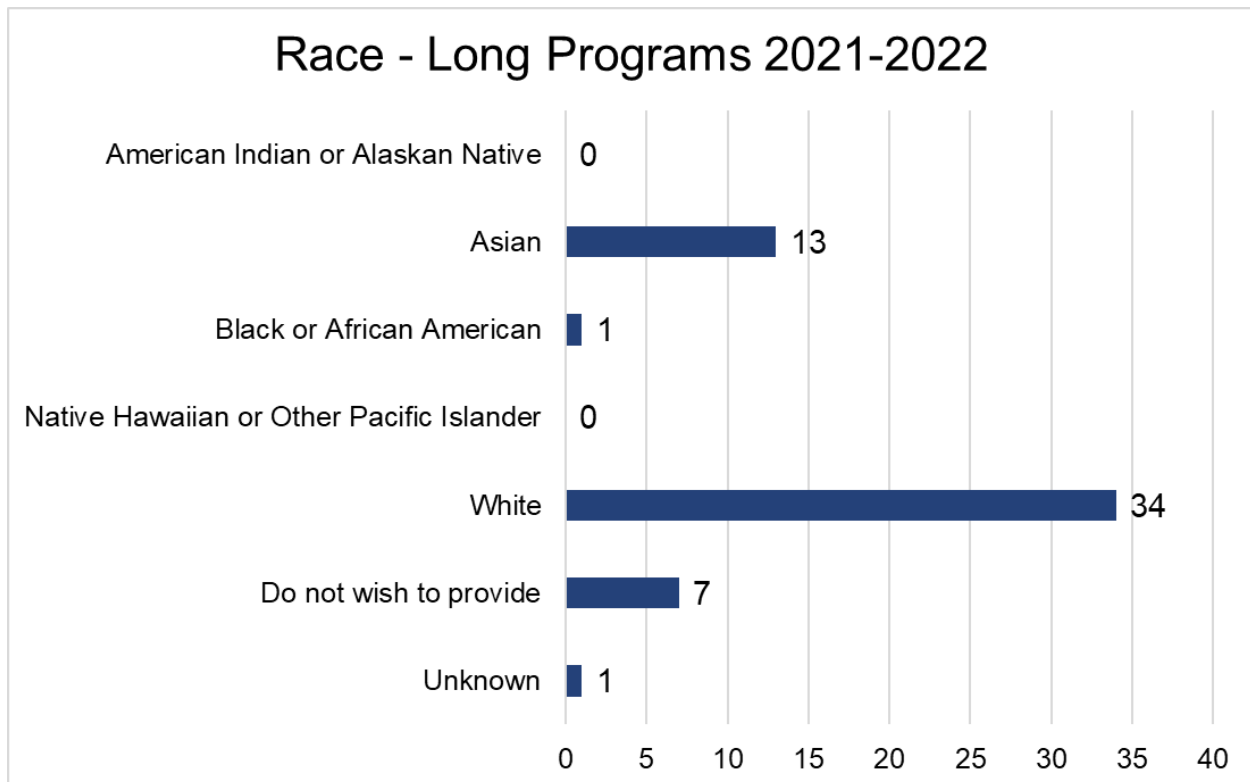
The following demographic information includes research members who were in residence during a long program. Some individuals may be reflected more than one time if they participated in more than one program.

Long Programs 2021-2022 - Participants by Gender

Gender - Long Programs 2021-2022

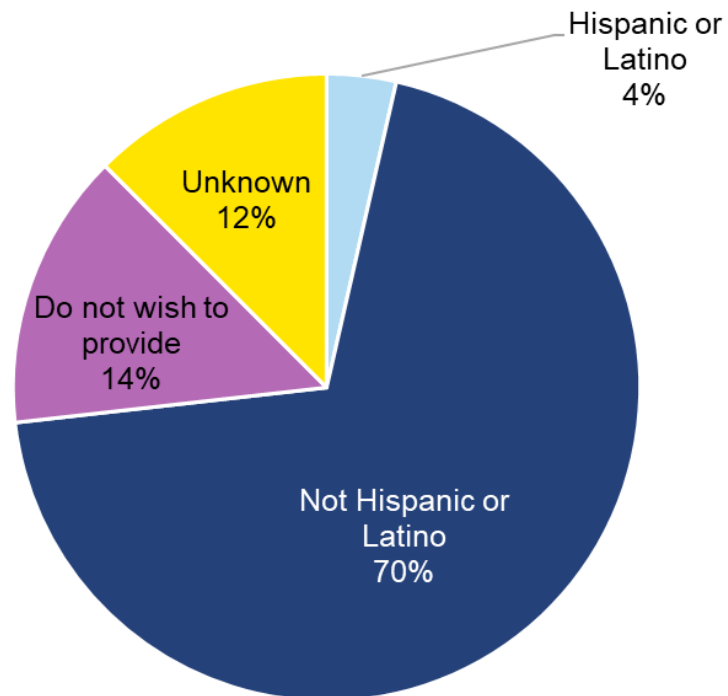


Long Programs 2021-2022 - Participants by Race

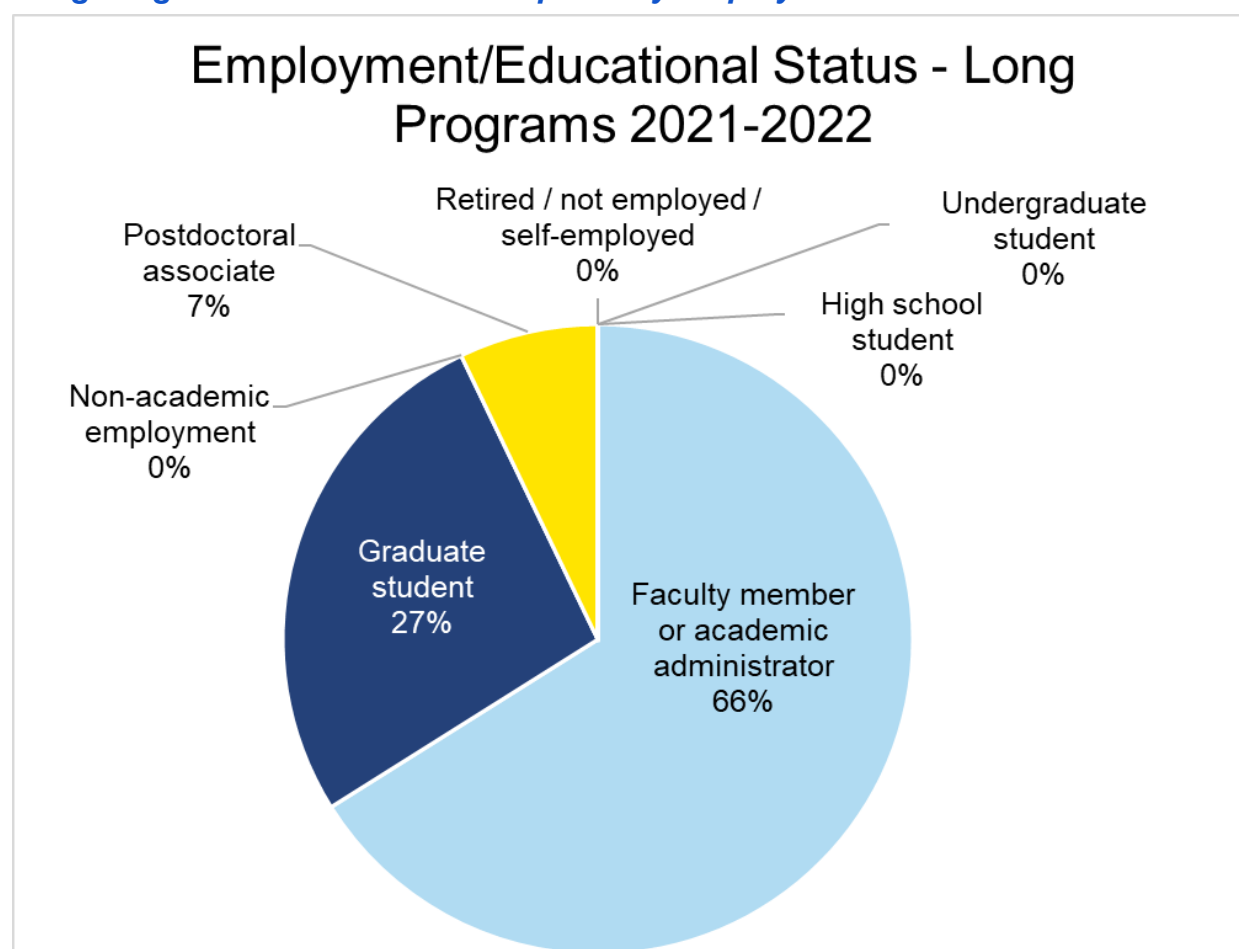


Note: Participants could select multiple races. Some individuals may be reflected in this chart more than once.

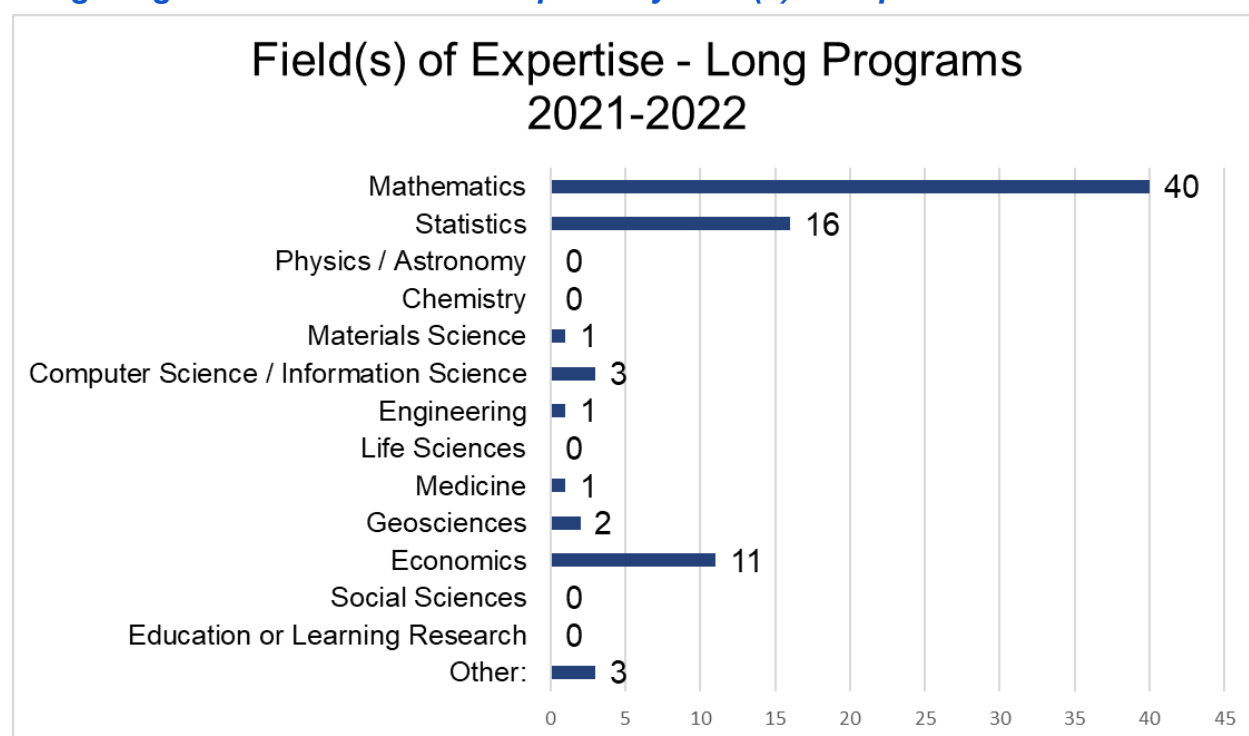
Ethnicity - Long Programs 2021-2022



Long Programs 2021-2022 - Participants by Employment/Educational Status

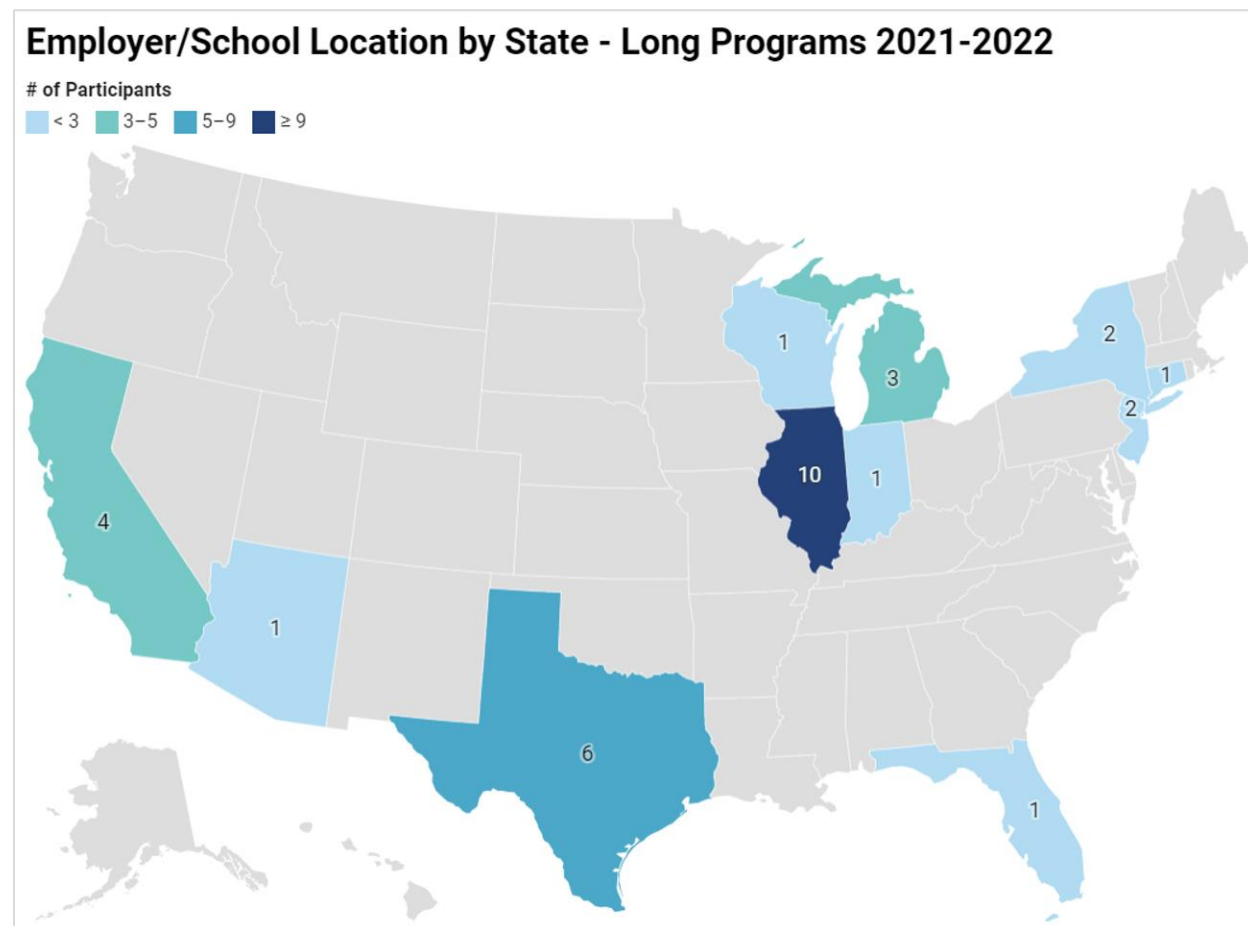


Long Programs 2021-2022 - Participants by Field(s) of Expertise



Note: Participants were able to indicate more than one field of expertise. Those that selected multiple fields of expertise are represented in the totals more than once.

