

## Network Science for the Next Generation (NetSci High)

Program website at: [www.bu.edu/networks/](http://www.bu.edu/networks/)

### Overview

NetSci High, a collaboration between Boston University (BU), The New York Hall of Science (NYSCI), and SUNY Binghamton, develops a rich experiential research-based program for disadvantaged high school students, science research graduate student mentors, and high school STEM teacher mentors in New York and Boston. The program includes a summer camp, an intensive summer research experience at participating laboratories, an academic year research program utilizing collaborative IT tools, periodic special workshops, industry lab tours and “virtual visits,” an academic research conference where students present the results of their work, and summer IT internships with industry and academic partners.

### Project Design

NetSci High will provide an immersive summer enrichment camp at Boston University for high school students, graduate student ITEST Fellows, and high school STEM teacher mentors (divided amongst three “cohorts” for each year of the project). The students and teachers will be drawn from urban Title I high schools in Boston and New York, as well as a focus on young women from the New York-Binghamton area. The summer camp will be followed by summer and academic year research-focused experiences. Student groups will collaborate with partnering research laboratories and pursue collaborative research projects on complex networks that integrate IT tools and practices. The summer and academic year program outside of the summer camp will also leverage the informal and formal capabilities and programs at Boston University and NYSCI, as well as collaborative technologies, to provide weekend workshops as well as field trips to IT-focused companies and academic groups so that students can gain practical insight on how IT tools and practices are used in the real world ITEST Research Conference to be held at Boston University each spring. Following the academic year research program, students will be provided with industry and academic IT and STEM research internship opportunities incurring zero project costs.

Summer Semester I	Fall Semester	Spring Semester	Summer Semester II
Summer Camp	Academic year research program with weekly and monthly progress reports	Academic year research program leading to development of research papers	IT summer internships
4-week research experience	Online collaborations	Online collaborations	Online Collaborations
	Periodic special events and virtual visits	ITEST NetSci Research Conference with IT-Opportunity Fair	

## **High School Teacher Mentors and Student Groups**

The design of NetSci High is focused on building cohesive teams of Grades 10-11 high school students with a corresponding teacher mentor from the same school and a research-based graduate student mentor from one of ten partner laboratories, termed an ITEST Fellow. While the various participants support each other, they will be further supported and enriched by project staff, other members of partnering research labs, and parents/guardians. Each participant will be offered a stipend as an incentive to fully participate and to foster accountability.

All student participants will be engaged in “cognitive apprenticeships” in which conceptual and factual knowledge is taught in the context of using IT tools to solve research problems. Through cognitive apprenticeships, students will learn by:

- (1) Carrying out tasks in an environment that mirrors how these activities would be accomplished in the real world;
- (2) Working in a dynamic social setting that is cooperative;
- (3) Choosing tasks and setting personal and group goals that are intrinsically interesting, and;
- (4) Receiving guidance from layers of mentors (ITEST graduate student Fellows, teacher mentors, undergraduate volunteers, parents/guardians, and project staff).

Student teams will each consist of four high school students. The project is aiming for four teams from Boston, three from New York City, and three from New York-Binghamton, as a “Northeast regional” effort focused on research in network science. All teacher mentors will be seasoned teachers with whom we have already collaborated in similar efforts.

Based on our ongoing experience with the NetSci-High program, it will be explained to students and parents/guardians what the expectations are for participation in the program and anticipated outcomes—most especially the transition to IT internships and opportunities for employment. We will open our program to all students, but also focus on extending invitations to those students who teachers identify as not fulfilling their potential due to limited opportunities, lack of perspective, or poor motivation. Students will be required to submit an application via the teacher mentor for their school and will be coached through the process of obtaining a letter of support from a science or mathematics teacher whom they feel knows them best as well as a letter from their parents or guardians.

## **Summer Camp**

Each of three cohorts of participants—40 high school students, 10 teacher mentors, 10 ITEST Fellows and project staff—will convene for two weeks at an annual immersive two-week summer camp at Boston University. We will make use of the existing infrastructure that Boston University Summer Term has established. The Summer Term program hosts a number of high school focused activities meant to introduce students to research experiences at different levels, from six week intensive research to one week research “preview” for over 500 students each summer. Accordingly, we will combine our program with activities they have developed, especially social activities. Additionally, our summer camp will include sessions on career counseling available to us through Boston University’s Center for Career Development. The design of the summer camp will be developed in the preceding spring semester through

collaborations of ITEST Fellows, teacher mentors and project staff. The purpose of this summer camp will be to: motivate students and teachers about network science; teach basic skills students will need for their research projects; codify the teams and graduate student (ITEST Fellow) mentors, and model strategies for online collaborations.

