Illinois Mathematics and Science Academy

Student Inquiry and Research
Summer Research Training Program

The Illinois Mathematics and Science Academy

The internationally recognized Illinois Mathematics and Science Academy (IMSA) develops creative, ethical leaders in science, technology, engineering and mathematics. As a teaching and learning laboratory created by the State of Illinois, IMSA enrolls academically talented Illinois students (grades 10-12) in its advanced, residential college preparatory program, and it serves thousands of educators and students in Illinois and beyond through innovative instructional programs that foster imagination and inquiry. IMSA also advances education through research, groundbreaking ventures, and strategic partnerships.

High-level student research is a cornerstone of IMSA's unique educational experience. Initially conceived more than thirty (30) years ago, the Student Inquiry and Research (SIR) program is a continually evolving program which enables students to learn how rigorous inquiry is done. After joining projects conceived of and/or championed by professional researchers, students conduct which concludes with the communication, in a peer reviewed forum (or equivalent). Research is conducted with on-campus experts or those from partner organizations, including Fermi National Accelerator Laboratory, Argonne National Laboratory, the Field Museum, and Loyola Medical Center. The work culminates with papers published and/or presented in peer reviewed (or equivalent) forums.

IMSA is a recognized leader in mathematics and science education at the national and international levels and serves students, educators and policymakers beyond Illinois. Several examples: (1) IMSA founded and helps lead the work of the National Consortium for Specialized Secondary Schools of Mathematics, Science and Technology which consists of 75+ member institutions, including IMSA and the similar residential programs in 14 other states; (2) IMSA provides extensive professional development in problem-based learning to teachers in the nation and abroad; (3) IMSA staff and students serve on important national panels and task forces and are invited as presenters at prestigious national and international conferences; and (4) IMSA is a model upon which a number of other schools in the U.S. and abroad are based.

Student Inquiry and Research

One of the most natural things for young people to do is to ask questions, to explore, and to dream. We learn about the world by experimentation, by model-making, and by prediction. We use this to generate ever greater skill sets and abilities. This process is inquiry, a way of asking and answering questions. Science is a method of undertaking inquiry. Science's central tenant is that the procedures employed generate answers that independent of the seeker. As a result, the answers to the questions will be the same no matter who answers the questions, how the answers are arrived at, or when. The art of doing science is the art of generating questions, methods of answering the questions, and of communicating the answers to the greater human community.

In fact, the scientific method is a specialized case of inquiry. We define inquiry as any set of methodologies in which logical arguments are formulated leading from a set of assumptions or facts to a set of conclusions. The logical arguments, in order to be accepted, must be independent of the source and based on assumptions or facts that are clearly stated and do not contradict one-another. Examples of other methods of inquiry include logical deductions, historical studies, and analyses of literature.

Just as there is no better way to learn to walk than simply walking, there is no better way to learn to explore than by doing it. The Student Inquiry and Research (SIR) Department is dedicated to aiding students' growth in science through a careful guidance of students through initial projects designed to expose them to all aspects of inquiry. Projects are cutting edge and relevant to the areas in which they are conducted but limited in scope so as to enable a student to complete the whole process in a timeframe that suits precollege students. The projects are deemed completed when they have been successfully submitted to peer reviewed conferences or the equivalent in the field of work.

A number of diverse projects are being undertaken by IMSA students under the guidance of scientists from partner institutions and on campus. These projects span a variety of fields including Alzheimer's research, historical studies, metaphysical investigations, theoretical physics, and energy research. We grow cells, chase flies, build models, and use a variety of tools and methods, all in the pursuit of knowledge. These projects add to the human knowledge and improve the human condition.

Introduction to the IMSA Summer Research Program

The IMSA Summer Research Training Program (SRTP) is a six week residential program designed to provide young people from all parts of Illinois and beyond with the opportunity to participate in cutting edge research. The SRTP puts research tools in the hands of students ready and willing to experience what it is like to be part of a research program. The goal is that, by the completion of the summer program, students will realize the awesome power they themselves control in terms of their ability to make positive and meaningful contributions to the world.