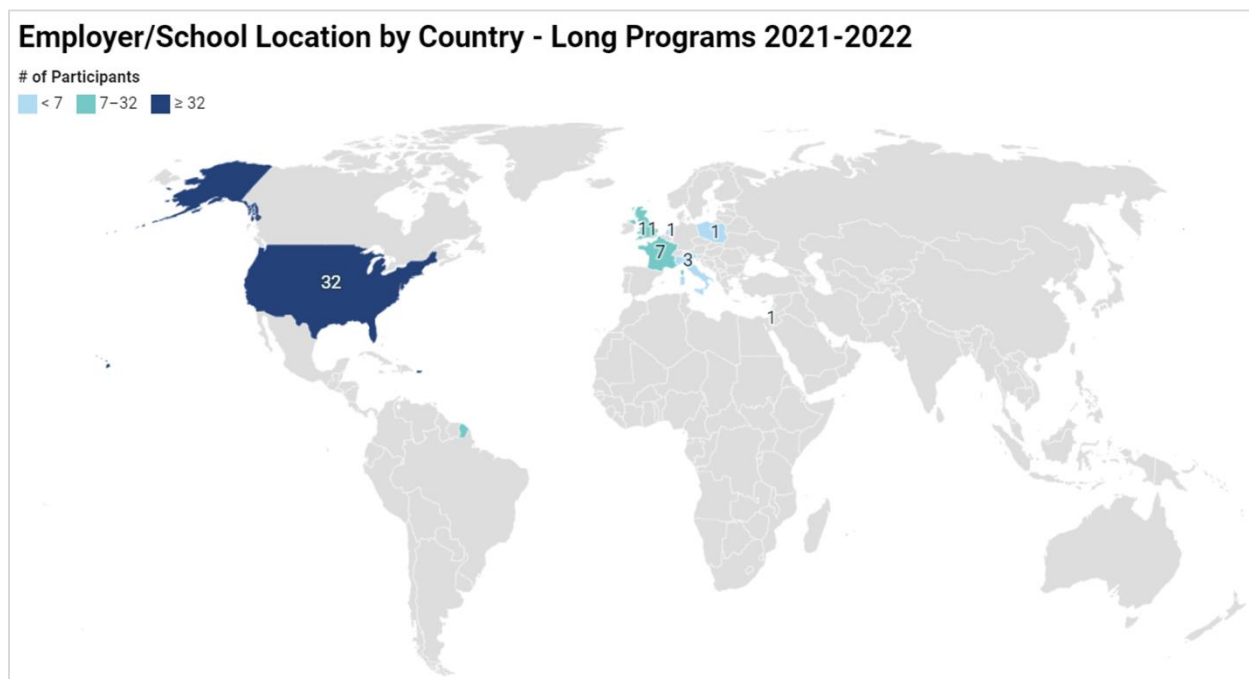
Long Programs 2021-2022 - Participants by Employer/School Location (United States)



Long Programs 2021-2022 - Participants by Employer/School Location (United States)			
State	Number of Participants	State	Number of Participants
Alabama	0	Montana	0
Alaska	0	Nebraska	0
Arizona	1	Nevada	0
Arkansas	0	New Hampshire	0
California	4	New Jersey	2
Colorado	0	New Mexico	0
Connecticut	1	New York	2
Delaware	0	North Carolina	0

District of Columbia	0	North Dakota	0
Florida	1	Ohio	0
Georgia	0	Oklahoma	0
Hawaii	0	Oregon	0
Idaho	0	Pennsylvania	0
Iowa	0	Rhode Island	0
Illinois	10	South Carolina	0
Indiana	1	South Dakota	0
Kansas	0	Tennessee	0
Kentucky	0	Texas	6
Louisiana	0	Utah	0
Massachusetts	0	Vermont	0
Maryland	0	Virginia	0
Maine	0	Washington	0
Michigan	3	West Virginia	0
Minnesota	0	Wisconsin	1
Mississippi	0	Wyoming	0
Missouri	0		

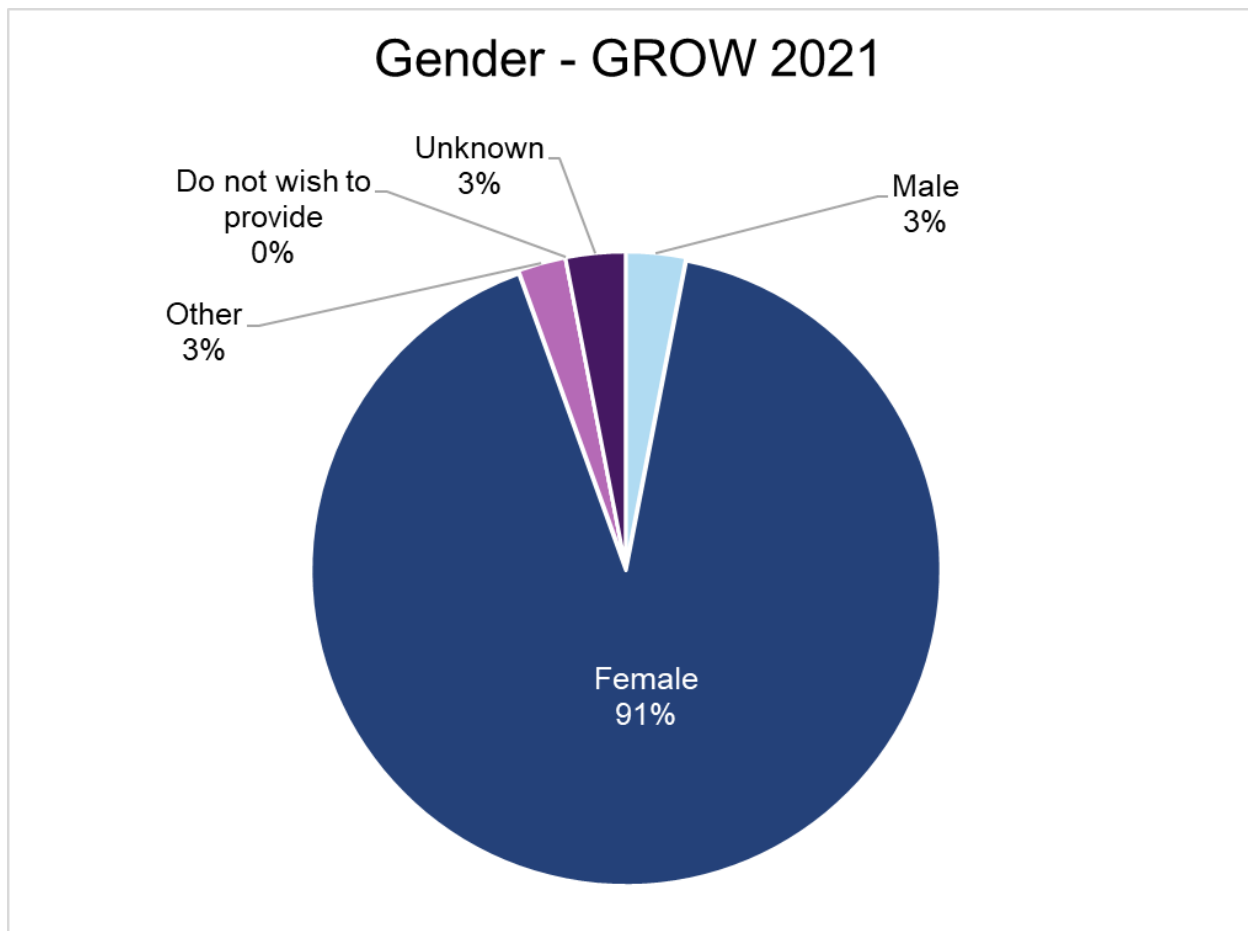
Long Programs 2021-2022 - Participants by Employer/School Location (Country)



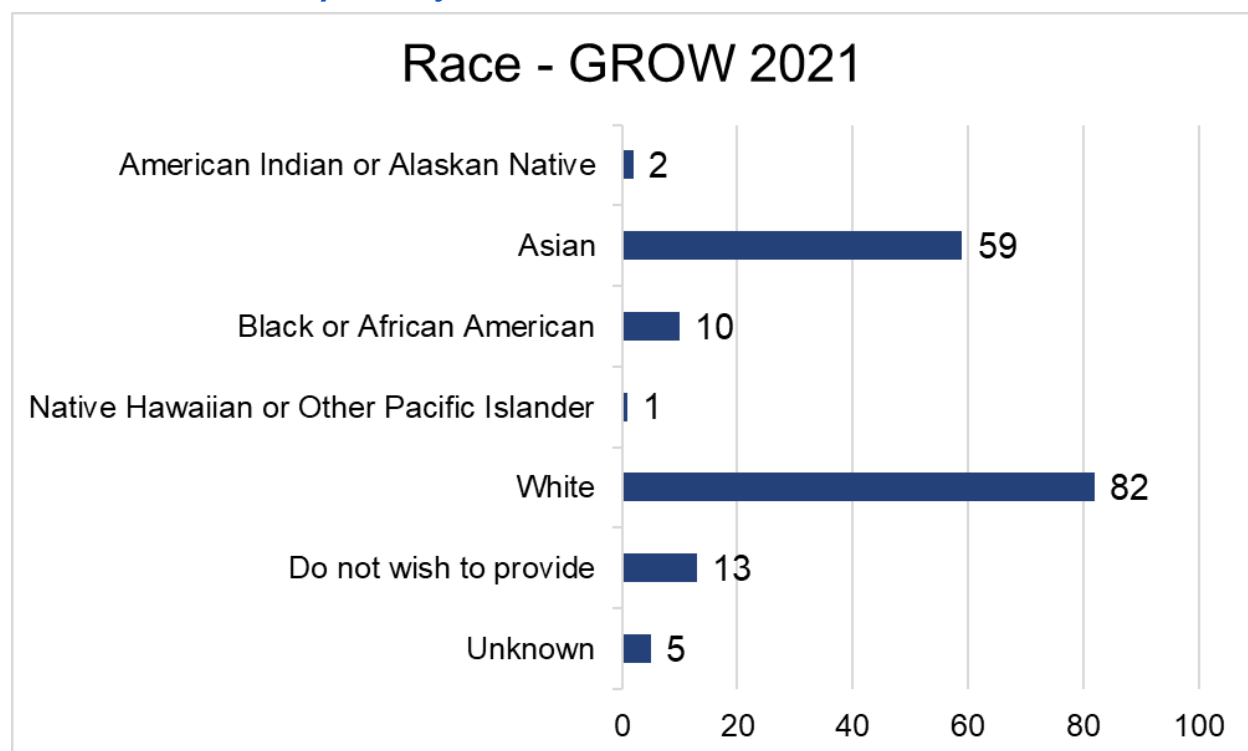
Long Programs 2021-2022 - Participants by Employer/School Location			
Country	Number of Participants	Country	Number of Participants
France	7	Poland	1
Israel	1	United Kingdom	11
Italy	3	United States	32
Netherlands	1		

2.6 Demographics for GROW

GROW 2021 - Participants by Gender

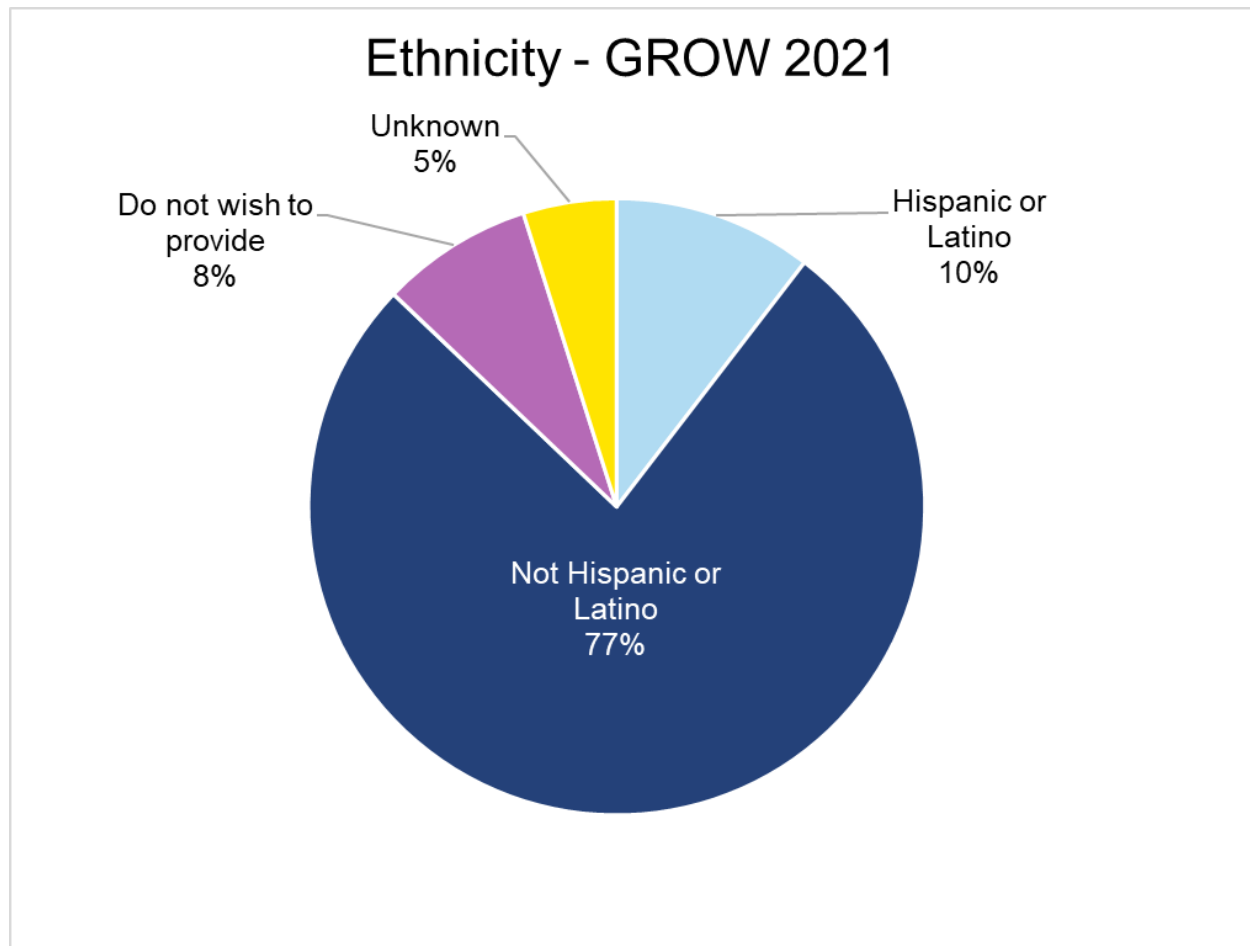


GROW 2021 - Participants by Race

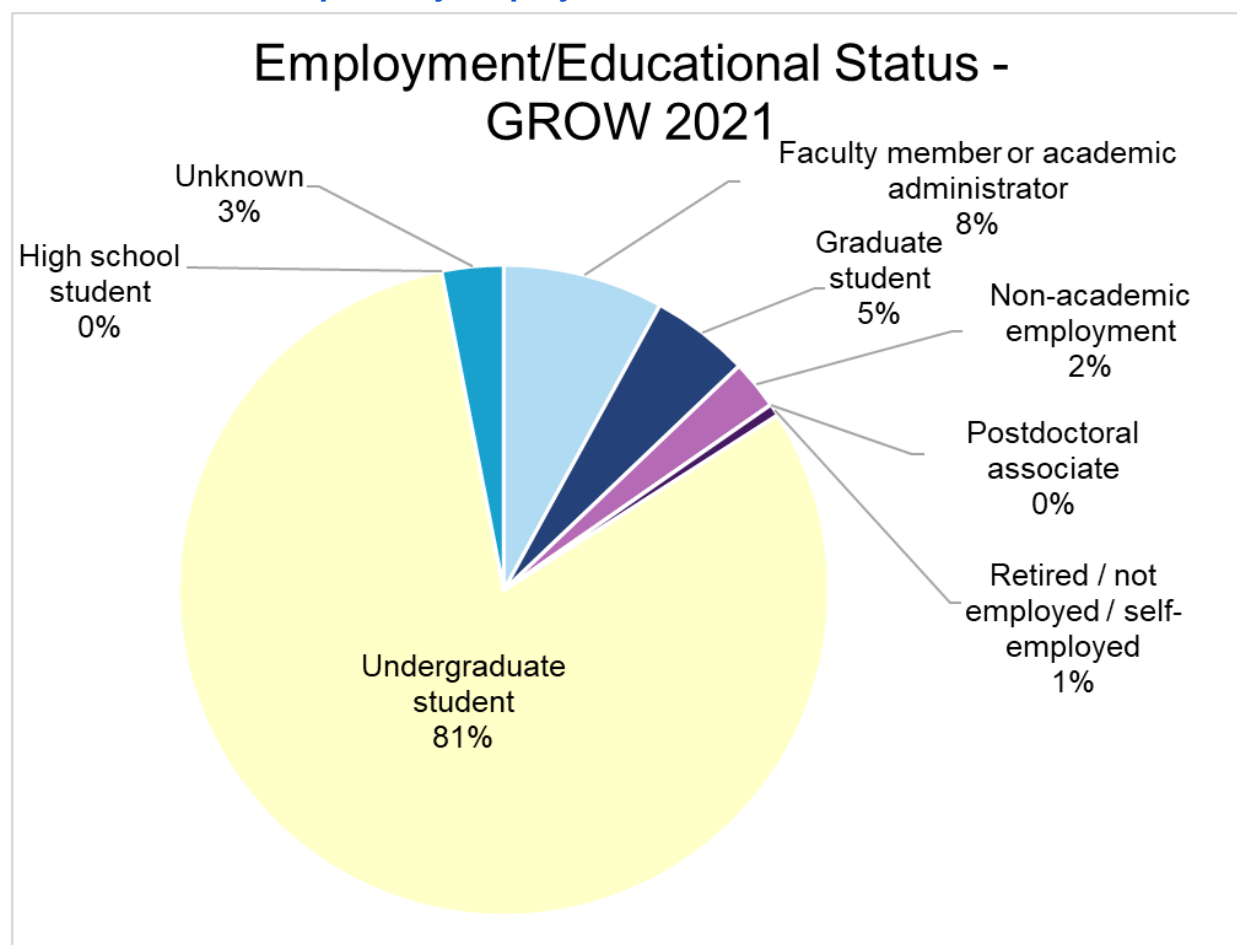


Note: Participants could select multiple races. Some individuals may be reflected in this chart more than once.