## **Motivation**

One core set of activities for the summer camp will be motivating students about how network science can be used to understand complex real-world problems. Research topics being explored by partnering labs will be presented by the ITEST Fellows and the corresponding faculty PI or senior personnel. The purpose of these accessible interactive lectures is to provide perspective and context for students. We will also help students appreciate the role that information technology tools play in research, from large-scale computations to data visualization. Additionally, our activities will be geared towards showing students that the practice of science research is accessible to them.

We are hosting the summer camp at Boston University to leverage the many laboratories and researchers who will be able to participate. Laboratories of possible interest to students include: (1) Center for Computational Science which manages the university's supercomputer facilities; (2) Center for Scientific Visualization which hosts the Laboratory for Immersive Virtual Environments (stereoscopic display to create the illusion of three dimensions, head-tracking to update the viewer's position, and hand-held or hand-worn input devices to interact with the scene) and the Deep Vision Display Wall (a 15-foot display to visualize large scientific data sets at very high resolution and in 3D); (3) College of Engineering which hosts the Biological Information Processing Laboratory, Broadband Wireless Communications Laboratory. These laboratories will host tours and other activities during the summer camp to help participants appreciate the ways in which IT tools are used in research.

## **IT Skills**

Activities will consist of building IT skills, using IT in the context of science and society, and discussing perspectives on technology—including advantages and disadvantages. Through working with teacher mentors and ITEST Fellows, we envision developing activities based on the results of a front-end student assessment to determine what fundamental IT and network science concepts need to be developed. This effort will strive to make the experience for students as rich as possible for students.

We anticipate identifying a number of necessary background concepts around which we will need to develop activities to support. These may include such skills as using computers to gather and plot data, regression and error analysis, computer programming, elements of network analysis, and web-based publishing. Many of these skills can be learned in the context of the network science focused activities. Some may require special training outside of that context. We will take advantage of the hands-on IT tutorials offered by Boston University's Office of Information Technology. These include tutorials on such topics as: PC, Macintosh and Linux operating systems; data transfer using FTP and other tools; data tools such as Microsoft Excel, Statistical Package for the Social Sciences (SPSS), Statistical Analysis Software (SAS), and other plotting packages; Web tools such as search engines, HTML coding and content management tools; and scientific visualization and modeling tools.

We will train students' creative and exploratory abilities that are essential in every scientific endeavor, but are not often or effectively taught in conventional K-12 educational settings. We will structure those abilities into the following seven "phases" and each of them will be taught through hands-on exercises using IT tools:

- (1) Data collection, processing and visualization skills: scientific literature search, data retrieval from online/offline repositories, file conversion, importing data to computer, plotting data, searching and filtering data, drawing networks.
- (2) Data analysis skills: drawing histograms, basic descriptive statistics (mean/median/mode, min/max, variance/standard deviation), counting, classifying, measuring network properties.
- (3) Pattern discovery skills: inductive reasoning, line fitting by hand, calculating correlation, linear/nonlinear model fitting, clustering, comparing different network topologies, path finding, community identification.
- (4) Hypothesis generation skills: abductive and deductive reasoning, developing multiple explanations (hypotheses) for discovered patterns, making predictions using hypotheses, assessing and comparing plausibility of hypothesis.
- (5) Research design skills: developing relevant research questions, identifying variables, designing research protocols (experimental or analytical), choosing research methods, human subject protection, ethical issues in scientific research.
- (6) Research implementation skills: conducting experiment/analysis, data management, lab note taking, evaluating results and re-designing research protocols.
- (7) Scientific communication and presentation skills: logical writing, referencing, visual data presentation, creating PowerPoint slides, creating posters, oral presentation, scientific communication.

The curriculum of the 12-day summer program will flow roughly in this order, giving the students a model experience of how a scientific research project unfolds through multiple steps. To facilitate this, we will prepare a mock data set of some biological or social networks and several research scenarios that can be pursued by using the data. Throughout the entire curriculum, students will be encouraged to ask "What is X?" or "How to do Y?" types of questions, and the instructions will be adjusted flexibly along the students' interest and curiosity.

### **Developing Research Teams**

The Summer Camp will focus on developing IT skills and STEM content learning leading to the formation of high school student research teams, each with a graduate student mentor, ITEST Fellow, and high school teacher mentor. While the makeup of the individual teams will be somewhat known in advance (based on which schools the high school students come from), a key activity of the summer camp will be to codify the teams to match them with research groups and projects. The goal will be to establish teams by the end of the first week so that the second week of the camp can be devoted to team building. By the end of the second week, teams will have clear research goals and will be ready to begin a 4-week summer effort of engagement in their research project.

### **Online Collaborations**

For today's young people, the next generation of our IT workforce, digital tools are an essential currency for learning and communicating. Multi-user technologies such as

social media sites, interactive maps and collaborative media creation software allow students to share their findings with a larger group and to build what Shneiderman (2008) calls Science 2.0 learning communities. These multi-user technologies can provide an authentic platform for sharing data, aid in understanding the relationship between social and individual learning, and enhance possibilities for understanding complex dynamic data (Edmonds & Candy, 2005). The use of both social tools and visual data environments deepen creative and reflective learning of complex processes, concepts, roles and activities.

Accordingly, our project will utilize collaboration technologies to allow for interaction of distributed participants. Such a distributed effort, we feel, is an important aspect of the program because it mirrors how science research is practiced. Most research requires interactions with colleagues who are not “next door.”

One principal feature is an online portal, which we will build during the first several months of the project to be launched for the first summer camp. The portal will aggregate a variety of existing collaboration tools such as Google Docs and Skype along with social networking platforms such as Ning. We will also leverage tools we have used successfully in other projects such as collaborative wiki systems, listservs and message boards. Our aim is not to develop a proprietary infrastructure because we want students to be able to utilize typical tools that will be commonly available in a variety of settings, such as school, home and the lab.

As examples, when students do research at school, they will be able to collaborate via Skype or through our collaborative website with both the ITEST Fellows and project staff (in addition to teacher mentors). Student groups will make all project participants aware of the times they are working by utilizing our online shared calendar, and we will have a support system in place to check in with and support each student group, from face-to-face support by teacher mentors during the weekdays after school to online support using collaborative technologies.

Finally, NYSCI will develop and conduct a network science “Virtual Visit” for use during the summer session to do live network science demonstrations from NYSCI’s Connections exhibition. This will include associated hands-on activities, and professional development resources intended to enhance the student’s understanding of network science and the teacher’s ability to give students a broader context for network science and how it is used for investigating complex scientific phenomena.

## **ITEST Fellows**

ITEST Fellows, advanced graduate students from partnering research laboratories, will be recruited to participate in the program. They will serve as core mentors for student research teams. Similar to the GK-12 Program, we will seek to involve graduate students who have expressed a keen interest in outreach. Accordingly, our budget proposes stipends for these students (one Boston University student is supported as personnel). We anticipate a substantial time commitment during the summer, when time of all participants is most flexible, and a more supportive role during the academic year. ITEST Fellows will help develop and attend the summer camp as well as mentor their assigned student team in the laboratory for a 4-week program after the summer camp.

There will be parallel workshops for ITEST Fellows (and teacher mentors) during the summer camp. At the beginning of the summer camp while high school students

are learning basic skills, we will have training sessions for graduate students and teacher mentors. The sessions will provide a forum for ITEST Fellows and teacher mentors to discuss approaches to mentoring.

### **Summer and Academic Year Research Program and Conference**

After the 2-week summer camp, research teams will use a roughly 4-week period during the rest of the summer to begin their research projects. The 4-week research program will provide student teams with an opportunity to intensively pursue their research goals outside of the constraints and demands of school. During the following academic year, student groups will continue their research in various after-school activities. While each group will choose an approach that works best for them, we propose a typical working model. For the 4-week summer program, we anticipate student research teams to devote at least 20 hours per week working in research labs. For the academic year during weekdays, students will formally work on their research projects after school while mentored by their teachers during one to two afternoon sessions per week. On weekends, students will be provided with opportunities to work at their partner laboratory while being directly mentored by their ITEST Fellows. Various other models can be explored, including making Boston University and NYSCI technology laboratories available to students.

