LLE BEST Student and Teacher Research Program: Broad Exposure to Science and Technology

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The primary goal of the Broad Exposure to Science and Technology (BEST) Research Program is to engage underrepresented high school students and their teachers in various aspects of science and technology that support LLE's laser science and applications research. This broad exposure helps guide students in their pursuit of STEM fields and encourages them to explore the next generation of related jobs and careers. Teacher participation equips educators with knowledge and experience that can be brought back to their schools to enhance science and technology curricula during the school year. The BEST program was carried out at East High School within the Rochester City School District (RCSD) during the summer of 2021. Four high school students and two teachers participated in the pilot program (Fig. 1). This research experience occurred over a six-week period during the months of July and August.

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Figure 1
The participants of the BEST program in 2021 included (from left to right) East High teachers Trent Russell and Gavin Jenkins, East High students Yusuf Gazali, Reganae Walters, Taiasia Gibson, and Ramir Wearen, and program coordinator Terry Kessler, LLE Diversity Manager.

The teachers and students were exposed to different areas of science and technology research such as optical microscopy, optical testing and design, holography, liquid crystals, the Omega Laser Facility, and technical communications. The importance of engineering support for research, including chemical, electrical, mechanical, optical, computer, and workspace engineering, were emphasized to highlight the extensive teamwork required to make advancements in these fields. Students and teachers were given tours of LLE's laser science and technology laboratories during the program period.

The BEST team attended LLE Zoom presentations and discussions each week. They carried out science and technology research at East High School using temporarily relocated LLE equipment including microscopy, interferometry, and holography systems. Some examples of the many experimental activities are shown on the screen located in the middle of the white board (Fig. 1). The white board or "Google Board" displays each day's goals and the many questions generated by the students and teachers during lectures, demonstrations, and laboratory investigations.

Large scientific institutions, such as UR/LLE, employ many different types of professionals to carry out their research activities. Each of the many research and support activities requires teams consisting of these professionals. This matrix relationship shown in Fig. 2 is what allows LLE to maintain a successful research program. Exposure to this science and technology matrix provided the students and teachers with an understanding of the broad diversity of research activities as well as the rich diversity of individual professionals that enable the research to flourish.

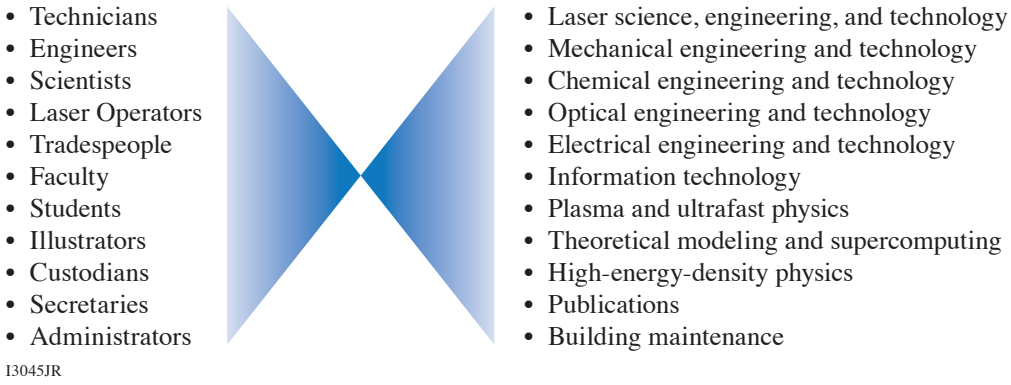

Figure 2
The BEST students and teachers were introduced to the many employment positions (left) that constitute the workforce at LLE. These positions support the wide variety of activities (right) needed to maintain the thriving science and technology research at LLE. Exposure to the LLE workforce provides guidance for students to choose their education and training experiences.

A team of LLE volunteers worked with the BEST students and teachers in a variety of science and technology fields (see Fig. 3). Each volunteer spent between one and four days at East High school over a six-week period. The program coordinator provided backup in order for the team members to maintain a flexible schedule during the summer months. Each volunteer, being an expert in their research field, was able to bring detailed information, coupled with hands-on opportunities, into the high school laboratory environment. For future summer programs, it is envisioned that the students and teachers will be exposed to additional fields of science and technology including laboratory operations, light–matter interaction, publications, and the technology trades that support all research activities at LLE.

LLE mentors exposed the students and teachers in the BEST Program to various technologies that are critical to the design and operation of the OMEGA 60 and OMEGA EP Laser Systems (see Fig. 4). Circuit board technologies were explored by dissecting computer systems, studying hardware design, and practicing the microsoldering techniques used to assemble electronic components. Laser hardware, such as alignment lasers and laser amplifier materials, were brought into the classroom for demonstration and exhibition. In addition, the phase transitions of liquid crystal materials were investigated, while optical components used to control the polarization and color of light were manufactured. This broad exposure highlighted the technologies that connect electronics, optics, and chemistry to laser systems.