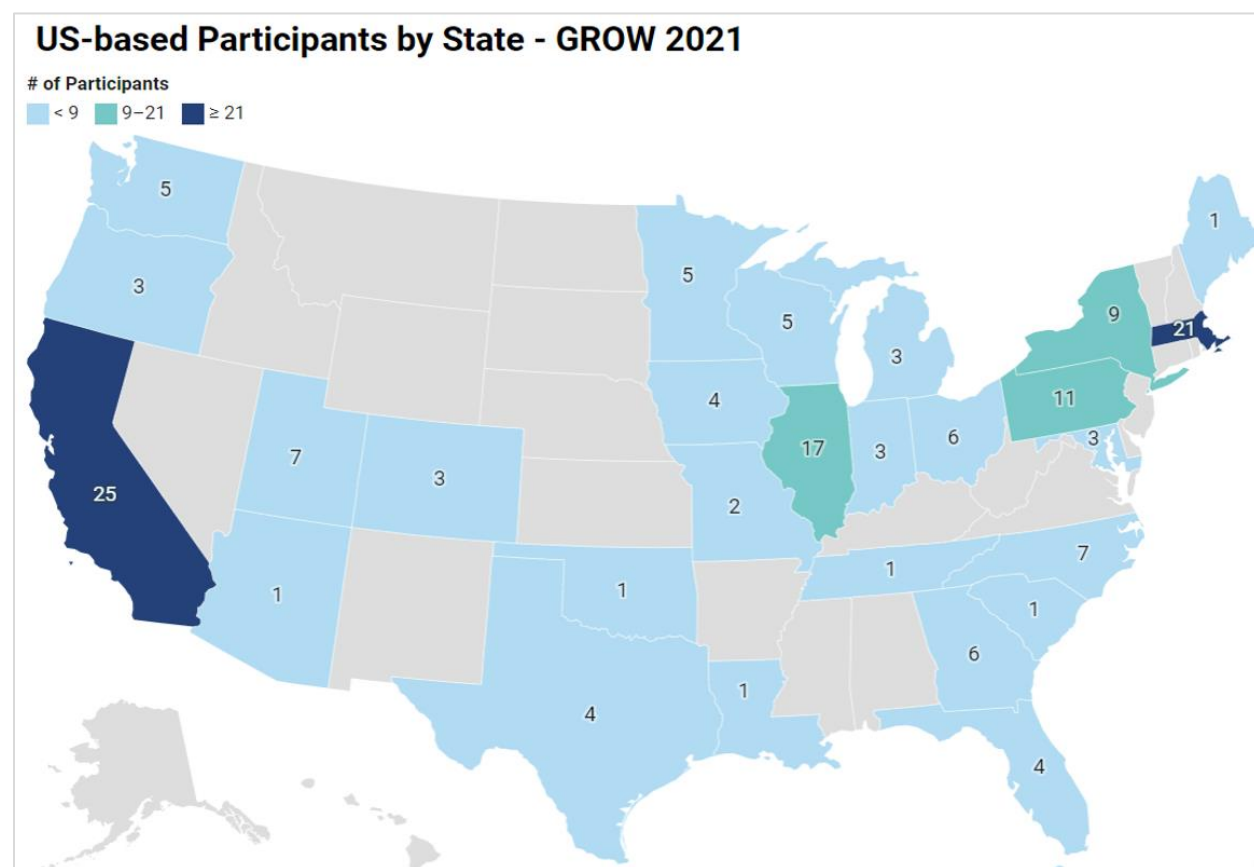
GROW 2021 - Participants by Ethnicity



GROW 2021 - Participants by Employment/Educational Status



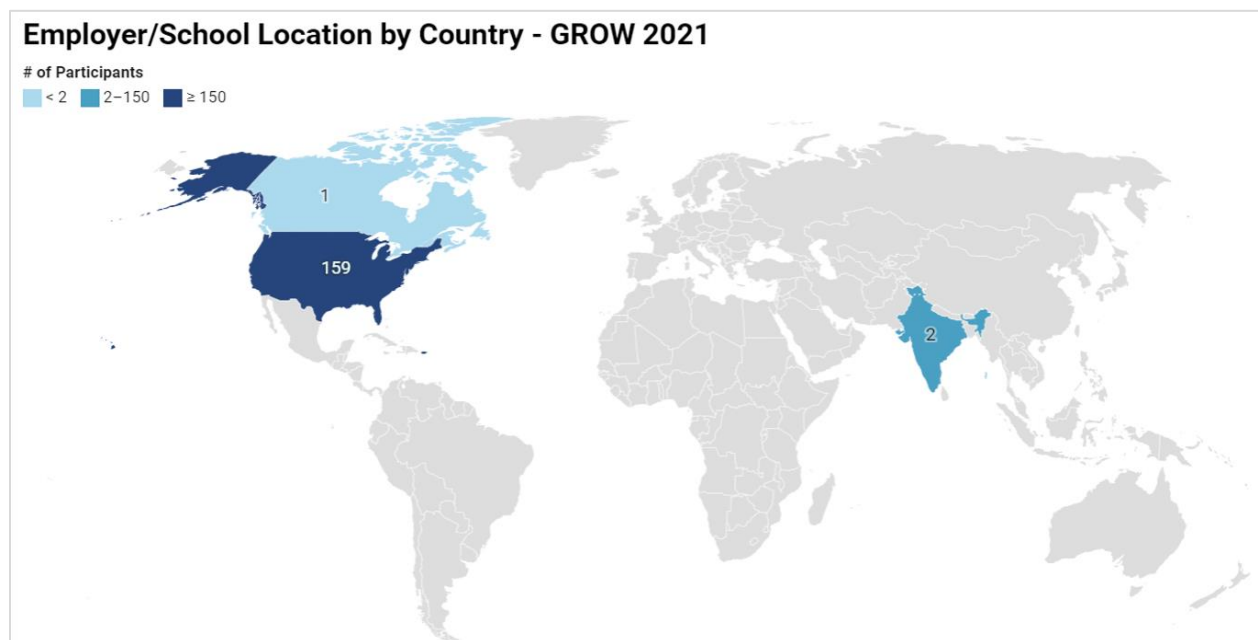
GROW 2021 - Participants by Employer/School Location (United States)



GROW 2021 - Participants by Employer/School Location (United States)			
State	Number of Participants	State	Number of Participants
Alabama	0	Montana	0
Alaska	0	Nebraska	0
Arizona	1	Nevada	0
Arkansas	0	New Hampshire	0
California	25	New Jersey	0
Colorado	3	New Mexico	0
Connecticut	0	New York	9
Delaware	0	North Carolina	7
District of Columbia	0	North Dakota	0
Florida	4	Ohio	6

Georgia	6	Oklahoma	1
Hawaii	0	Oregon	3
Idaho	0	Pennsylvania	11
Iowa	4	Rhode Island	0
Illinois	17	South Carolina	1
Indiana	3	South Dakota	0
Kansas	0	Tennessee	1
Kentucky	0	Texas	4
Louisiana	1	Utah	7
Massachusetts	21	Vermont	0
Maryland	3	Virginia	0
Maine	1	Washington	5
Michigan	3	West Virginia	0
Minnesota	5	Wisconsin	5
Mississippi	0	Wyoming	0
Missouri	2		

GROW 2021 - Participants by Employer/School Location (Country)

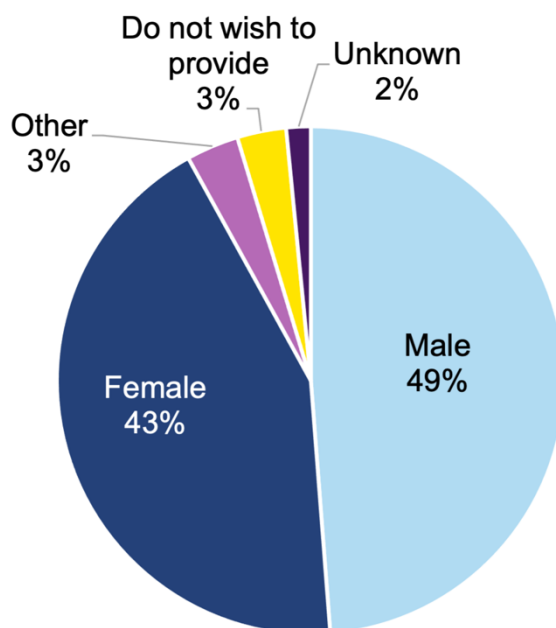


GROW 2021 - Participants by Employer/School Location			
Country	Number of Participants	Country	Number of Participants
Canada	1	United States	159
India	2		

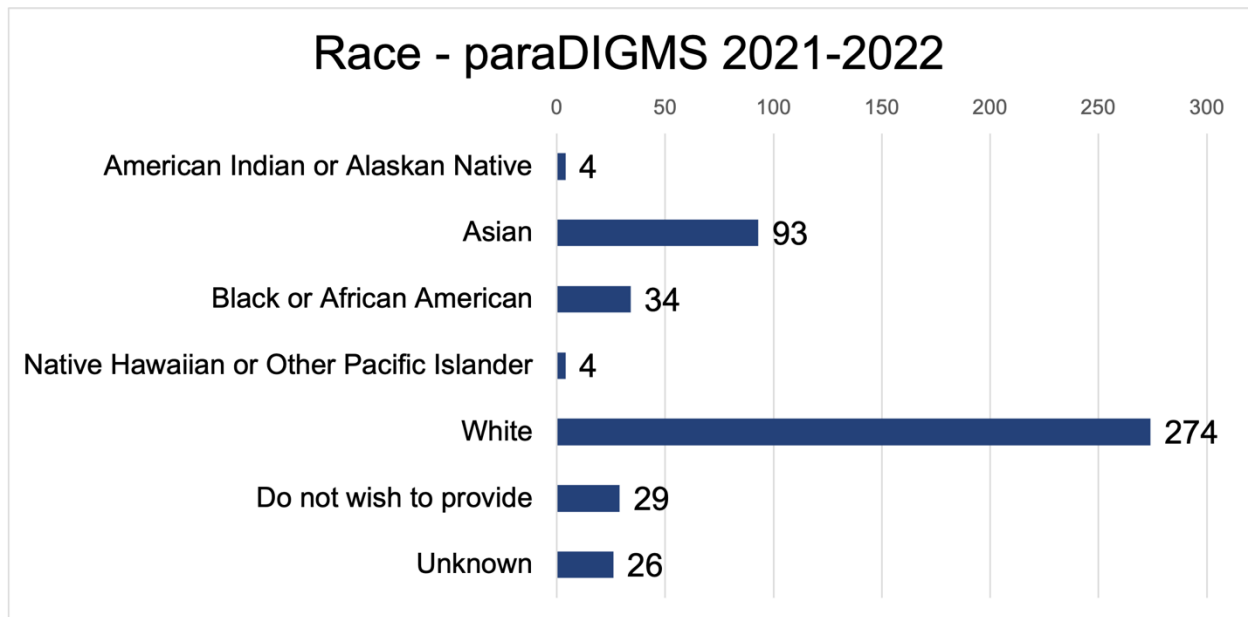
2.7 Demographics for Fall & Spring paraDIGMS

paraDIGMS 2021-2022 - Participants by Gender

Gender - paraDIGMS 2021-2022

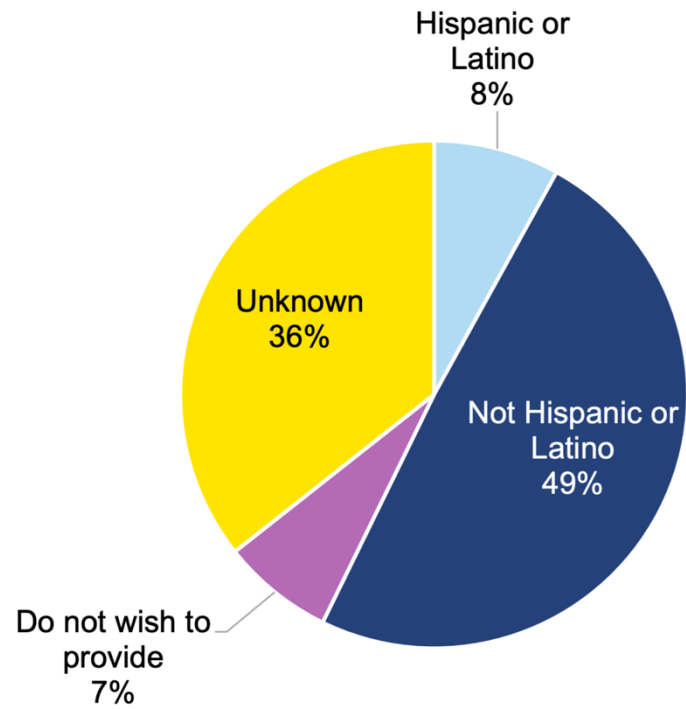


paraDIGMS 2021-2022 - Participants by Race

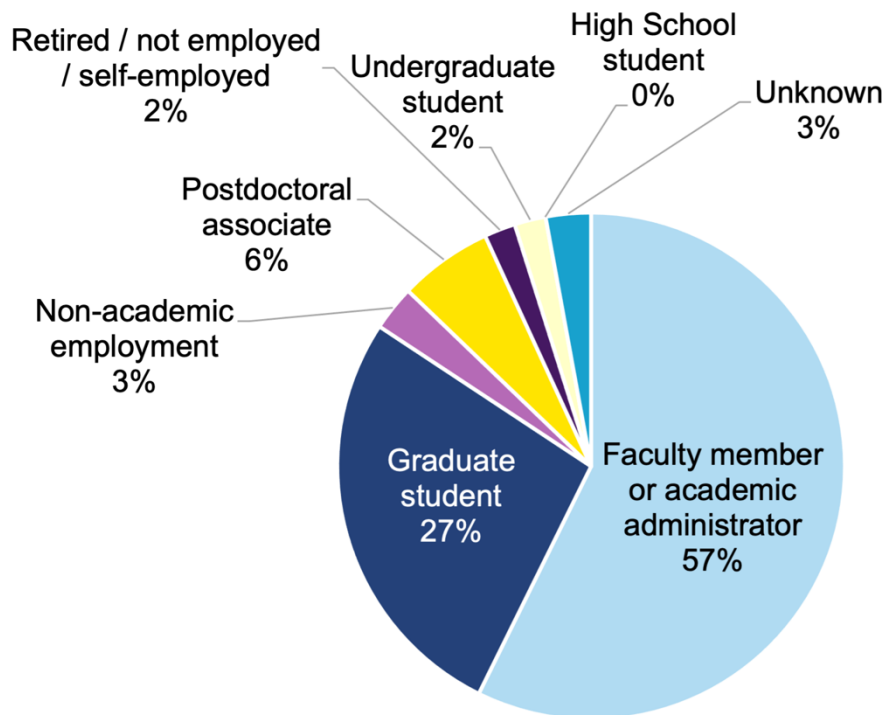


Note: Participants could select multiple races. Some individuals may be reflected in this chart more than once.