Since this is research being performed by high school students, typically with no prior research experience, in addition to the face-to-face and online supports, student groups will provide regular reports on progress. Weekly summaries will be submitted online for review by labs and project staff. We will ask students to discuss the activities they have done during the week, address any technical or scientific issues they may have, and discuss a plan for the following week. This effort, while perhaps time consuming, is critical to ensure that projects remain on track and problems are documented and identified. The reports will be reviewed and commented on by teacher mentors, ITEST Fellows, and project staff, as appropriate. The academic year research program will culminate in the one day ITEST NetSci Research Conference held at Boston University in the late spring of each year. All stakeholders will be invited and include all project participants (high school students, ITEST Fellows, teacher mentors, parents) as well as school community members (teachers, students and administration) and the network science research community. In this programmatic element, we are departing from the existing NetSci-High program, which includes a competition and travel to the NetSci conference for winning teams. Instead, we felt it was important to continue the community cohesiveness we are establishing for the entire year through an independent student-focused conference. The conference will have a select few keynotes from industry and research leaders, but the major focus of the conference will be student team presentations and discussions. Additionally, the conference will have an "IT Opportunity Fair" hosted by local industry during the afternoon that will allow students to learn about opportunities for summer internships and other ways to become engaged in the industry.

### **Volunteer Participants: Parents/Guardians, Undergraduates, IT Industry**

The project will involve multiple types of volunteer participants. Parents and guardians will be given accounts with access to our online support system. This system will allow them to see the progress their students are making as well as learn about network science. They will have the ability to connect with all project participants and

be an integral part of the overall program. Parents will be provided with information in their native language on how to navigate this system and how to access the appropriate technology within their communities. In addition, we anticipate participation of other researchers in partnering laboratories beyond the ITEST Fellows. Of course, each Fellow is part of a larger group, so high school students will be exposed to faculty and other students, and we expect that they will participate in laboratory meetings and other group collaborations.

Boston University has a long tradition of involving undergraduates in volunteer opportunities through its Community Service Center (CSC). Through several annual programs and events, more than 3,000 volunteers contribute over 90,000 hours of service in the Greater Boston area and across the US. We have reached out to the CSC on other projects, with good success, and will do the same throughout the course of this project. Undergraduates will help in a number of ways. First, they will be invited to serve as additional mentors during the Summer Camp. We will draw from students who are already on campus during the summer, so they would not incur subsistence costs. These students are typically driven to help in the community and many of them will be already pursuing summer research in other Boston University laboratories. We have found that many of these students are dedicated to the goal of helping others (high school students) achieve similar opportunities. During the academic year, undergraduate volunteers will be invited to participate in all aspects of the project.

While students will be participating in research most weekends, there will be periodic “IT Special Events” or a workshop on a weekend day twice per semester that will involve industry volunteers. Both Boston University and NYSCI will offer events such as focused area museum tours, industry tours, and career presentations by scientists and IT professionals in the community. By involving IT-industry volunteers in the academic year activities, we hope to build and sustain interest that will help lead to industry internship opportunities and participation in our proposed “IT Opportunity Fair” during our research conference.

### **Transition Beyond the Year-Long Experience**

Of particular importance is the fact that the students’ year-long research is aimed at providing opportunities to utilize skills they have learned in possible industry and academic internships. This aspect of the project does not incur budget expenses, since it is mostly outside the formal scope of the project.

When students “graduate” from their research participation, if they wish, the project will assist in helping them in applying for and obtaining summer internships. Boston University and NYSCI have a number of industry and academic partners, and the breadth of opportunities is not limited to network science. As discussed above, we will involve IT-industry and academic partners as volunteers during the academic year and invite them to our end-of-year research conference. During the lunch break of that conference, corporate and academic partners will host our “IT Opportunity Fair.” New York based students will also be given the opportunity to feed into the renowned Science Career Ladder and become paid explainers for NYSCI science programs and gallery experiences.

**For more information on the NetSci High Program, contact Paul Trunfio at [trunfio@bu.edu](mailto:trunfio@bu.edu)**