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Figure 3
A team of nine LLE participants [(shown left to right) Terry Kessler, lasers/holography; Karen Cera, laboratory safety; Stavros Demos, spectroscopy/microscopy; Tanya Kosc, light polarization; Mike Krowl, electronics technology; Ken Marshall and Nate Urban, liquid crystals; Brian Kruschwitz, grating applications; and Nickolaos Savidis, optical design] worked with the BEST students and teachers in a variety of science and technology fields including laboratory safety, holography, spectroscopy, microscopy, light polarization, mechanical systems, electronics technology, liquid crystals, chemistry, diffraction gratings, and optical system design and prototyping.

(a)

(b)

(c)

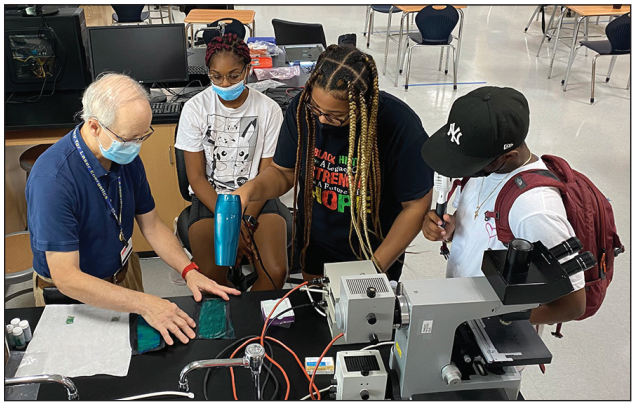

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Figure 4
(a) Tanya Kosc, Optical Materials Technology Group Scientist, is shown exhibiting a neodymium-doped laser amplifier rod. (b) Mike Krowl, Electronics Group Technician, is shown instructing the students and teachers in circuit board technology including computer components and microsoldering techniques. (c) Ken Marshall, Optical Materials Technology Senior Research Engineer, is shown working with students on techniques to apply layers of liquid crystal to flexible fabrics.

A holographic interferometer was constructed at East High to record array-generating diffraction gratings. The number of reconstructed spots (orders) was plotted as a function of the development time in seconds (Fig. 5). Students view the multicolor orders by looking through the diffraction grating at a white-light source. The array of multicolor spots was photographed showing the characteristic blue to red angular shift for each order. This activity provided the hands-on experience to understand how gratings and grating spectrometers work. LLE mentors built on this experience to instruct the students and teachers on the basic concepts of chirped-pulse amplification and smoothing by spectral dispersion, two important laser schemes to produce high-intensity short pulses and uniform focal spots, respectively.

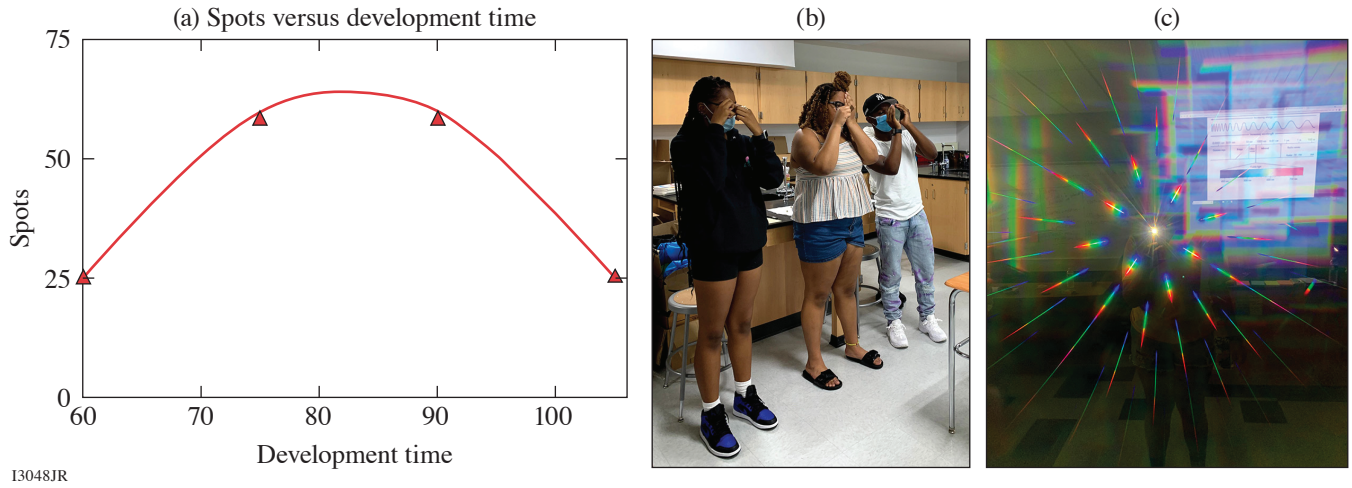

Figure 5
(a) The number of reconstructed spots from a multi-order diffraction grating was plotted as a function of the development time in seconds. (b) Students view the multicolor orders by looking through the diffraction grating at a white-light source. (c) The array of multicolor spots shows the characteristic blue to red angular shift for each order.