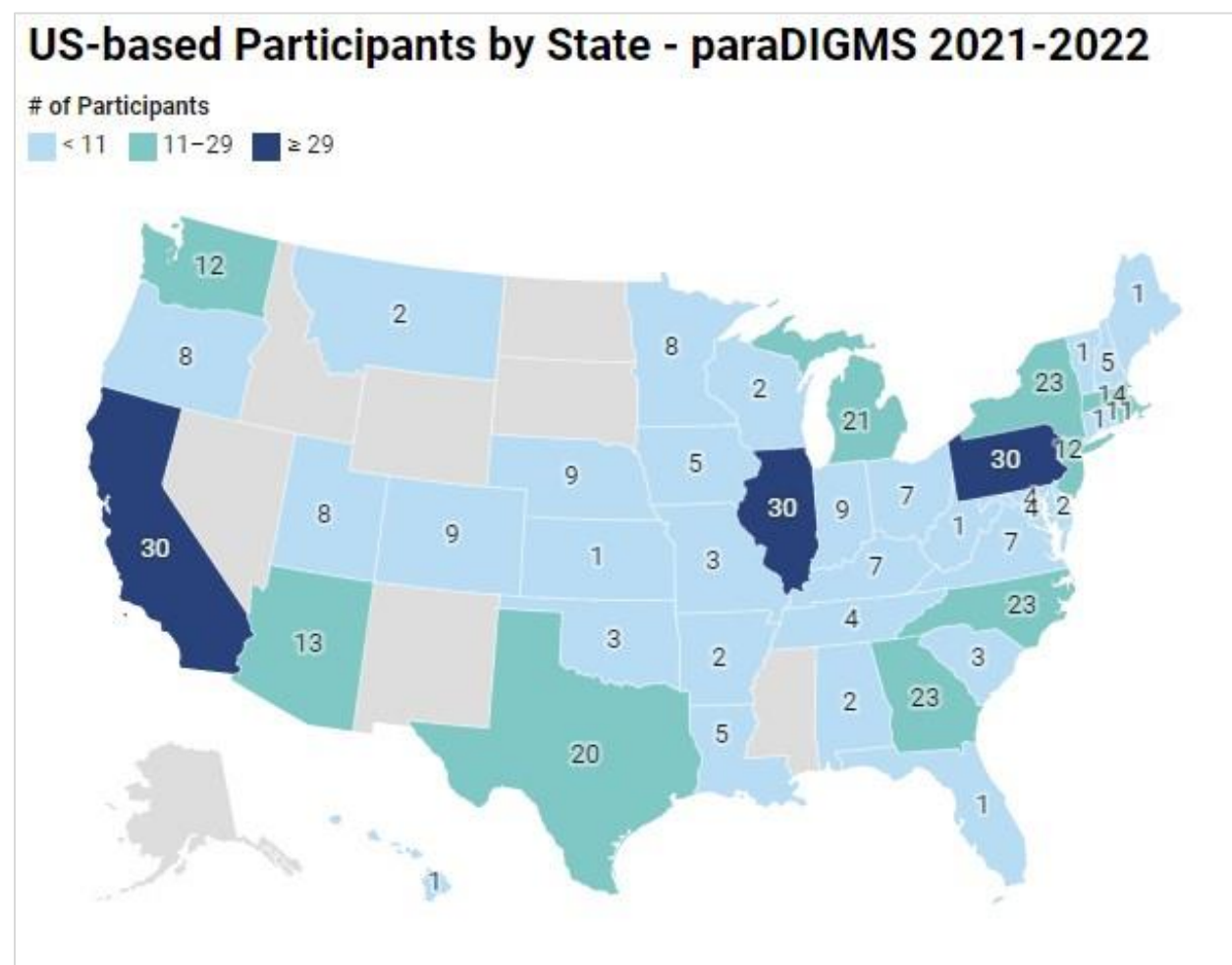
Ethnicity - paraDIGMS 2021-2022



Employment/School Type - paraDIGMS 2021-2022



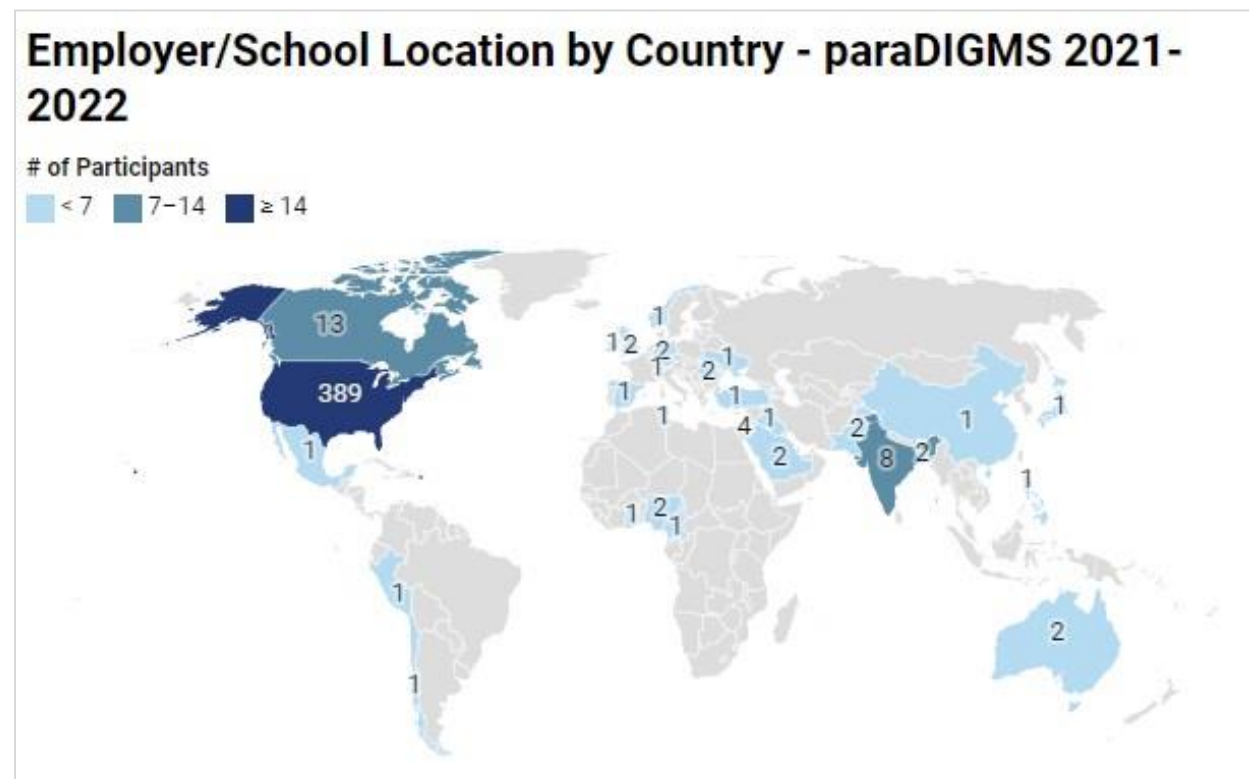
paraDIGMS 2021-2022 - Participants by Employer/School Location (United States)



paraDIGMS 2021-2022 - Participants by Employer/School Location (United States)			
State	Number of Participants	State	Number of Participants
Alabama	2	Nebraska	9
Alaska	0	Nevada	0
Arizona	13	New Hampshire	5
Arkansas	2	New Jersey	12
California	30	New Mexico	0
Colorado	9	New York	23
Connecticut	1	North Carolina	23
Delaware	2	North Dakota	0

District of Columbia	4	Ohio	7
Florida	1	Oklahoma	3
Georgia	23	Oregon	8
Hawaii	1	Pennsylvania	30
Idaho	0	Puerto Rico	1
Iowa	5	Rhode Island	11
Illinois	30	South Carolina	3
Indiana	9	South Dakota	0
Kansas	1	Tennessee	4
Kentucky	7	Texas	20
Louisiana	5	Utah	8
Massachusetts	14	Vermont	1
Maryland	4	Virginia	7
Maine	1	Washington	12
Michigan	21	West Virginia	1
Minnesota	8	Wisconsin	2
Mississippi	0	Wyoming	0
Missouri	3	Unknown	1
Montana	2		

paraDIGMS 2021-2022 - Participants by Employer/School Location (Country)



paraDIGMS 2021-2022 - Participants by Employer/School Location			
Country	Number of Participants	Country	Number of Participants
Australia	2	Nigeria	2
Bangladesh	2	Norway	1
Cameroon	1	Pakistan	2
Canada	13	Peru	1
Chile	1	Philippines	1
China	1	Romania	2
Germany	2	Saudi Arabia	2
Ghana	1	Spain	1
Guam	2	Switzerland	1
India	8	Tunisia	1
Iraq	1	Turkey	1
Ireland	1	Ukraine	1

Israel	4	United Kingdom	2
Japan	1	United States	389
Mexico	1	Unknown	1

3. Description of Activities

For each activity, organizers, speakers, panelists, and other presenters are listed. Full participant lists are included in an appendix.

3.1 Fall 2021 Long Program: Distributed Solutions to Complex Societal Problems

IMSI hosted a long program on *Distributed Solutions to Complex Societal Problems* from September 20 through December 17, 2021. A summer school on *Introduction to Mean Field Games and Applications* during June 2021 served as an introduction to this program, and there were seven research workshops embedded in this program. The summer school and workshops are described in greater detail below.

Program Organizers	Affiliation & Department
Pierre Cardaliaguet	Université Paris-Dauphine and PSL, Mathematics
René Carmona	Princeton University, Operations Research and Financial Engineering
Annalisa Cesaroni	Università degli Studi di Padova, Statistics
Pierre-Louis Lions	Collège de France
Daniela Tonon	Università degli Studi di Padova, Mathematics
Takis Souganidis	University of Chicago, Mathematics

The central motivation for the program was the need to understand and model large populations of rational agents interacting through intricate networks of connections, which is ubiquitous in modern science. These populations are ubiquitous in economics (heterogeneous agents models), finance (price formation, limit order books), engineering (crowd analysis, smart cities, and self-driving vehicles), and public health (the spread of disease, vaccination issues). In these settings, the main questions are, on the one hand, to quantify the relative merits of centralized versus decentralized intelligence and, on the other hand, the impact of perturbations of the model impacting all the agents.

The theory of Mean Field Games (MFG) is an important mathematical framework that contributes to the understanding of such problems. It provides an approach to studying models in which a large number of agents interact strategically in a stochastically evolving environment, all responding to various shocks and incentives, and all trying to simultaneously forecast the decisions of others.

The mathematical paradigm of MFG offers a powerful approach to the study of a number of challenging problems in social economics. It leads to a set of effective equations capturing the equilibrium behavior of large populations of interacting agents, often in situations which were believed to be intractable not so long ago. Many of the

early successes of MFG were in engineering, but a second generation of applications will have broader impact and lead to better regulations, policies, and approaches to conflict resolution. The program facilitated an extensive interaction between mathematicians, statisticians, and applied scientists to advance the theory and better understand the applications.

This program was significantly impacted by the COVID-19 pandemic. A number of researchers who had planned to visit in person either cancelled or shortened their visits, and some of the planned workshops moved to fully or primarily virtual formats. There were seventeen research members (visitors who do not come exclusively for the purpose of attending a workshop) in residence for all or part of the program. This group included two organizers (Pierre Cardaliaguet and Takis Souganidis); the remaining members were Ph.D. students and early career researchers. Here are some quotes from final reports of research members:

- *The semester was also the opportunity to meet researchers from my discipline and interact with them. On the one hand, there has been many excellent talks and the whole program was a scientific success, giving a large and complete overview of the area. Second, even if few participants could attend the semester in person, the interactions with these researchers has been all the more deep and interesting.*

Let me finally mention that the size of the Institute, the disposition of the offices, the beautiful lecture room (not to mention the coffee hours!) favored the interactions between participants of the program. Last but not least, I would also like to underline the beautiful work done by the staff of the Institute: despite the fact that this was the first meeting in person at the Institute, despite also the pandemic crisis which made the organization very complex, things went on very smoothly and, ultimately, in a very satisfactory way.

- *I made substantial progress while at IMSI. The collaboration with has been especially helpful for me because it gave me an opportunity to work in a new area (mean field control) and learn some tools which will be useful in other research projects. The project is now almost complete, and the paper should be available online relatively soon. I also made some progress on other ongoing projects.*

I think the most important aspect was getting to meet other researchers in person. Because of the pandemic, I have not been able to attend many conferences in person during my PhD, and so it has been difficult to network and make connections with other researchers. I think being here in person has been very beneficial, both because I have learned a lot of new mathematics and because it has been a rare opportunity to network during the pandemic.

- *I am new to the topic of mean field games and this IMSI program provides me with a fantastic opportunity to expose myself to this field. A series of wonderful workshops on the broad topics of mean field game theory and applications and precious chances to talk to the leading researchers in this field equipped me with the necessary knowledge to launch my exploration and research in the mean*

field games. It also showed me a broad overview of this field. There were also plenty of chances to discuss with my colleagues here from which I gain enormous inspiration.... In addition to the main workshop series, I enjoyed the nice setting of workspace and office, contingent lectures in addition to the workshops, regular coffee and snack hours with staff and colleagues, and so on, all of which continuously excited me and boosted my working efficiency.

- *Given that my visit was rather short and to a large part filled with conferences, substantial progress on my research program in terms of writing papers was limited. However, that was also not the main goal of my stay as stated above. I rather used my time to reflect on the big picture questions like where my research is positioned within the literature and where it should be headed.*
- *The most valuable [aspect] to me was that IMSI brought Economists and Mathematicians together for the aforementioned workshop. I work at the intersection of both disciplines (although more through the lens of economics) and discussing with experts of both fields was enormously useful to me.*

Summer School: Introduction to Mean Field Games and Applications, June 1-25, 2021

This virtual summer school provided mathematical background for the long program on *Distributed Solutions to Complex Societal Problems*, and took place June 1-25, 2021. The topics of the school were organized into six modules:

- Mean Field Games: The Analytic Approach
- Mean Field Games: The Probabilistic Approach
- Mean Field Games and Applications: Numerical Methods
- Economic Models and MFG Theory
- Network Games
- Crowd and Social Dynamics

The audience consisted of advanced graduate students, postdocs, and researchers interested in the general topic who had some knowledge of probability, stochastic analysis, and partial differential equations. It was attended by 256 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Daniela Tonon	University of Padova
Daniel Lacker	Columbia University, Industrial Engineering and Operations Research
Yves Achdou	Université Paris-Diderot, Mathematics
Fernando Alvarez	University of Chicago, Economics
René Carmona	Princeton University, Operations Research and Financial

	Engineering (ORFE)
Benedetto Piccoli	Rutgers University, Mathematics
Speakers	Affiliation & Department
Daniela Tonon	University of Padova
Marco Cirant	University of Padova, Mathematics
Daniel Lacker	Columbia University, Industrial Engineering and Operations Research
Francois Delarue	University of Nice, Mathematics
Ludovic Tangpi	Princeton University, Operations Research and Financial Engineering (ORFE)
Yves Achdou	Université de Paris, Laboratoire Jacques-Louis Lions (LJLL)
Mathieu Laurière	Princeton University, Operations Research and Financial Engineering (ORFE)
Fernando Alvarez	University of Chicago, Economics
Adrien Bilal	Harvard University, Economics
René Carmona	Princeton University, Operations Research and Financial Engineering (ORFE)
Alexander Aurell	Princeton University, Operations Research and Financial Engineering (ORFE)
Yichen Feng	University of California, Santa Barbara, Statistics
Francesca Parise	Cornell University, Electrical and Computer Engineering
Agathe Soret	Columbia University, Industrial Engineering and Operations Research
Benedetto Piccoli	Rutgers University, Mathematics
Felisia Angela Chiarello	Politecnico di Torino, Mathematics
Xiaoqian Gong	Arizona State University, Mathematics
Andrea Tosin	Politecnico di Torino, Mathematics
Office Hours/Teaching Assistants	Affiliation & Department
Peter Morfe	University of Chicago, Mathematics
Sebastian Munoz	University of Chicago, Mathematics
Nikiforos Mimikos-Stamatopoulos	University of Chicago, Mathematics

Mark Cerenzia	University of Chicago, Mathematics
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Here are a few comments from participants:

- *“It gives an introduction to most aspects of the mean field game. And the instructors are very experienced in this area.”*
- *“It was very well organized and it covered both the analytic approach and numerical methods. It provided necessary mathematical background to help us better understand the topics.”*
- *“I loved hearing about the crowd dynamic modeling on Thursday of Week 4, although that is way more applied than my thesis work is.”*
- *“The whole concept of this summer program is a highlight: a consistent and detailed coverage of a concrete area (MFG). Huge thanks!”*
- *“Great course for graduate students and post-docs. Even I myself appreciated these lectures as a senior faculty.”*
- *“I totally loved the course. Couldn't attend the last week, but I really enjoyed it!”*
- *“I very much enjoyed this workshop, and I found it useful as I work on my thesis. I really enjoyed seeing the breadth of perspectives and applications present in this area of research.”*

The embedded workshops for the long program were as follows.

Workshop 1: Introduction to Distributed Solutions, October 4-6, 2021

This workshop consisted of three series of lectures, the aim of which was to present the main issues at stake in the analysis of distributed solutions to complex societal problems and to describe some mathematical tools to handle these questions. Applications ranged from collective behavior in economy and finance to crowd analysis and the spread of diseases, and from machine learning to stochastic optimization and artificial intelligence.

This workshop was attended by 71 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Pierre Cardaliaguet	Université Paris-Dauphine and PSL, Mathematics
René Carmona	Princeton University, Operations Research & Financial Engineering
Speakers	Affiliation & Department
Francis Bach	INRIA, Ecole Normale Supérieure, PSL Research University, Computer Science/Information Science
Mérouane Debbah	CentraleSupélec and Technology Innovation Institute in Abu

	Dhabi, Engineering
Pierre-Louis Lions	Collège de France

Workshop 2: Short Courses on the Mean Field Approach in Machine Learning and Statistics, October 18-20, 2021

This online short course consisted of three series of lectures discussing aspects of the Mean Field approach in machine learning and statistics. The topics included

- Deep Learning, Dynamical Systems and Optimal Control (Qianxiao Li)
- Mean Field Asymptotics for High Dimensional Linear Models (Song Mei)
- The Mean-Field Limit for Shallow Neural Networks: Implications for Trainability and Generalization (Grant Rotskoff)

This workshop was attended by 53 unique participants, including speakers and organizers.

Speakers	Affiliation & Department
Qianxiao Li	National University of Singapore, Mathematics
Song Mei	University of California, Berkeley, Statistics
Grant Rotskoff	Stanford University, Chemistry

Workshop 3: Aggregate Dynamics in Models with Heterogeneous Agents, October 27-29, 2021

This workshop invited participants to present and discuss current research on models with the following features: The heterogeneous agents feature refers to agents solving dynamic problems subject to idiosyncratic random shocks, each agent with non-trivial interactions with the remaining agents. The “aggregate dynamics” feature refers to the focus on the understanding and characterization of the dynamics of the entire system, either itself subject to aggregate shock or as a deterministic system, using analytical or numerical techniques. Examples of such models are variants of Mean Field Games, but the workshop considered a broader set of complex societal problems. The workshop consisted of the presentation of models with applications in several fields in economics and intersections with other disciplines.

This workshop was attended by 74 unique participants, including speakers and organizers.

Organizer	Affiliation & Department
Fernando Alvarez	University of Chicago, Economics

Speakers	Affiliation & Department
David Argente	Pennsylvania State University, Economics
Adrien Auclert	Stanford University, Economics
Isaac Baley	Universitat Pompeu Fabra, Economics
Adrian Bilal	Harvard University, Economics
Katka Borovickova	New York University, Economics
Jesús Fernández-Villaverde	University of Pennsylvania, Economics
Jen Jen La'O	Columbia University, Economics
Erzo Luttmer	University of Minnesota, Twin Cities, Economics
Marti Mestieri	Federal Reserve Bank of Chicago
Ezra Oberfield	Princeton University, Economics
Elisabeth Proehl	University of Amsterdam, Economics

Workshop 4: Mean-Field Models for Interacting Agents, November 2-4, 2021

Interacting particle models are a powerful mathematical tool to model the behavior of large groups in economics, as well as in the life and social sciences. Here, particles may correspond to agents trading certain goods, fish or birds moving collectively, or individuals exchanging ideas in social networks, for example. Understanding the dynamics of these systems on different levels is of great importance, as it gives insights into the emergence of many complex phenomena. This workshop focused on recent developments and emerging challenges in the derivation and analysis of these micro- and mean-field models. It featured different perspectives and approaches to these challenges, by bringing together applied mathematicians working at the interfaces between statistics, social sciences and the life sciences.

This workshop was attended by 67 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Annalisa Cesaroni	Università di Padova, Statistics
Qiang Du	Columbia University, Applied Physics and Applied Mathematics
Benedetto Piccoli	Rutgers University, Mathematics
Marie-Therese Wolfram	University of Warwick, Mathematics Institute

Speakers	Affiliation & Department
Jose Carrillo	University of Oxford
Marco Cirant	Università degli Studi di Padova, Mathematics
Quentin Cormier	Princeton University
Sharon Di	Columbia University
Susana Gomes	University of Warwick, Mathematics
Xiaoqian Gong	Arizona State University
Pierre-Emmanuel Jabin	Pennsylvania State University
Jian-Guo Liu	Duke University, Mathematics
Angelika Manhart	University College London, Mathematics
Levon Nurbekyan	University of California, Los Angeles, Mathematics
Kaiyan Peng	University of California, Los Angeles
Nancy Rodriguez	University of Colorado Boulder, Applied Mathematics
Fillippo Santambrogio	Universite Claude Bernard Lyon 1, Mathematics
Andrea Tosin	Politecnico di Torino, Mathematical Sciences "G. L. Lagrange"
Yao Yao	National University of Singapore, Mathematics

Workshop 5: Applications of Mean Field Games: From Models to Practice, November 16-19, 2021

The paradigm of Mean Field Games (MFG) has become a major connection between distributed decision-making and stochastic modeling. Starting out in the stochastic control literature, it is gaining rapid adoption across a range of industries. The objective of this workshop was to give a clear vision of how MFG tools are being used in practical settings, both in complement and in contrast to the usual methodologies. The workshop gathered researchers from industry and universities and focused on diverse application areas, including (but not exclusively):

- Energy sector, including smart power grids and natural commodity markets
- Control and mitigation of Epidemics, including in the context of the Covid-19 pandemic response
- Financial market microstructure for algorithmic and high-frequency trading and cryptocurrencies

This workshop was attended by 71 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Clémence Alasseur	Électricité de France (EDF) R&D
Damien Fessler	Institut Louis Bachelier
Mike Ludkovski	University of California, Santa Barbara, Statistics and Applied Probability
Speakers	Affiliation & Department
René Aïd	Université de Paris Dauphine – PSL, Economics
Dario Bauso	University of Groningen
Louis Bertucci	Institut Louis Bachelier
Gökçe Dayanikli	Princeton University, Operations Research & Financial Engineering
Merouane Debbah	CentraleSupélec and Technology Innovation Institute, Abu Dhabi
Roxana Dumitrescu	King's College
Romuald Elie	DeepMind and Université Gustave Eiffel
David Evangelista	Fundação Getúlio Vargas, Escola de Matematica Aplicada
Dena Firoozi	HEC Montreal, Decision Sciences
Jameson Graber	Baylor University, Mathematics
Emma Hubert	Princeton University, Operations Research & Financial Engineering
Wuchen Li	University of South Carolina, Mathematics
Roland P. Malhamé	Polytechnique Montréal
Sergey Nadtochiy	Illinois Institute of Technology, Applied Mathematics
Max Reppen	Boston University, Questrom School of Business, Finance
Ronnie Sircar	Princeton University, Operations Research & Financial Engineering

Workshop 6: Applications to Financial Engineering, December 6-9, 2021

Mean Field theories, Mean Field Games, and Mean Field Control are theoretical concepts which can naturally be brought to bear on applications to financial engineering. The workshop examined how they influence the development of financial mathematics theory and the implementation of financial engineering solutions to problems involving large ensembles of individuals or robots optimizing their behaviors in uncertain and complex environments.

Applications included contract theory, cyber currency mining, high frequency trading, systemic risk, and recent developments in the applications of machine learning techniques to the numerical solutions of some of these problems.

This workshop was attended by 82 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Beatrice Acciaio	ETH-Zurich
René Carmona	Princeton University, Operations Research and Financial Engineering
Speakers	Affiliation & Department
Alexander Aurell	Princeton University, Operations Research and Financial Engineering
Erhan Bayraktar	University of Michigan
Luciano Campi	University of Milan
Alvaro Cartea	University of Oxford, Mathematics
Roxana Dumitrescu	King's College
Jean-Pierre Fouque	University of California, Santa Barbara, Statistics and Applied Probability
Xin Guo	University of California, Berkeley, Applied Mathematics
Ulrich Horst	Humboldt University Berlin, Mathematics
Emma Hubert	Princeton University, Operations Research and Financial Engineering
Sebastian Jaimungal	University of Toronto, Statistics
Daniel Lacker	Columbia University, Operations Research
Mathieu Laurière	Google Brain, Paris
Laura Leal	Princeton University, Operations Research and Financial Engineering
Sergey Nadtochiy	Illinois Institute of Technology, Applied Mathematics
Marcel Nutz	Columbia University, Statistics
Huyên Pham	University of Paris 6 and CNRS, LPSM
Dylan Possamai	ETH Zürich, Mathematics
Max Reppen	Boston University, Questrom School of Business, Finance

Ludovic Tangpi	Princeton University, Operations Research and Financial Engineering
Peter Tankov	ENSAE
Nizar Touzi	École Polytechnique, Applied Mathematics
Thaleia Zariphopoulou	University of Texas, Austin

Workshop 7: Mathematical Advances in Mean Field Games, December 13-16, 2021

Complex societal problems can be studied and modeled through the mathematical theory of Mean Field Games. Indeed, MFGs are a mathematical modeling approach to stochastically evolving systems which involve a large number of indistinguishable rational agents that have the same optimization criteria. The theory of MFG is very lively and productive at the moment and several important results have been achieved that can be applied to engineering, economics, finance, social sciences. In this final workshop of the Long Program, recent analytic, probabilistic and numerical advances in this theory were presented.

This workshop was attended by 92 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Pierre Cardaliaguet	Université Paris-Dauphine and PSL, Mathematics
René Carmona	Princeton University, Operations Research and Financial Engineering
Annalisa Cesaroni	Università di Padova, Statistics
Takis Souganidis	University of Chicago, Mathematics
Daniela Tonon	Università degli Studi di Padova, Dipartimento di Matematica
Speakers	Affiliation & Department
Alain Bensoussan	University of Texas, Dallas, Jindal School of Management
Charles Bertucci	Ecole Polytechnique
Alekos Cecchin	École Polytechnique, Applied Mathematics
Marco Cirant	Università degli Studi di Padova, Mathematics
Fabrice Djete	Ecole Polytechnique
Wilfrid Gangbo	University of California, Los Angeles, Mathematics
Alessandro Goffi	Università degli Studi di Padova, Mathematics

Diogo Gomes	King Abdullah Univ. of Science and Technology, Applied Mathematics
Ziad Kobeissi	Institut Louis Bachelier
Daniel Lacker	Columbia University, Operations Research
Mathieu Laurière	Google Brain, Paris
Paola Mannucci	Università degli Studi di Padova, Dipartimento di Matematica
Alpar Meszaros	Durham University, Mathematics
Alessio Porretta	University Rome Tor Vergata, Mathematics
Filippo Santambrogio	Universite Claude Bernard Lyon 1, Mathematics
Ben Seeger	Université Paris Dauphine
Mete Soner	Princeton University, Operations Research & Financial Engineering
Agathe Soret	Columbia University, Industrial Engineering and Operations Research

3.2 Spring 2022 Long Program: Decision Making and Uncertainty

IMSI hosted a long program on *Decision Making and Uncertainty* from March 21 through May 27, 2021. A summer school on *Introduction to Mean Field Games and Applications* from June 28 through July 23, 2022 served as an introduction to this program, and there were seven research workshops embedded in this program. The summer school and workshops are described in greater detail below.

Organizers	Affiliation & Department
Tomasz Bielecki	Illinois Institute of Technology, Applied Mathematics
Rama Cont	Oxford University, Mathematics Institute
Xin Guo	University of California, Berkeley, Industrial Engineering and Operations Research
Lars Hansen	University of Chicago, Economics, Statistics, and the Booth School of Business
Peter Klibanoff	Northwestern University, Kellogg School of Management, Managerial Economics & Decision Sciences
Marcel Nutz	Columbia University, Statistics
Thaleia Zariphopoulou	University of Texas, Austin; McCombs School of Business; Mathematics; Information, Risk, and Operations Management

Economics, finance, and business activities like marketing, operations management, and R&D all substantially rely on the use of formal mathematical approaches to model human behavior, agents' interaction, trading exchanges, mitigation of risks, and more. However, these areas are all rich enough that many important challenges remain unmet and new ones are constantly arising. For example, recent advances in data science, new platforms and means of human interaction, the growing speed of trading exchanges and flow of information, and various technological and other breakthroughs are all fertile ground for motivating the use of new mathematical and statistical models and methods.

The mathematical sciences can play a crucial role by providing a platform on which to build and analyze innovative and complex models and as well as rigorous frameworks to solve the associated problems. However, this alone is not enough to make breakthrough progress. An intense scientific dialogue is needed so that the analysis of real-world problems may benefit from mathematical and statistical innovations, while, at the same time, the discipline and focus provided by such problems may help the mathematics from becoming remote from the real-world challenges. This program created and facilitated such an interdisciplinary dialogue by bringing together mathematicians, statisticians, economists, computer scientists, and researchers from operations research and business.

While there are many areas in need of high-level mathematical and statistical analysis, the program focused on two broad directions covering a quite large spectrum of problems in social sciences.

The first direction was decision making and optimization (e.g., of expected utility or expected costs) under model ambiguity and potential misspecification. Partial or incomplete model knowledge are present in the analysis of any real-world application. Moreover, quantitative models used in decision making are necessarily simplified abstractions and necessarily "wrong." This misspecification could be innocuous, or it could have big consequences for decision makers. For example, pension fund management requires good models and forecasts about economic growth which is notoriously difficult to do with much precision over long horizons. Prudent policies designed to confront climate change must confront both geo scientific and economic uncertainty. High frequency trading needs assessment of the upcoming, even to the millisecond, asset price fluctuations. Real-world applications involve decisions at both the personal (single-agent) and collective (multi-agent, games, etc.) level. Frequently, model ambiguity from multiple sources can have percolating impact that compounds over time. For example, in so-called integrated assessment models, geo scientific uncertainty about consequences of carbon emissions and the uncertainty about the potential economic and social damages can be reinforcing and have serious consequences on macroeconomic decisions and policies. In general, optimizing under misconceived simplifications may result in large losses, severe mismanagement, and flawed valuation, etc. Thus, the manner in which uncertainty is navigated affects not

only individuals like investors, fund managers, and pensioners, but also communities, municipalities, states, and society on the aggregate.

The second direction was the interface between decision making and machine learning. The recent explosive progress in machine learning provides a wide array of powerful optimization tools. On the other hand, a plethora of more complex problems related to the learning and modeling of human preferences and behavior and, in turn, their role and impact in decision making are now emerging quickly. These problems require much more sophisticated analysis, well beyond the ones in most existing ML settings with stylized cost/payoff functionals (square error, convex losses, concave utilities, etc.). They arise in many real-world applications related to decisions of investors, patients, consumers, pensioners, voters, etc., at both personal and collective levels. Furthermore, many such applications are now incorporating human-machine interaction (e.g., robo-advising), and this requires the development of additional modeling, methodological, and technical approaches and tools. In parallel, recent methodological advances in data analysis based on optimal transport provide new ways of studying ML problems, and give rise at the same time to new mathematical models and new problems at the interfaces between data analysis, machine learning, optimization, and decision making.

There were 34 research members (visitors who do not come exclusively for the purpose of attending a workshop) in residence for all or part of the program. This group included two organizers (Tomasz Bialecki and Thaleia Zariphopoulou), while the remaining members ranged in career stage from Ph.D. students to senior researchers. Here are quotes from final reports of some of these visitors:

- *The in person visit was a significant benefit and was extremely valuable. It allowed me to have direct collaboration with my co-authors and research assistants to finalize results that we used in our IMSI workshop presentation and that will serve as the main results in our draft for that paper which we will complete soon. It also allowed for collaboration with other visitors ... so that we could regularly meet and discuss our planned project which has outlined us to develop a plan and begin to carry out analysis for that research project. Finally, the interactions and discussions with other researchers were incredibly valuable. They helped me develop and improve the work done for my three other projects mentioned. This included discussions with other visitors and conference participants including ..., which will help us improve my research, develop better computational tools for my analysis, spurred new research ideas, and hopefully will lead to research collaborations in the future. Without this visit, many of these discussions and interactions likely would not have taken place or would have been far more difficult. This visit has been exceptionally valuable for strengthening and building my research agenda now and in future work.*
- *The topics and talks were very frontier.*
- *During my visit at IMSI I worked on several ongoing project but also started several new ones. Attended all workshops, some of them directly related to my*

research interests. During these workshops, it was great meeting new researchers, learn about current state of the art methods and recent advances. The personal interaction with participants was great.

- *During the time at IMSI I initiated a variety of projects, which I hope to develop over the coming months. ... The meetings were valuable, particularly given the ample opportunities to interact and discuss – the more relaxed format, with time to discuss and develop ideas, was particularly productive.*
- *Almost all the aspects of my visit to IMSI were valuable for my professional development as I had some eye-opening experiences in regards to various mathematical and statistical researches done in some topical sectors including financial mathematics, risk managements, modeling climate change effects, statistical learning, etc. in conjunction to the advancement in classical decision theory, game theory, optimal transport, and uncertainty quantification.*
- *I was introduced to a new area (BSPDEs) which has interesting applications in mean field games, and I have some ideas about how to study these equations which ... and I are now pursuing. I think being introduced to new problems like this is really helpful for me at this stage of my career, since I am nearing the end of my PhD and it is a good time for me to be expanding the breadth of my research. As mentioned I also made some progress on an ongoing project more closely related to my PhD. Finally, I also had some discussions with another visitor about a potential collaboration which seems interesting, but nothing concrete has come out of this yet.*
- *I had an extremely productive time during my stay at IMSI. I was able to meet many new members of the applied optimal transport community, and to reconnect with familiar faces both during the workshop (Applied Optimal Transport) and during my longer stay. As I have stronger ties with researchers who lean more toward the theoretical side of optimal transport, mainly in PDE and geometry, this opportunity to develop connections with people from the applied side was invaluable.*
- *It has been a while since I was able to concentrate on research, and IMSI provided a good environment to conduct research. Consequently, I was able to finally make some progress. ... I also had some discussions with some of the other long-term visitors that has sparked potential collaborations/new research directions.*
- *imsi is such a great place to visit, it has a very supportive and welcoming staff and environment. The fact that congregates many researchers at the same time is great from a networking perspective. The ethos on innovation serves as a great motivation. I felt that I had to 'live up' to the invitation.*
- *The IMSI workshops were very well organised and stimulated research discussion. I especially liked the proper trade-off between number of participants and in-depth seminar type discussions during the workshops. Also, the invited people were recognised experts in the workshops and shared a lot of interesting and novel ideas.*

- *First and foremost, I benefited from a concentrated period of research. IMSI provided an ideal environment. Second and perhaps more importantly, I thoroughly enjoyed discussing with colleagues from other disciplines and with different research interests. This was a fantastic opportunity to interact with other disciplines. Nowhere else would this have been possible. I also enjoyed the workshop. And last but not least, the organization was second to none.*
- *First of all, it was very valuable just to get inspiration from working in new surroundings and being alongside new colleagues with whom you can have informal chats over coffee and lunches. The IMSI building and the coffee hours provided the perfect setting for this. Additionally, it was great to be able to attend several workshops close to each other with such high quality talks, covering both the broader aspects of my field and the specific area of my research. Being a long term visitor allowed for all of this, as opposed to just coming to Chicago for the one workshop where I gave a talk.*

Secondly, I was very positively surprised to see that several early career researchers including finishing PhDs were among the long-term visitors. Most of these I had never met in person before. As an early career researcher myself, I felt that this was a very valuable chance to extend my academic network. While more senior academic can be beneficial for guidance and very pointed feedback, meeting other young researchers and finishing PhDs can be a better way of finding future collaborators.

- *I enjoyed attending talks at the four workshops that took place during my stay at IMSI and I had several conversations with people of economic background ...This has certainly broadened my mind in several aspects, and I will feel more confident in learning these topics further. I had insightful, informative discussions on mathematics with ..., and we agreed to stay in touch for a possible future project. Overall, it has been an inspiring and encouraging environment for me, and I hope to keep reaping the fruits of my stay at IMSI for a long time.*
- *IMSI provided a perfect platform during my stay. The weekly workshops gave me countless opportunities to discuss research with many renown scientists who are experts in their respective fields. Having my own office gave me the opportunity to conduct some in-depth research in a fruitful environment, and exchanging ideas with other long-term guests, who stayed there at the same time I did. The admin team contributed a lot to the overall positive atmosphere at IMSI during my stay. I am very grateful for the opportunity to stay there.*

Summer School: Introduction to Decision Making and Uncertainty, June 28-July 22, 2021

This virtual summer school provided mathematical background for the long program on *Decision Making and Uncertainty*, and took place June 28-July 22, 2021.

How are decisions made in the face of risk? The need to make decisions in the presence of uncertainty cuts across a wide range of issues in science and human

behavior. The underlying problems require both sophisticated modeling and advanced mathematical and statistical approaches and techniques. This school introduced participants to a variety of modeling questions and methods of current interest in this area, and was structured into modules arranged around emerging areas of application. The modules included were

- Foundations of stochastic optimization, BSDE and applications
- Probabilistic methods for elliptic and parabolic PDEs: from linear equations to free-boundary problems
- Foundations of Backward Stochastic Differential Equations and their applications
- Introduction to Functional Itô Calculus and applications
- Optimal transport and machine learning
- Time-inconsistent and relaxed stochastic optimization, and applications
- Markov decision processes with dynamic risk measures: optimal control and learning
- Machine learning and Mean Field Games
- Models for climate change with ambiguity and misspecification concerns
- Games with ambiguity

Each of the modules began with tutorial lectures on the first day followed by supporting lectures on mathematical and statistical topics related to the underlying theme. There were also panel discussions, together with poster sessions and short presentations by the participants.

The intended audience was researchers interested in mathematical modeling and methods applicable to decision making under uncertainty in economics, finance, business, and other areas. Advanced Ph.D. students, postdocs, and junior faculty were especially encouraged to apply.