The ISRP comprises a six week intensive immersion in the scientific process, centered around few areas of scientific research. The areas are chosen from areas of active research at IMSA. Each IMSA researcher has a specific set of research goals that are part of their ongoing work. These goals change from month to month and year to year, reflecting not only what the individual researcher does, but also what the field is doing. Students are inserted into this process where the research is. For six weeks, students not only learn about the field as it is, but they participate in the active investigations going on at the time they are here.

Working with experts in their area of expertise on projects of current interest to the broader scientific community gives students a number of great experiences!

- Experience in a lab setting

Nothing can replace experience! Working in a lab environment enables students to see just what doing science is like. It's not just memorizing facts and solving problems based on what one finds in a book. It's about being creative, collaborative, communicative, and using all tools available to answer a real, unsolved question.

- Parsing hard problems

Few significant research questions can be answered in one step. It generally takes time and multiple steps, each building on one-another, to generate answers. Many times these require other, smaller questions which themselves require experiments, theoretical work, simulation, or any combination of these three. Students get experience attacking hard problems in systematic ways through achievable sub-goals

- Communicating results

Science *requires* the communication of results to other researchers in the area. There are lots of ways to do this ranging from lab meetings to conferences to publications. Students will participate in some of these activities, learning how to organize their thoughts and work into pieces that can be communicated and discussed.

As a world renowned educational institution and part of the Illinois Department of Higher

Education, IMSA is uniquely equipped to provide a world class research experience to students with diverse backgrounds in an environment that is both exciting and intellectually stimulating!

What Will I Be Doing During the Summer?

Since most students who participate in a summer research program have never participated in research before, we have crafted a program designed to give students a solid introduction to science in a way that enables students to contribute to a real, ongoing research effort. You will carry out your research by following the steps given below.

1. Choose your research project.

As much as possible, we want to give students the ability to pick from available projects rather than assigning projects. As a result, we will allow students to rank the available projects from most to least desired . We will then match up students with projects, attempting to give the most desired projects first and the least last.

2. Meet your Research Mentor and learn about the field of research

Each Research Mentor is different and each project is different. In fact, from year to year, both Research Mentors and projects will change. The first thing you will do is learn about your Research Mentor and the project. This will entail lots of reading, lots of discussion, and lots of listening. You will need to learn about what you're doing, why, what the approach is, and how you're going to accomplish the research goals you're trying to accomplish. You'll also be picking up, in a very abbreviated way, skills that are needed to accomplish the summer research goals of the project.

3. Preliminary research activities

You will carry out initial experiments based on the needs of your research project. These experiments will be primarily used to train you in the ways in which this work is done. Data produced during this stage will not be used in the larger research program. The focus will be on learning to use equipment, databases, and references; learning to document results; analyzing and interpreting results; and in developing new research activities based on the outcomes of those being undertaken.

4. Active research activities

At this point, you will understand the field, the set of activities to be undertaken, why they are being undertaken, and how the activities will be undertaken. Now it's time to carry out the proposed work, generating data that will be analyzed and understood in view of the larger research program. You and your research team will carry out the proposed activities, multiple

times if appropriate, and compare your results. Conclusions based on this work will be drawn together with your Research Mentor.

5. Communicate your results

You will produce a combination of a research after-action summary and research poster. The posters will be shared with the IMSA community during a short poster session during the last week. The posters and summaries will communicate what was done, why it was done, and how it moved the overall research effort forward.

2017 IMSA SRP Calendar

The IMSA SRTP is a six week program that runs from June 18th, 2017 through July 28th, 2017. The calendar is indicated below. The program runs five days a week with full eight hour days during the program.

June 18, 2017	IMSA SRTP begins. Students arrive on campus.
June 19, 2017	Students meet Research Mentors, find lab sites, get campus tour, and begin training.
June 30, 2017	Students complete prerequisite training and begin work on designing remaining summer research.
July 3, 2017	Students begin one-week in-field (lab, campus, computer) research activity and trial run period.
July 10, 2017	Students carry out data-generating research activity
July 25, 2017	Data-generating activity ends. Students begin write-up and poster preparation.
July 27, 2017	Final report due. Poster session on campus.
July 28, 2017	SRTP ends. Students depart campus.