Spectroscopy is the study of the absorption and emission of light and other radiation by matter. There are numerous applications of spectroscopy at LLE including optical material composition analysis, light-scattering investigations, and the study of laser–matter interaction. Brian Kruschwitz, Group Leader of OMEGA System Science, worked with students to construct a grating spectrometer in a chemistry classroom at East High School. Stavros Demos, Group Leader of Optical Materials Technology, brought a spectrometer into the classroom to measure the wavelength transmission of optical filter glass. Using a color scale on a large classroom monitor, the students were able to make visual assessments of the filters' transmissions in order to compare objective and subjective spectral analyses (Fig. 6).

Due to COVID 19, the BEST participants visited LLE for only one day during the last week of the summer program to tour the OMEGA and OMEGA EP lasers, optical manufacturing facilities, and other support laboratories (Fig. 7). Together, the students and teachers were exposed to elements of science and technology that underscored the importance of their normal high school curricula. In addition, this group participated in tours of optics and imaging-related departments at Monroe Community College, the Rochester Institute of Technology, and the University of Rochester.

An important aspect of the BEST program involves the students' roles as ambassadors for outreach to other students enrolled at East High and other RCSD high schools. Two projects were completed for this purpose. First, the students and teachers created a PowerPoint presentation showing the broad range of science and technology topics included in the program. Second, a photomontage video was created to show the relationship between the BEST program and the work carried out at LLE. This video was accepted as an Innovative Spotlight in the 2022 University of Rochester Equity, Diversity, and Inclusion Leadership Summit. In planning for the 2022 BEST program, students from several RCSD high schools including East High, Young Women's College Prep, Monroe Upper High, and Rochester Early College others are being invited to participate.

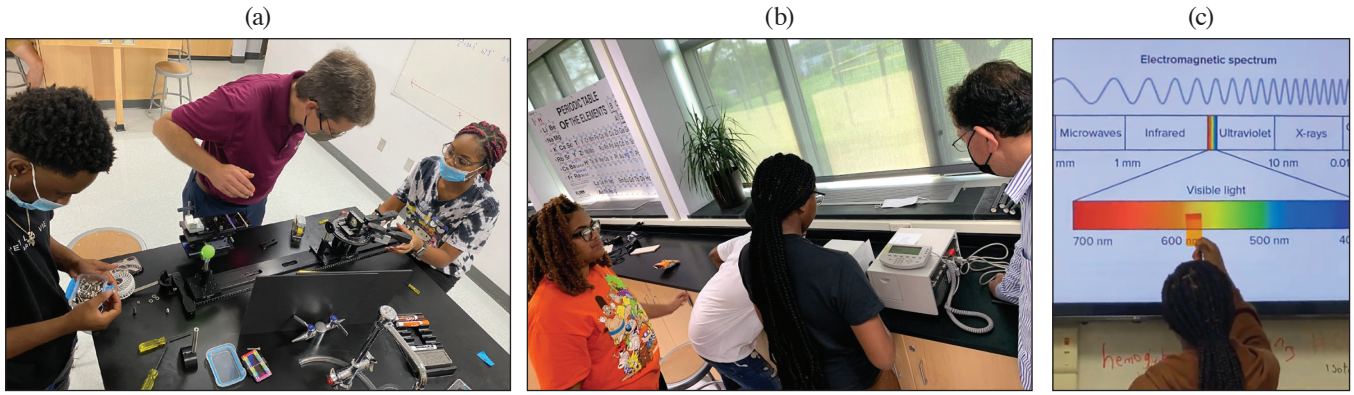

Figure 6
(a) Brian Kruschwitz, System Science Group Leader, is shown working with Ramir Wearen and Taiasia Gibson to construct a grating spectrometer. (b) Stavros Demos, Optical Materials Technology Group Leader, is shown demonstrating the procedure for operating a spectrometer to measure the wavelength transmission of optical filter glass. (c) Taiasia is shown visually comparing a glass filter to a large spectral scale.

Figure 7
The BEST students and teachers visited various LLE laboratories. (a) Amy Rigatti, Optical Manufacturing Group Leader, explains the work carried out in the coating facility. (b) Mike Campbell, LLE Director, discusses science and education with East High students Reganae Walters and Taiasia Gibson.