This summer school was attended by 544 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Thaleia Zariphopoulou	University of Texas at Austin, Mathematics and McCombs Business School
Marcel Nutz	Columbia University, Statistics
Xunyu Zhou	Columbia University, Industrial Engineering and Operations Research
Tomasz Bielecki	Illinois Institute of Technology
Andrzej Ruszczyński	Rutgers University, Rutgers Business School
Xin Guo	University of California, Berkeley, Industrial Engineering and Operations Research

Lars Hansen	University of Chicago, Economics
Peter Klibanoff	Northwestern University, Kellogg School of Management
Speakers	Affiliation & Department
Thaleia Zariphopoulou	University of Texas, Austin, Mathematics and McCombs Business School
Sergey Nadtochiy	Illinois Institute of Technology, Mathematics
Gordan Zitkovic	University of Texas, Austin, Mathematics
Joseph Jackson	University of Texas, Austin, Mathematics
Rama Cont	Oxford University, Mathematics
Agostino Capponi	Columbia University, Mathematics
Sveinn Olafsson	Columbia University, Statistics
Marcel Nutz	Columbia University, Mathematics and Statistics
Bodhisattva Sen	Columbia University, Mathematics
Aude Genevay	Massachusetts Institute of Technology (MIT), Mathematics
Jonathan Niles-Weed	New York University, Mathematics
Xunyu Zhou	Columbia University, Mathematics
Wenpin Tang	Columbia University, Industrial Engineering and Operations Research
Xuedong He	The Chinese University of Hong Kong, Systems Engineering and Engineering Management
Moris Strub	SUSTECH, Mathematics
Christa Cucherio	University of Vienna, Statistics and Operations Research
Andrzej Ruszczyński	Rutgers University, Department of Management Science and Information Systems
Dacheng Xiu	University of Chicago, Booth School of Business
Huyên Pham	Université de Paris Diderot, Mathematics
Tomasz Bielecki	Illinois Institute of Technology
Xin Guo	University of California, Berkeley, Industrial Engineering and Operations Research
Alexander Shapiro	Georgia Institute of Technology, Industrial and Systems Engineering
Darinka Dentcheva	Stevens Institute of Technology, Mathematical Sciences
Igor Cialenco	Illinois Institute of Technology, Mathematics

Mert Gurbuzbalaban	Rutgers University, Rutgers Business School, Management Science and Information Systems
Massimo Marinacci	Bocconi University, Decisions Sciences
Lars Hansen	University of Chicago, Booth School of Business, the College, Economics, and Statistics
Eran Hanany	Tel Aviv University, School of Industrial Engineering
William Brock	University of Wisconsin-Madison, Economics
Peter Klibanoff	Northwestern University, Kellogg School of Management, Managerial Economics and Decision Sciences
Michael Barnett	Arizona State University, Finance
Sujoy Mukerji	Queen Mary University of London, School of Economics and Finance
Office Hours/Teaching Assistants	Affiliation & Department
Yanwei Jia	Columbia University, Mathematics

The following are some of the comments from participants.

- *“The course was very organized, the instructors were well prepared, and the topics relevant.”*
- *“Great course for mathematicians. I was able to get some sense about the mathematical complexity of the topic, and certainly the course encourages me to continue studying the topic.”*
- *“I enjoyed the topics on Reinforcement Learning, Optimal transport, GANs, robust control, and Mean field Games.”*
- *“Free lectures from experts in the field. What more can one want?! Much appreciation. I am very grateful.”*
- *“The quality of the seminars is the best: OT seminars are self-contained, sufficiently deep, sufficiently broad.”*
- *“Excellent multifaceted program - I very much enjoyed it.”*
- *“Great program, great instructors and great organizers. Keep it up.”*

The embedded workshops for the long program were as follows.

Workshop 1: Advances in Optimal Decision Making under Uncertainty: New Directions, Methods, and Applications, March 28 - April 1, 2022

This workshop brought together experts and young researchers interested in the most recent developments of mathematical finance and insurance in both academia and industry. Experts presented state of the art topics in among others: fintech, high-frequency trading, robo-advising, risk measures, market impact and optimal execution, reinsurance, and commodity and energy markets. Talks on recent theoretical advances in BSDE systems, robust optimization in pricing and hedging, relaxed control in reinforcement learning, and decision-making under non-standard criteria were also presented.

This workshop was attended by 85 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Thaleia Zariphopoulou	University of Texas, Austin
Speakers	Affiliation & Department
Hansjoerg Albrecher	University of Lausanne, Actuarial Science
Elisa Alos	Universitat Pompeu Fabra, Economics
Agostino Capponi	Columbia University, Industrial Engineering and Operations Research
Darrell Duffie	Stanford University, Economics
Paul Embrechts	ETH Zurich, Mathematics
Jean-Pierre Fouque	University of California, Santa Barbara, Statistics and Applied Probability
Xin Guo	University of California, Berkeley, Applied Mathematics
Sebastian Jaimungal	University of Toronto, Statistics
Sigrid Källblad	KTH Royal Institute of Technology, Stockholm, Mathematics
Steven Kou	Boston University, Finance
Morton Lane	University of Illinois at Urbana-Champaign, Financial Engineering
Sergey Nadotchiy	Illinois Institute of Technology, Applied Mathematics
Jan Obloj	University of Oxford, Mathematical Institute

Huyên Pham	University of Paris 6 and CNRS, LPSM
Christoph Reisinger	University of Oxford, Mathematical Institute
Alberto Rossi	Georgetown University
Johannes Ruf	London School of Economics, Mathematics
Jose Scheinkman	Columbia University, Economics
Moris Strub	Southern University of Science and Technology, Information Systems and Management Engineering
Ludovic Tangpi	Princeton University, Operations Research and Financial Engineering
Nizar Touzi	École Polytechnique, Applied Mathematics
Xunyu Zhou	Columbia University, Industrial Engineering and Operations Research
Gordan Zitkovic	University of Texas, Austin, Mathematics

Workshop 2: Systemic Risk and Stress Testing, April 4-8, 2022

Stress testing has become an important tool for the risk management of financial institutions and for assessing the resilience of the financial system as a whole. In the wake of the 2008 financial crisis, research has focused on more detailed representations of balance sheets and a better modeling of interactions across institutions, contagion channels and shock amplification mechanisms in stress tests. This workshop brought together leading academic experts, practitioners, and regulators to discuss recent methodological developments and new challenges in stress testing and systemic risk assessment in the following areas:

- Solvency and liquidity stress testing
- Macro-prudential regulation
- Systemic risk and financial stability
- Network models
- Risk management and stress-testing of market infrastructures
- Stress testing of non-bank financial institutions
- Climate stress tests for financial institutions

This workshop was attended by 73 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Rama Cont	Oxford University, Mathematical Institute
Speakers	Affiliation & Department
Tobias Adrian	International Monetary Fund
Hamed Amini	Georgia State University, Risk Management & Insurance
Paolo Barucca	University College London, Computer Science
John Birge	University of Chicago, Booth School of Business
Yann Braouezec	IESEG School of Management
Agostino Capponi	Columbia University, Industrial Engineering and Operations Research
Laurent Clerc	Autorité de contrôle prudentiel et de résolution Banque de France, Research and Risk Analysis
Giovanni Covi	Bank of England, Financial Stability
Fernando Duarte	Federal Reserve Bank of New York, Economics
Darrell Duffie	Stanford University, Economics
Zachary Feinstein	Stevens Institute of Technology
Paul Glasserman	Columbia University, Business School
Anne-Caroline Huser	Bank of England
Artur Kotlicki	Bank of England
Caterina Lepore	International Monetary Fund
Andreea Minca	Cornell University
Mark Paddrik	Office of Financial Research U.S. Treasury (OFR)
Agathe Pernoud	Stanford University, Economics
Alireza Tahbaz Salehi	Northwestern University Kellogg Graduate School of Management
Eric Schaanning	Credit Suisse, Risk Management
Andreas Søjmark	London School of Economics and Political Science

Laura Valderrama	International Monetary Fund
Luitgard Veraart	London School of Economics and Political Science, Mathematics

Workshop 3: Confronting Uncertainty in Climate Change, April 13-15, 2022

Climate change is well-recognized as an important economic, social, and political challenge. To develop meaningful quantitative models that guide prudent policymaking requires methods that quantify the pertinent uncertainty and approaches to incorporate them into the assessment of alternative courses of action. This workshop will bring together decision theorists, geoscientists and economists to discuss recent advances in stochastic modeling, uncertainty quantification and applications to the economics of climate change.

This workshop was attended by 49 unique participants, including speakers and organizers.

Organizers	Affiliation & Department	
Lars Hansen	University of Chicago, Departments of Economics, Statistics and the Booth School of Business	
Speakers	Affiliation & Department	
Michael Barnett	Arizona State University, Finance	
Simone Cerreia-Vioglio	Bocconi University	
Michael Ghil	UCLA and Ecole Normale Supérieure, Paris, Geosciences	
Ishan Nath	Princeton University and Federal Reserve Bank of San Francisco	
Simon Scheidegger	HEC Lausanne, Switzerland; Economics	
Jose Scheinkman	Columbia University, Economics	
Martin Schneider	Stanford University, Economics	
Neng Wang	Columbia Business School	

Workshop 4: Decision Making under Uncertainty, May 2-6, 2022

Decision Theory, including its applications and closely-related topics, is a deep and active area of research. It includes theories of how people make or should make decisions, often in the face of uncertainty. Mathematically, such theories often connect preferences or choices with functional representations, and/or analyze and apply such functionals as models of behavior. At this workshop, invited scholars presented their recent work and engaged in discussion with the participants.

This workshop was attended by 50 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Peter Klibanoff	Northwestern University Kellogg School of Management, Managerial Economics & Decision Sciences
Speakers	Affiliation & Department
David Ahn	Washington University, St. Louis, Olin Business School
Sarah Auster	University of Bonn, Economics
Simone Cerreia-Vioglio	Bocconi University
Christopher Chambers	Georgetown University, Economics
David Dillenberger	University of Pennsylvania
Mira Frick	Yale University, Economics
Itzhak Gilboa	Tel Aviv University, Economics
Eran Hanany	Tel Aviv University, Engineering
Shaowei Ke	University of Michigan
Fabio Maccheroni	Bocconi University
Luca Rigotti	University of Pittsburgh, Economics
Jacob Sagi	University of North Carolina Chapel Hill Kenan-Flagler Business School
Marciano Siniscalchi	Northwestern University, Economics
Jean-Marc Tallon	Paris School of Economics

Workshop 5: Dynamic Assessment Indices, May 2-6, 2022

Over the past two decades significant progress has been made in developing a general framework for studying preference orders in an uncertain and dynamic environment, primarily with applications to risk management, economics, pricing, and hedging, as well as stochastic optimal control. The theory and practice of assessment indices is an integral part of this general framework. At the abstract level, an assessment index is a functional defined on the set of objects to be ordered that satisfies a set of minimal assumptions, such as monotonicity (better for better) and quasi-concavity (diversification is preferred to concentration). In particular, assessment indices can be used in rendering a trade-off between reward opportunities and risk of losses. Some of the key research directions in this area are: (a) finding analytically tractable descriptions of such classes of functionals; (b) establishing adequate description of intertemporal properties, also known as time (in)consistency in decision making.

This workshop brought together leading experts in the field of decision making, dynamic risk and performance measures to exchange latest developments in these research areas, discuss open problems and challenges in solving them, as well as to foster collaborations between participants and their collaborators.

This workshop was attended by 42 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Tomasz Bielecki	Illinois Institute of Technology, Applied Mathematics
Igor Cialenco	Illinois Institute of Technology, Applied Mathematics
Speakers	Affiliation & Department
Tao Chen	University of Michigan, Mathematics
Ziteng Cheng	University of Toronto
Igor Cialenco	Illinois Institute of Technology, Applied Mathematics
Delia Coculescu	Universität Zürich
Samuel Cohen	University of Oxford, Mathematics
Stephane Crepey	Université de Paris, Mathematics
Darinka Dentcheva	Stevens Institute of Technology, Mathematics
Giulia Di Nunno	University of Oslo, Mathematics
Zachary Feinstein	Stevens Institute of Technology

Ruediger Frey	Vienna University of Economics and Business, Statistics and Mathematics
Marco Frittelli	Università degli Studi di Milano
Gero Junike	Carl von Ossietzky University of Oldenburg
Gabriela Kovacova	Vienna University of Economics and Business
Dilip Madan	University of Maryland, Finance
Thilo Meyer-Brandis	University of Munich, Mathematics
Marcin Pitera	Jagiellonian University, Institute of Mathematics
Emanuela Rosazza Gianin	University of Milano-Bicocca, Statistics and Quantitative Methods
Birgit Rudloff	Vienna University of Economics and Business, Institute for Statistics and Mathematics
Andrzej Ruszczyński	Rutgers University, Management Science and Information Systems
Alexander Shapiro	Georgia Institute of Technology
Ruodu Wang	University of Waterloo

Workshop 6: Applied Optimal Transport, May 16-20, 2022

This workshop showcased current developments in theoretical and computational optimal transport with a focus on applications in machine learning and statistics.

This workshop was attended by 92 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Aude Genevay	Massachusetts Institute of Technology (MIT)
Marcel Nutz	Columbia University, Statistics
Bodhisattva Sen	Columbia University, Statistics
Speakers	Affiliation & Department
David Alvarez-Melis	Microsoft Research, Computer Science
Francis Bach	Institut National de Recherche en Informatique et Automatique (INRIA)

Julio Backhoff-Veraguas	Universitaet Wien
Jose Blanchet	Stanford University
Guillaume Carlier	Université Paris Dauphine
Elsa Cazelles	Centre National de la Recherche Scientifique (CNRS)
Lenaic Chizat	Centre National de la Recherche Scientifique (CNRS), Mathematics
Marco Cuturi	Apple ML Research and École Nationale de la Statistique et de l'Administration Économique
Nabarun Deb	Columbia University
Eustasio del Barrio	Universidad de Valladolid, Statistics
Alfred Galichon	New York University, Economics / Mathematics
Promit Ghosal	Massachusetts Institute of Technology (MIT)
Florian Gunsilius	University of Michigan
Jun Kitagawa	Michigan State University, Mathematics
Anna Korba	École Nationale de la Statistique et de l'Administration Économique, Statistics
Gonzalo Mena	University of Oxford
Long Nguyen	University of Michigan, Statistics
Jonathan Niles-Weed	New York University, Courant Institute of Mathematical Sciences
Soumik Pal	University of Washington, Mathematics
Johan Segers	l'Université catholique de Louvain, ISBA/LIDAM
Johannes Wiesel	Columbia University, Statistics

Workshop 7: Machine Learning and Mean-Field Games, May 23-26, 2022

Multi-agent reinforcement learning (MARL) with incorporation of techniques and ideas from the theory of mean field games is one of the most active areas in learning and control. This workshop brought together leading experts and junior researchers to showcase the latest developments in this interdisciplinary field.

This workshop was attended by 101 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Xin Guo	University of California, Berkeley, Applied Mathematics
Speakers	Affiliation & Department
Beatrice Acciaio	ETH Zürich
Haoyang Cao	The Alan Turing Institute
Rene Carmona	Princeton University, Operations Research & Financial Engineering
Rama Cont	University of Oxford, Mathematical Institute
Christa Cuchiero	University of Vienna
Jean-Pierre Fouque	University of California, Santa Barbara, Statistics and Applied Probability
Camilo A Garcia Trillos	University College London, Mathematics
Oliver Gueant	Université Paris 1 Pantheon Sorbonne
Anran Hu	University of California, Berkeley
Ruimeng Hu	University of California, Santa Barbara, Mathematics, Statistics and Applied Probability
Sebastian Jaimungal	University of Toronto, Statistics
Daniel Lacker	Columbia University, Operations Research
Martin Larsson	Carnegie-Mellon University, Mathematics
Mathieu Lauriere	New York University Shanghai
Siting Liu	University of California, Los Angeles, Mathematics
Thibaut Mastrolia	University of California, Berkeley
Sarah Perrin	Université de Lille, Computer Science
Huyên Pham	University of Paris 6 and CNRS, LPSM
Zhenjie Ren	University Paris Dauphine – PSL, Applied Mathematics
Mathieu Rosenbaum	École Polytechnique

Johannes Ruf	London School of Economics and Political Science, Mathematics
Lukas Szpruch	University of Edinburgh, Mathematics
Wenpin Tang	Columbia University, Industrial Engineering and Operations Research
Josef Teichmann	ETH Zürich, Mathematics
Renyuan Xu	University of Southern California
Jiacheng Zhang	University of California, Berkeley (UC Berkeley), Industrial Engineering and Operations Research
Yufei Zhang	London School of Economics and Political Science
Xunyu Zhou	Columbia University, Industrial Engineering and Operations Research

3.3 Topical Workshops

IMSI held four research workshops during the reporting period which were outside the framework of long programs. These are described in this section.

Eliciting Structure in Genomics Data: Bridging the Gap between Theory, Algorithms, Implementations, and Applications, August 30 - September 3, 2021

Methods for dimension reduction play a critical role in a wide variety of genomic applications. Indeed, as technology develops, and datasets grow in size and complexity, the need for effective dimension reduction methods that help visualize and distill the primary structures remains as essential as ever. Examples of the many practical applications in genomics include: (a) understanding (i) the structure of wild populations (particularly endangered species) from population genetic variation, (ii) human evolutionary history, also from population genetic variation, (iii) the 3-D structure of DNA from hi-C data, and (iv) genetic factors that influence risk for different human disease; (b) identifying (i) substructure among cell populations based on single-cell transcription patterns, and (ii) distinctive signatures of somatic mutations distinguishing different cancer subtypes; c) estimating confounding factors and other sources of unwanted variation in gene expression studies; d) segmenting and annotating genomic regions based on chromatin marks and other molecular features.

The development and provision of effective methods for dimension reduction involves connecting a series of areas of expertise: from theory to algorithms, implementations, and applications. Theory is required to help decide what methods and algorithms to focus on; algorithms are required that help turn theoretical ideas into practical tools; and implementation of these algorithms is an often-overlooked step, where decisions are

sometimes made that can greatly influence results. And all these steps need performing with at least one eye on the details of the practical applications and the data-types to which they will be applied. Unfortunately, there are relatively few opportunities for experts in these different areas to come together and learn from one another. This workshop addressed this problem by bringing together mathematicians and computer scientists with a deep understanding of the theory and algorithmic and implementation issues, with applied statistical geneticists who have invaluable experience with both implementing and applying these methods to data and interpreting the results. The goal was to start new conversations across disciplinary barriers. The workshop exposed theoretical experts to the many ways that these methods are used in practice and the ongoing challenges that arise; and it exposed those familiar with applications to recent developments on the theoretical side.

This workshop was attended by 73 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Mihai Anitescu	Argonne National Laboratory; University of Chicago, Statistics
Anna Gilbert	University of Michigan, Mathematics
Dan Nicolae	University of Chicago, Human Genetics and Medicine; Statistics
Matthew Stephens	University of Chicago, Statistics
Speakers	Affiliation & Department
Soledad Villar	Johns Hopkins University, Applied Mathematics and Statistics
Zhou Fan	Yale University
Karl Rohe	University of Wisconsin-Madison, Statistics
Sriram Sankararaman	University of California, Los Angeles, Computer Science
Smita Krishnaswamy	Yale University, Computer Science, Genetics, Applied Math
Tracy Ke	Harvard University, Statistics
Jingshu Wang	University of Chicago, Statistics
Boris Landa	Yale University
Gal Mishne	University of California, San Diego, HDSI
Ben Raphael	Princeton University, Computer Science
Anna Gilbert	University of Michigan
Miaoyan Wang	University of Wisconsin-Madison, Statistics
Kasper Hansen	Johns Hopkins University, Biostatistics

Tandy Warnow	University of Illinois at Urbana-Champaign, Computer Science
Alex Bloemendal	Broad Institute of MIT and Harvard University
Bianca Dumitrascu	University of Cambridge, Computer Science
Petros Drineas	Purdue University, Computer Science

Participant comments on the workshop included the following:

- *“Let's do it again!”*
- *“This was a super enjoyable conference. I got to hear from multiple research communities that I would otherwise not get to hear. We have significant overlap! This is great to learn about and will inspire my future research.”*
- *“Please continue to make such great workshop on genetic data.”*
- *“[A highlight was h]earing from people working in a diverse set of research areas.”*

One valuable adjunct to this conference was a Slack Workspace for participants. Some of the benefits mentioned by participants were:

- *“Quick interactions with other participants.”*
- *“Side chat during talks, documented for others to trace back to.”*
- *“Links to papers.”*
- *“One-on-one questions and reference dissemination.”*
- *“Very active discussions.”*
- *“Followed people posting papers and comments.”*

Private AI: Machine Learning on Encrypted Data, February 7-11, 2022

This workshop identified and highlighted a range of significant privacy concerns in the practice of AI, and mathematical solutions which can be building blocks for solutions. The workshop brought together researchers from the fields of cryptography, security, machine learning, programming languages and domain experts from biomedicine, health and finance.

The workshop uncovered new problems arising from innovative applications, identified which technologies are needed to develop new solutions and what are the key barriers and challenges. The workshop also highlighted existing techniques and future opportunities.

Each day of the workshop was arranged around a specific theme. The daily themes were:

- Homomorphic Encryption
- Adversarial Machine Learning
- Biomedical Applications
- Emerging Applications in Statistics, Economics, Manufacturing, and Language
- Privacy Preserving Technologies

Each day of the workshop included a panel discussion among the day's speakers, and a dedicated student session.

This workshop was attended by 144 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Jung Hee Cheon	Seoul National University, Mathematical Sciences
Kristin Lauter	Facebook AI Research
Vinod Vaikuntanathan	Massachusetts Institute of Technology (MIT), Computer Science
Speakers	Affiliation & Department
Jung Ho Ahn	Seoul National University
Brian Anthony	Massachusetts Institute of Technology (MIT), Medical
David Cash	University of Chicago, Computer Science
Kamalika Chaudhuri	University of California, San Diego
Hoon Cho	Broad Institute
Wei Dai	Microsoft Research
Gamze Gursoy	Columbia University, Biomedical Informatics
Shai Halevi	Algorand Foundation
Jean-Pierre Hubaux	EPFL
Seung-won Hwang	Seoul National University
Xiaoqian Jiang	University of Texas Health Science Center and Texas Heart Institute, Computer Science
Chiraag Juvekar	Analog Devices Inc.
Miran Kim	Ulsan National Institute of Science and Technology, Computer Science and Engineering
Kim Laine	Microsoft Research
Yuriy Polyakov	Duality Technologies Inc.

Mariana Raykova	Google
Brandon Reagen	New York University, Electrical and Computer Engineering
Keunkwan Ryu	Seoul National University, Economics
Daniel Sanchez	Massachusetts Institute of Technology (MIT), Computer Science
Laurens van der Maaten	Facebook
Dongkwon Lee	Seoul National University
Heather Zheng	University of Chicago, Computer Science

Participant comments included the following:

- *“The workshop was informative and a dedicated session for students’ meetup was awesome! I met with other lab students and discussed our research. I hope to see the second edition of this workshop!”*
- *“I personally enjoyed the discussion on genomic privacy techniques.”*
- *“The workshop would clearly have been much better if it were in person. But given the constraints, this was close to the best we could've done.”*

Multiscale Microbial Communities: Dynamical Models, Ecology, and One Health, February 21-24, 2022

Microbial communities are an integral and essential part of life on earth. Their relevance ranges from control of epidemics to understanding of the gut microbiome, to understanding beneficial and harmful microbial impacts on farming and ecological systems, to understanding the impact of climate on microbial systems. This workshop aimed to bring together experts in ecology, microbial genomics, population evolution, dynamical modeling, and high throughput data science to share the current state of knowledge and catalyze new interactions across biology, computational, and mathematical sciences.

The potential range of topics was huge. To provide focus for this effort, the organizing team chose to emphasize two key areas and their interplay: microbial genomics and microbial population dynamics. The first two days of the workshop were arranged into sessions with talks around each of these themes. During the remaining two days, participants divided into working groups for discussion of future directions.

This workshop was attended by 36 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Hongzhe Li	University of Pennsylvania, Biostatistics, Epidemiology and Informatics
Pamela Martinez	University of Illinois at Urbana-Champaign, Microbiology and Statistics
Shulei Wang	University of Illinois at Urbana-Champaign, Statistics
Speakers	Affiliation & Department
Stefano Allesina	University of Chicago, Ecology and Evolution
Ed Ionides	University of Michigan, Statistics
Nianqiao Ju	Purdue University, Statistics
Tal Korem	Columbia University, Systems Biology
Jing Ma	Fred Hutchinson Cancer Research Center
Li Ma	Duke University, Statistical Science
Mercedes Pascual	University of Chicago
Mihai Pop	University of Maryland, Computer Science
Byron Smith	Gladstone Institutes, Data Science and Biotechnology
Fengzhu Sun	University of Southern California
Tandy Warnow	University of Illinois at Urbana-Champaign, Computer Science
Michael Wu	Fred Hutchinson Cancer Research Center

Participant comments included the following:

- *I think meeting and getting feedback from the wonderful attendees was definitely the highlight.*
- *All the talks I attended were helpful in shedding light on the issues with applying mathematics to studying the microbiome. A highlight of the workshop is that there will be ongoing work as a result. If this happens, then this will be the highlight, for me.*
- *Both the talks and working group discussions were helpful.*
- *I thought the "coincidental" conversations with other attendees were the most important part of the experience.*
- *Discussions on third day were fantastic, and so were the ones after the talks.*

- *I was very impressed with the quality of presentations and speakers at this workshop.*
- *I participated on Zoom. The moderator and other participants always welcomed my contributions/questions, which was extremely gratifying to me.*

The Mathematics of Soft Matter: Structure and Dynamics, February 28 - March 4, 2022

Recent advances to experimental and modeling/simulation methods are providing high resolution data within soft matter systems that are of increasing complexity. There is an aim to tailor the design of soft matter materials, where the community is at a tipping point of innovation that mimics the tremendous growth of hard-materials design that has emerged over the last two decades. However, the intrinsic disorder and multiscale structural and dynamic characteristics of soft matter challenges mathematical descriptions and models that are needed for more robust predictive capability and a fundamental understanding of the underlying physics. This workshop brought together mathematicians, computational and theoretical chemists and chemical engineers, and experimental scientists to identify critical topical areas that intersect mathematics and the physics and chemistry of soft matter. The workshop inspired mathematical development and provided a platform for mathematicians and the domain scientists to share tools and methodologies that are mutually beneficial to these communities. These included the following mathematics areas: 1) graphs, topology, and geometry for the development of physically-motivated descriptors, 2) dimensionality reduction for identifying correlated motion and phenomena (including linear and non-linear methods) and 3) model reduction for creating simplified mathematical representations that support transfer of information across the atomistic/molecular scale to the macroscale.

The research talks during this workshop were arranged into sessions devoted to the following themes:

- Structural and Dynamic Characterization of Soft Matter
- Dimensions and Models of Soft Matter
- Integration of Experiment and Simulation
- Multiscale Phenomena of Soft Matter

In addition to the research talks, the workshop included software tutorials, a poster session for early career researchers held in Gather.town, a professional development session with talks by researchers on working at national labs and TDA startups and a roundtable discussion on transitioning out of a Ph.D. and into an independent career, and a final working lunch to discuss future directions for the field.

This workshop was attended by 80 unique participants, including speakers and organizers.

Organizers	Affiliation & Department
Aurora Clark	Washington State University, Chemistry
Vasileios Maroulas	University of Tennessee, Mathematics
Kathleen Stebe	University of Pennsylvania, Chemical and Biomolecular Engineering
Guo-Wei Wei	Michigan State University, Mathematics
Speakers	Affiliation & Department
Rick Archibald	Oak Ridge National Laboratory
Rob Coridan	University of Arkansas, Fayetteville, Chemistry and Biochemistry
Benjamin Doughty	Oak Ridge National Laboratory, Chemistry
Magali Duvail	CEA - Saclay
Marina Guenza	University of Oregon, Chemistry
Mahantesh Halappanavar	Pacific Northwest National Laboratory, Computer Science
Rigoberto Hernandez	Johns Hopkins University, Chemistry
Bala Krishnamoorthy	Washington State University, Mathematics and Statistics
Daeyeon Lee	University of Pennsylvania
Sven Leyffer	Argonne National Laboratory, Mathematics
Kostia Lyman	Washington State University, Mathematics and Pacific Northwest National Laboratory
Christopher Oballe	University of Notre Dame
Monica Olvera de La Cruz	Northwestern University
Benjamin Peherstorfer	New York University, Courant Institute
Dan Pope	Washington State University, Chemistry
Robert Rallo	Pacific Northwest National Laboratory
Sapna Sarupria	University of Minnesota, Twin Cities, Chemistry
Mark Schlossman	University of Illinois at Chicago, Physics
Mridul Seth	NetworkX

Julien Tierny	Sorbonne
Ahmet Uysal	Argonne National Laboratory, Chemical Sciences and Engineering
Soledad Villar	Johns Hopkins University, Applied Mathematics and Statistics
Konstantinos Vogiatzis	University of Tennessee Knoxville, Chemistry
Bei Wang	University of Utah, Computer Science
Yusu Wang	University of California, San Diego
Kelin Xia	Nanyang Technological University Singapore, Mathematics
Xiao-Ying Yu	Pacific Northwest National Laboratory
Poster Presenters	Affiliation & Department
Alexander Smith	University of Wisconsin, Madison, Chemical Engineering
Caleb Wagner	University of Nebraska, Lincoln, Mechanical and Materials Engineering
Mohammad Nooranidoost	Florida State University, Mathematics
Nitesh Kumar	Washington State University, Chemistry
Terrence Alsup	New York University, Mathematics
Tiancheng Wang	University of Pennsylvania
Yihui Wei	Washington State University

In comments on the post-workshop survey, one participant praised “[t]he excellent mix of experimentalists and mathematicians,” while others spoke highly of the talks, discussions, and breakout sessions.

3.4 Special Events

Graduate Research Opportunities for Women 2021, October 15-17, 2021

The *Graduate Opportunities for Women* (GROW) conference is intended to provide support and encouragement to women and non-binary undergraduate students who may be considering going to graduate school in the mathematical sciences. The conference runs annually and is open to undergraduates from U.S. colleges and universities, including international students. GROW began at Northwestern University in 2015, and ran there for three successive years. It has been hosted at different institutions every year since then. With support from IMSI via IMSI’s grant from NSF, in 2020, the GROW Steering Committee formed to help ensure the continuity of the series. The members of the committee are drawn from the four institutions involved in the

management of IMSI (Northwestern University, the University of Chicago, the University of Illinois at Chicago, and the University of Illinois at Urbana-Champaign) as well as representatives from the organizing committees of the most recent and upcoming editions of GROW. The current members are: Kevin Corlette (IMSI, University of Chicago), Vera Mikyoung Hur (University of Illinois at Urbana-Champaign), Bryna Kra (Northwestern University), Julius Ross (University of Illinois at Chicago), Brooke Shipley (University of Illinois at Chicago), and Shira Viel (Duke University). The Steering Committee works in cooperation with IMSI to recruit host institutions for GROW, to provide advice and support to organizing committees, and to maintain continuity and adherence to the underlying vision for GROW.

The 2021 edition of GROW was hosted by the University of Illinois at Chicago, with financial support from IMSI. It featured plenary lectures, panel discussions about graduate research in the mathematical sciences, networking opportunities, and advice on preparing applications for graduate school. It was attended by 162 unique individuals, including organizers, speakers, and panelists.

Organizing Committee	Affiliation & Department
Julius Ross	University of Illinois at Chicago, MSCS
Will Perkins	University of Illinois at Chicago, Mathematics
Dima Sinapova	University of Illinois at Chicago, Mathematics
Laura Schaposnik	University of Illinois at Chicago, Mathematics
Mimi Dai	University of Illinois at Chicago, Mathematics
Bryna Kra	Northwestern University
Additional Scientific Committee Members	Affiliation & Department
Irina Nenciu	University of Illinois at Chicago, Mathematics
Yichao Wu	University of Illinois at Chicago, Mathematics
Jeremy Tyson	University of Illinois at Urbana-Champaign, Mathematics
Plenary Speakers	Affiliation & Department
Niall Mangan	Northwestern University
Antonio (Tuca) Auffinger	Northwestern University, Mathematics
Yaiza Canzani	University of North Carolina at Chapel Hill
Brooke Shipley	University of Illinois at Chicago, Mathematics, Statistics, and Computer Science
Panelists	Affiliation & Department
Betsy Stovall	University of Wisconsin, Mathematics

Keri Sather-Wagstaff	Clemson University, Mathematics
Fernando Guevara Vasquez	University of Utah, Mathematics
Jacqueline Hughes-Oliver	North Carolina State University, Statistics
Nsoki Mamie Mavinga	Swarthmore College
Ayse Sahin	Wright State University

paraDIGMS Fall 2021 and Spring 2022 Conferences: Diversity in Graduate Mathematics Education

paraDIGMS was founded by a small group of mathematicians with logistical support from IMSI starting in 2020. It is sponsored by the American Mathematical Society, and IMSI has provided logistical support and advice to the organizing committee over the past two years.

The goal of paraDIGMS is to highlight the work of individuals and organizations to build a diverse and equitable profession at the graduate level, while also challenging the community to see how far it still has to go. The target audience is the mathematical sciences community at large. Individuals at all career stages and from all kinds of institutions (including undergraduate-only institutions) are welcome to participate. paraDIGMS takes place in a remote conference format (plenary talks, panels, breakouts) over four consecutive half days. During the current reporting period, there was one conference in the fall (October 28-31, 2021) and one in the spring (April 28-May 1, 2022).

As an ongoing adjunct to the twice-yearly paraDIGMS conference, the organizers also convened Working Groups (WG). The goals of the WG were individual and systemic: to support individuals in a professional role for which they usually don't have special preparation; and to help build connections among individuals and departments to foster a shared responsibility for supporting the next generation of mathematicians, especially those from groups historically marginalized in mathematics---building a "professional community" around graduate education in the mathematical sciences. The WG consisted of small groups of graduate program leaders in the mathematical sciences meet virtually on a monthly basis throughout the academic year. Most were either graduate directors (most common), graduate committee members, diversity committee members, or department chairs. Most participants are faculty in departments that grant PhDs, but a number work in Master's-only departments. The WG functioned as discussion groups to share common issues and concerns about running a graduate program and supporting students---especially those from marginalized groups--- as well as to ask for advice and to share successes. WG participants also receive monthly reflection prompts from the paraDIGMS organizers to help guide the conversations. In 2021-22, there were 30 WG participants.

The Fall 2021 paraDIGMS was attended by 315 individuals, and the Spring 2022 paraDIGMS was attended by 134 individuals, including organizers, speakers, and panelists.

paraDIGMS Fall 2021 Conference

Organizers	Affiliation & Department
Matthew Ando	University of Illinois at Urbana-Champaign, Mathematics
Justin Lanier	University of Chicago, Mathematics
Marissa Loving	Georgia Tech, Mathematics
Bianca Viray	University of Washington, Mathematics
Plenary Speakers	Affiliation & Department
Monica F. Cox	Ohio State University, Mathematics
Dennis Davenport	Miami University of Ohio, Mathematics
Lloyd E. Douglas	Independent Consultant
Panelists	Affiliation & Department
Tarik Aougab	Haverford College, Mathematics and Statistics
Candice Laster	Texas Tech University
Judy Walker	University of Nebraska, Lincoln, Mathematics
Deanna Haunsperger	Carleton College, Mathematics and Statistics
Herbert Medina	University of Portland, Mathematics
Ivelisse Rubio	Universidad de Puerto Rico, Computer Science
Ben Braun	University of Kentucky, Mathematics
Anne M. Ho	University of Tennessee, Mathematics
Richard McGehee	University of Minnesota, Mathematics

paraDIGMS Spring 2022 Conference

Organizers	Affiliation & Department
Matthew Ando	University of Illinois at Urbana-Champaign, Mathematics
Justin Lanier	University of Chicago, Mathematics
Marissa Loving	Georgia Tech, Mathematics
Bianca Viray	University of Washington, Mathematics

Plenary Speakers	Affiliation & Department
Tabbatha Dobbins	Rowan University
Craig Ogilvie	Montana State University
Panelists	Affiliation & Department
Mitchell Everett	Georgia Tech
Sarah Garner	University of Washington
Rhonda Olson	Arizona State University, School of Mathematical and Statistical Sciences
Courtney Gibbons	Hamilton College, Mathematics and Statistics
Dagan Karp	Harvey Mudd College, Mathematics
Adriana Salerno	Bates College and National Science Foundation

Blackwell-Tapia Conference 2021 Satellite Event, November 18-20, 2021

MSRI and the Mathematical Science Institutes Diversity Initiative (MSIDI) organized the 2021 Blackwell-Tapia Conference (rescheduled from Fall 2020). The conference was held simultaneously at four institutes nationwide, including IMSI, and celebrated the 2020 Blackwell-Tapia prize winner, Tatiana Toro (University of Washington). IMSI played host to two of the plenary speakers, Jacqueline Hughes-Oliver and Carlos Kenig. IMSI also hosted 16 participants in-person for the event. Activities included a poster session.

3.5 Summer Internship Program

The IMSI Internship program is a workforce development effort to accelerate the preparation of PhD students in the mathematical sciences for careers in interdisciplinary and translational research, in industry, and in government laboratories by providing them with broadening professional experiences. Eight interns were selected from a national pool of over 100 applicants from PhD programs in mathematics, statistics, and related mathematical sciences.

The interns began with two weeks of intensive training participating in the IMSI Data Science Bootcamp, offered online via Zoom May 28 – June 11, 2021. The bootcamp was led by an expert in data science and engineering. The training was a full time, interactive experience with lecture material available in advance, hands-on daily group work, and group instruction with the opportunity to interact with other interns. The aim was to provide highly capable PhD student interns with a jump start into data science, machine learning, modeling, and analysis to enhance success in their interdisciplinary internship appointments. In anonymous surveys following the boot camp, interns indicated a high degree of satisfaction with the relevance, range of topics, and their overall experience. They felt they received a level of material that was not available in

their academic training, and they enjoyed the experience of coming together to work with different members of the group.

The internship placements were for 8 weeks (about 2 months) duration. Interns were placed individually or in teams depending on the scope of host projects and their mentorship capacity. Interns completed necessary onboarding for the host and were embedded in labs or groups at the host institution with a lead investigator as their direct supervisor and project mentor. Upon completion of the internship, participants authored brief technical reports in the format of a scientific paper to describe their project. Hosts expressed enthusiasm for the work the interns were able to do for them. In some cases, the laboratories had not previously engaged graduate students from the mathematical sciences and were pleased with what they were able to accomplish for them. At least one intern reported that their project was leading to ongoing collaboration, and another reported that their industry internship was extended by the company through the next academic year. Post-internship surveys indicated strong agreement with the statement, “The internship provided me with new knowledge and skills that will be beneficial in my career or career decision making.”

Participant home institutions and graduate degree programs:

Participant Home Institution	Participant PhD Degree Program
Kent State University	Applied Mathematics
University of Connecticut	Statistics
University of Illinois Urbana-Champaign	Statistics
University of Illinois Urbana-Champaign	Statistics
University of North Carolina Charlotte	Statistics
University of Utah	Mathematics
University of Utah	Mathematics
University of Washington	Mathematics

Internship host organizations:

Internship Host Organization	Area
AbbVie, Inc	Biopharmaceutical research
University of Illinois Chicago College of Medicine	Applied cognitive neuroscience using hidden Markov models and machine learning
University of Illinois Urbana-Champaign Entomology Laboratory	Machine learning and computer vision analysis of the biophysics of insects

University of Illinois Urbana-Champaign / US Department of Agriculture Laboratory for Realizing Increased Photosynthetic Efficiency	Crop science and the environment
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3.6 Education Outreach

Education Outreach Programs at UChicago

IMSI supports and provides partial funding for three education outreach programs run out of the UChicago Math Department: the Young Scholars Program (focused on pre-college students), and the Polk Bros & SESAME programs (targeted at math teachers mainly grades 3-8).

The Young Scholars Program (YSP) is a 4-week summer enrichment for grades 7-12, most of whom come from Chicago Public Schools. YSP is designed to attract advanced math students who are highly motivated to do math they would typically not see in school. The gender mix is very balanced, with about half the participants being female. YSP was run remotely in July 2021.

The Polk Bros & SESAME are credit-awarding summer teacher professional development programs, primarily attracting Chicago Public School teachers. Polk Bros had 149 teachers taking three separate courses (Modern Methods of Teaching Mathematics, Algebra, and Number Theory) all given remotely. Similarly, SESAME targets middle grade teachers and the courses taught connect to the Chicago Public Schools Algebra Initiative.

Young Scholars Program, UIC

The Young Scholars Program (YSP) at the University of Illinois at Chicago, is aimed at math-enthusiastic students, primarily from Chicago Public Schools. The target audience is designed to be not as highly math-skilled as the YSP hosted by UChicago. In summer 2021, there were four, one-week sessions in July and they hosted about 40 students per week, in-person. The program is free. Each day includes a guest speaker on careers, grad school, etc. UIC math students serve as “counselors.” The UIC YSP attracted a diverse cohort of participants:

- 71 unique participants
- 26 female / 45 male
- 172 student-sessions: each unique student participated in 2.4 week-long sessions

In 2021, the topics included: Week 1 - probability, games, and statistics; Week 2 – number theory and cryptography; Week 3 – graph theory; Week 4 – algorithms and networks.

The overall success of the program was perhaps captured best by one happy parent, who said, “I would like to express my appreciation to you and your team for a wonderful summer program. My daughter has an inherent fear of mathematics, especially geometry. However, I have seen her getting ready for the sessions with so much enthusiasm. Although she still has a sort of inertia about geometry, I now see a positive change in her. So, THANK YOU for making geometry fun for students like her!”

3.7 Communications and Engagement

IMSI Communications Bootcamps

Concept

As part of its mission to improve communication within the mathematical and statistical fields, IMSI offers several bootcamps to help early career researchers develop their communication skills. The bootcamps are offered online and in person, and last about two hours. They build skill sets applicable to academic careers and individuals’ broader communication goals. When participants complete all three bootcamps, they qualify for recognition of their work through a LinkedIn badge.

Initial Set of Topics Covered

Storytelling & Narrative Structure

Storytelling isn't just for fiction writers. In order to write a successful grant application or a compelling teaching statement, one must use a narrative structure that pulls the reader along. This workshop reviews the scientific literature on why narratives are so compelling for the human brain, followed by hands-on work developing narrative structure in a written piece of the attendee’s choice (teaching statement, diversity statement, grant proposal, science reporting, etc).

How to Write for a General Audience

Have you ever wondered how a scientific paper is picked up and covered in news outlets like The New York Times or the Washington Post? This workshop teaches attendees about the process of how journal articles are translated into press releases and how those releases are picked up and made into news stories. Attendees learn to evaluate what makes a scientific finding newsworthy and practice a hands-on writing exercise to draft and refine a press release based on their work.

Job Talks & Stage Presence

No matter how exciting a researcher’s work is or how well they’ve rehearsed their slides for a talk, stage presence is key. Knowing how to use the surrounding space, how to recover from a mistake, and how to project vocally so that even those in the back of the room can hear are key to a successful talk. This workshop develops attendees’ presentation skills, so they’re comfortable during their next presentation.

Future Plans

Math Communications Bootcamps will continue to be offered each academic quarter, and will include the three core topics described above. For the 2022 Winter and Spring Quarters, IMSI offered all bootcamp topics online. We are expanding promotion of the opportunity nationally through university listservs and social media. For each quarter, each topic was offered twice. Additionally, as interest grows in the program, we have plans to add bootcamp topics focusing on social media, scientific poster design, and data visualization.

Current Impact

As of the end of the Spring 2022 quarter, 27 attendees had taken part in the Communications Bootcamps. Nine of those attendees were also Long Program attendees, visiting IMSI, who were able to attend in person. Additionally, 5 attendees completed all three topics offered and earned the LinkedIn Badge. Of those, 4 of them were also Long Program attendees.

MathStatBites

MathStatBites is a mathematical and statistical research blog, written by early career researchers and students in those fields to translate peer-reviewed journal and preprint articles for a general audience. There is significant interest from early career researchers who want to learn how to write accessible summaries of research for their peers and colleagues who are not experts in a particular area of research, as well as for broader audiences outside the fields of mathematics and statistics. The goal is to present one or more interesting papers per week in a brief format that is accessible to a broad audience of people who are generally interested in research.

A website for the blog is under development, and an initial set of writers is being recruited.

Carry the Two Podcast

As part of IMSI's goal to broaden participation and interest in mathematics and statistics, a podcast called ***Carry the Two*** is being developed. The basic premise is that each podcast episode is a conversation between two hosts, with one leading the other through a discussion of math research that shows how the field is interesting, applicable to our everyday lives. Each episode will also integrate excerpts from a separate conversation with an expert mathematician or statistician on that episode's topic. The intention of the podcast is to show that math and statistics are everywhere, are relevant, and are useful for navigating the complexities of everyday life.

Each episode tackles a different topic on how mathematics and/or statistics intersect with our daily lives. This can be anything from understanding the statistics behind breakthrough COVID cases, to modeling how swarming bees make group decisions, to how textual analysis can be used to reveal bias. The structure will be somewhat similar

to NPR's [Planet Money](#) in tackling difficult topics or [Short Wave](#) in its use of personal narrative to connect with larger ideas.

4. Preparation for Future Activity

The institute will host two long programs in 2022-23: *Confronting Global Climate Change* (September 19-December 9, 2022) and *Mathematics, Statistics, and Innovation in Medical and Health Care* (March 27-June 2, 2023). The Scientific Committee recommended moving forward with these programs during its January 2021 meeting, at which point work with the organizing committees for both programs began. Potential participants were identified and invited to apply, workshop schedules were finalized, and workshop organizing committees have been formed. Applications for both programs opened in the fall, and were announced through a number of channels, including advertisements in *SIAM News* and *Amstat News*.

The IMSI Scientific Committee met in June and November of 2021, and in April 2022. The Committee agreed to formalize a schedule for proposal deadlines. There will be two proposal cycles each year, with deadlines on March 15 and September 15, and a corresponding Science Committee meeting after each.

The Scientific Committee approved two proposals for long programs in 2023-24: *Algebraic Statistics and Our Changing World* in fall of 2023, and *Data-Driven Materials Informatics: Statistical Methods and Mathematical Analysis* in spring of 2024.

5. Governance

IMSI has two principal governing boards.

The IMSI **Board of Advisors** provides guidance to the Director on Institute activities, operations, and strategic planning. In addition, it plays a role in the search for and appointment of the Director. The Board has dedicated seats for one institutional member from each of the partner institutions (Northwestern University, the University of Chicago, the University of Illinois at Chicago, and the University of Illinois at Urbana-Champaign), with the remaining seats allocated to general and *ex officio* members. Members serve four-year terms, except in the case of *ex officio* members. At full strength, the Board is expected to have 12-20 members in all, exclusive of *ex officio* members; it will build to full size over the next 2-3 years. The current institutional and general members of the Board of Advisors are as follows.

Board of Advisors	Affiliation
Chid Apte	Thomas J. Watson Research Center
C. Allen Butler	Daniel H. Wagner Associates, Inc.
T. Tony Cai	University of Pennsylvania
Adrian Coles	Bristol Myers Squibb
Lee DeVille	University of Illinois at Urbana-Champaign
Laura Frerichs	University of Illinois at Urbana Champaign
Tamara Kolda	MathSci.ai
Pierre-Louis Lions	Collège de France
Brooke Shipley	University of Illinois at Chicago
Karen Willcox	University of Texas at Austin
Patrick Wolfe (Chair)	Purdue University
Eric Zaslow	Northwestern University

The **Scientific Committee** provides guidance on the overall direction for scientific activity at the Institute and evaluates proposals for specific activities. Terms for members are typically three years in length. The current members of the Scientific Committee are as follows.

Scientific Committee	Affiliation
Alicia Carriquiry	Iowa State University
René Carmona	Princeton University

Andrew Childs	University of Maryland Institute for Advanced Computer Studies
Amir Dembo	Stanford University
Bjorn Engquist (Chair)	University of Texas at Austin
Thomas Grandine	The Boeing Company (retired)
Larry Hedges	Northwestern University
Jacqueline Hughes-Oliver	North Carolina State University
Claude Le Bris	École des Ponts and Inria
Claudia Tebaldi	Joint Global Change Research, PNNL
Rebecca Willett	University of Chicago

6. Evaluation

IMSI works with East Main Evaluation and Consulting (EMEC) to evaluate its programs and activities. EMEC offers consulting and evaluation services with expertise in science and mathematics education and technology. The proposed effort will be managed by Barbara P. Heath, Ph.D. Dr. Heath founded EMEC in 2004 and has evaluated over 30 STEM focused programs including CyVerse (formerly iPlant), multiple Math and Science Partnerships, and various informal education efforts.

This year, post-activity surveys were deployed for the following programs and events:

- Introduction to Mean Field Games and Applications
- Introductions to Decision Making and Uncertainty
- Eliciting Structure in Genomics Data:
- Distributed Solutions of Complex Societal Problems
- Introduction to Distributed Solutions
- Mean-Field Models for Interacting Agents
- Applications of Mean Field Games
- Applications to Financial Engineering
- Mathematical Advances in Mean Field Games
- GROW 2021
- paraDIGMS Fall 2021 Conference
- Private AI
- Multiscale Microbial Communities
- The Mathematics of Soft Matter
- Decision Making and Uncertainty
- Advances in Optimal Decision Making Under Uncertainty
- Systemic Risk and Stress Testing
- Confronting Uncertainty in Climate Change
- Decision Making Under Uncertainty
- Dynamic Assessment Indices
- Applied Optimal Transport
- Machine Learning and Mean-Field Games
- paraDIGMS Spring 2022 Conference

The surveys were designed to gauge the nature of participant experience during each activity, to measure the degree to which participants thought the specific goals for each activity were achieved, and to gather feedback about possible future directions. Surveys were typically deployed a few days after the end of the activity, and participants were given two weeks to respond. A reminder was typically sent a week after the initial deployment of each survey.

In addition, IMSI worked with EMEC on the development of a longer-term framework and plan for evaluating the degree to which IMSI's activities and strategies advance its

mission and goals. This effort will inform the evaluation process for the more ambitious and longer-term activities IMSI will undertake as it emerges from its ramp-up period and COVID restrictions.

7. External Funding

IMSI receives substantial in-kind support from the University of Chicago. This support includes a full teaching release and administrative supplement for the Director, an administrative supplement for the Scientific Adviser, and the full salary of the Executive Director. In addition, the University covered the cost of the renovation of the space IMSI occupies and its ongoing maintenance.

The University of Illinois at Urbana-Champaign provided support through a partial teaching release for the Associate Director.

Other Funding Support

University of Chicago Provost	\$92,000.00
University of Chicago Physical Sciences Division Dean	\$24,798.63
University of Chicago Macro Finance Research Program	\$15,000.00
Gifts	\$500.00
Total	\$132,298.63

8. Director Biographies

Kevin Corlette, Director

Kevin Corlette was appointed as the Director of IMSI on August 1, 2020. He has been a faculty member of the Department of Mathematics at the University of Chicago since 1987. He served as chair of the department from 2001-2007, and again from 2017-2020. In addition, he served as director of the Master's Program in Financial Mathematics from 2012-2015. His research lies in differential and algebraic geometry, and has touched on areas such as non-Abelian Hodge theory, rigidity of lattices in Lie groups, and representations of fundamental groups of Kähler manifolds. He was a recipient of an NSF Postdoctoral Fellowship, a Sloan Research Fellowship, and a Presidential Young Investigator Award. He was an invited speaker at the 1994 International Congress of Mathematicians.

Douglas Simpson, Associate Director

Douglas Simpson was appointed as the Associate Director of IMSI on August 1, 2020. He has been a faculty member of the Department of Statistics at the University of Illinois at Urbana-Champaign since 1985, serving as chair of the department from 2000-2019. In addition, he served as director of the department's statistical consulting center 1995-2000. His research areas include applied and computational statistics, robust statistical methods, machine learning, and functional data methodology for quantitative image analysis. He was a recipient of an NSF Mathematical Sciences Postdoctoral Research Fellowship. He has served on NSF review panels and as a regular member of the NIH Biostatistical Methods and Research Design study group. He is a fellow of the American Association for the Advancement of Science, the American Statistical Association, and the Institute for Mathematical Statistics.

Takis Souganidis, Scientific Adviser

Takis Souganidis is Professor of Mathematics and Member of the Committee in Computational and Applied Mathematics at the University of Chicago. He works in deterministic and stochastic partial differential equations, and is interested in applied mathematics. He was a recipient of a Sloan Research Fellowship, and a Presidential Young Investigator Award. He was an invited speaker at the 1994 International Congress of Mathematicians and the 2019 International Congress on Industrial and Applied Mathematics. He is a Fellow of the AAAS, AMS, and SIAM.

Philip W. Hammer, Executive Director

Philip (Bo) W. Hammer was appointed Executive Director of IMSI on January 1, 2021. Hammer comes to IMSI after 10 years at the American Institute of Physics, where he was the founding and interim Executive Director of the AIP Foundation. He also led AIP's major antiracism initiative that addressed underrepresentation of African Americans in physics and astronomy. Hammer received his BS in Physics from Humboldt State University and his PhD in Physics from the University of Oregon. From

1991-93, Hammer was an ONR Postdoctoral Fellow at the Naval Surface Warfare Center in Silver Spring, MD. Hammer spent the '93-'94 year as an APS Congressional Science Fellow working on the staff of the Subcommittee on Science in the US House of Representatives. He worked at AIP from 1994-2000, and was Director of the Society of Physics Students and Sigma Pi Sigma. From 2000-2008, Hammer was a vice president of The Franklin Institute Science Museum in Philadelphia. Hammer is a Fellow of the American Physical Society.