The cost of the IMSA SRTP

The IMSA SRTP has the following fee schedule. Note that the fees are inclusive; they cover room, board, and the operational program costs.

Illinois Residents	$6,000.00
Non-Illinois Residents	$10,000.00

Limited Financial Aid is available to families in need. Please call the SIR office at IMSA at (630) 907-5885 or email at amlofthouse@imsa.edu to inquire about financial assistance.

IMSA Research Mentors and Research Foci

IMSA research is diverse, ranging from topics in physics to biology to engineering to history to social science. Each project is driven by a specific individual and reflects their individual interests and capabilities. Below is a subset of the areas of research that IMSA staff and faculty participate in.

Epidemiology

Dr. Jordan Hasler holds his PhD in mathematical biology from the University of Illinois. During his PhD studies, he worked with Dr. Lee DeVille focusing on epidemiology. He has taught a variety of mathematics course ranging from finite mathematics to geometry to Calculus.

Dr. Hasler is currently carrying out research in the area of mathematical epidemiology. Using the RSI model, he is looking at the dynamics of the spread of disease. He looks forward to continuing to teach and research with the students through the SIR program.

Satellite tracking solutions

Higgs boson (high energy physics) research

Dr. Peter Dong received his Bachelor's degree in physics and music from Harvard University and his Ph.D. in physics from the University of California, Los Angeles. Most of his research focused on top quark and Higgs physics at high-energy colliders.

Dr. Dong has recently branched out into satellite communication, in which he is leading a group. Additionally, Dr. Dong is in the midst of joining a research collaboration through the Fermi National Particle Accelerator Laboratory which will enable him to carry out research using data obtained from the Higgs project at CERN in Switzerland.

Russian History and Sociology

Game design

Dr. Kitty Lam received her doctorate in Russian history from Michigan State University in 2013 under the direction of Dr. Lewis Siegelbaum. Dr. Lam has published academic research articles on Finnish-Russian borderlands in the context of late Imperial Russia. She is currently working on a book manuscript entitled *Empire on Vacation: Finnish-Russian Encounters in the Karelian Isthmus Dacha Zone, 1890-1921*.

Dr. Lam is currently leading a research team examining the behaviors and interactions that led to the Great Terror in the Soviet Union from 1936 to 1938. Many factors contributed to the Great Terror including the perverse set of choices that individuals had under the social system imposed by Stalin. The question Dr. Lam is wrestling with is whether the actions of the various players in the system are natural consequences of the system or somehow unique to these players in the story. Dr. Lam is building, together with her team, an online multiplayer game intended to subject participants to similar conditions. Through this game-generated interaction, Dr. Lam hopes to gain insight into some of the factors that led to the Great Terror.

Motivation in Education

STEM learning

Generating and encouraging diversity

Dr. Adrienne Coleman received her Doctorate in Educational Leadership from Argosy University, Master of Science Degree in Health, Physical Education and Recreation with an

emphasis in Health Education from Illinois State University, and Master of Science in Educational Administration and Foundation with an emphasis in College Student Personnel Administration from Illinois State University.

Dr. Coleman has examined the role of motivation in the educational decisions of intellectually gifted populations of underrepresented students. Her published research is centered around understanding what the motivations of Black and Latino students in these populations report as their motivational factors in going into STEM. Dr. Coleman is expanding her research as part of a comprehensive approach that seeks similar data from additional intellectually gifted underrepresented populations (URP) including low income and rural populations, already identified as underrepresented in higher education.

Water Filtration Solutions Appropriate for the Developing World

Dr. Mark Carlson received his undergraduate degree in Biophysics from University of California Berkeley, his doctorate in Biophysics from the University of Virginia, and performed post-doctoral research at Cornell University. He was an Associate Professor of Physics at Benedictine University before joining the faculty at IMSA in 2007. Previously, his research involved heme protein spectroscopy and molecular modeling.

Since 2008 Dr. Carlson has been working on small-scale water filtration devices for the developing world. Partnering with Professor Emeritus Manny Hernandez of the Northern Illinois University, Dr. Carlson has led a team of students through a series of developmental steps in the generation of ceramics-based water filters. Professor Hernandez has gone around the world, aiding in the production of ceramic filter factories in varied locations enabling the inhabitants of developing societies to manufacture their own water filtration solutions on site. Dr. Carlson's research is aimed at improving the efficacy of these filters, increasing the elimination of harmful bacteria, the flow rate of the filters themselves, and the length of the filter's useful life.

Swarm Engineering
Entrochemical Systems

Dr. Sanza Kazadi is a graduate of IMSA who obtained both his BS in Physics and his PhD in Computation and Neural Systems from the California Institute of Technology. Dr. Kazadi founded and led the Jisan Research Institute, where he worked between 1995 and 2015. Dr. Kazadi worked primarily in the areas of evolutionary computation, swarm engineering, and entrochemical systems. In 2016, Dr. Kazadi returned to IMSA where he now leads the SIR program.

Dr. Kazadi heads two research efforts at IMSA. Swarm engineering, a term Dr. Kazadi coined in his PhD thesis, centers around the rational design of swarms that can carry out well defined tasks or have specific properties. At present, there is no accepted design methodology around swarms. Dr. Kazadi's research centers around generating methods of swarm design that are rigorous, provable, and predictive. Current research centers around the use of swarms of agents in making decisions collectively that individual agents in the swarm cannot accomplish. Work done in this area at IMSA will be presented in 2017 at the ICAART 2017 conference.

Dr. Kazadi's second research focus centers around the use of systems known as entrochemical systems to acquire useful energy from the environment and use it to do work. Long described as “impossible” by the physics community, this action is possible by coupling the energy acquisition to the water cycle with two positive entropy transfers. Dr. Kazadi has created two prototypical distillation devices using this process and hopes to develop this technology into a form that will enable people everywhere to use it to generate clean, potable water without the need for an energy infrastructure.

Miscellaneous Details

- The program is open to high school students. No preference is given to any particular race, creed, or sexual orientation.
- Students must have their applications to the Illinois Mathematics and Science Academy by April 1st, 2017.
- Admissions are rolling; student applications will be evaluated on a first-come first-served basis.
- All work is done in IMSA laboratories; students will be taught all required skills on site.
- Students will work side by side with their Research Mentor and other students in the program. This gives students the opportunity to collaborate with people doing things that are similar to the things students will be doing.

Eligible Students

Students are eligible to apply to the Illinois Mathematics and Science Academy Summer Research Program if they are between the ages of 13 and 17 and enrolled in 8th – 11th grades.

Application Instructions and Checklist

In order to apply for the IMSA SRTP, please fill out the application form and send it along with supporting documents indicated below to:

IMSA SRTP
Office of Student Inquiry and Research
1500 Sullivan Rd.
Aurora, IL 60506

or email it to:

amlofthouse@imsa.edu

Checklist:

☐ Application form
☐ Official school transcripts
☐ At least one and not more than three recommendation letters

ISRP

Admissions Application

Student's Full Name: Date:

Phone Number: Alt. Contact:

Home Address: Email:

Date of Birth: Gender:

Father's Name: Parent Contact:

Mother's name: Parent Contact:

Siblings name and age if applicable:

Hobbies:

Extracurricular Activities:

Year in School: Estimated GPA:

Class rank if applicable:

Awards/Honors:

Finally, we ask that you send a copy of unofficial transcripts from your educational institution and provide IMSA with a minimum of one letter of recommendation.

In this section, we will ask several short answer questions particularly relevant to research. We ask that you answer completely and truthfully to ensure acceptance of your application to be reviewed. These questions are used to evaluate you as a student as well as help us to gain an understanding of how to best provide a successful research opportunity for each individual student. If necessary, you may provide your answers on an additional sheet of paper. Please be sure all answers are typed.

1. Please describe what you believe scientific research entails and why you wish to undertake it:

2. What relevant research training and/or experience have you received either in or out of school:

3. What area of research interests you most and why:

4. Please describe your future educational and career goals: