Optical Engineering

GUEST EDITORIAL

# Special Section Guest Editorial: Education and Training in Optical Instrumentation and Lens/Illumination

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The impact of optics in our modern world is vast, with applications ranging from photography, aerospace and defense, medical devices, consumer electronics, environmental monitoring, augmented and virtual reality, and machine vision. As technology increasingly relies on optics, the demand for a well-educated and technically proficient workforce in this field grows accordingly. However, optics remains a specialized discipline, without the widespread public familiarity and educational resources of some other more general fields.

While efforts to increase engagement through specialized optics societies (SPIE and Optica) and dedicated university and graduate programs have been made, the need for a robust educational framework persists. Educators face challenges such as determining which essential topics to teach and the most effective methods of presenting the material. Simultaneously, aspiring students and early professionals grapple with foundational questions, such as where to begin their studies and which areas of optics will lead to the most impactful and successful careers. Clear guidance from a reliable body of experts can facilitate the advancement of optics education and the growth of the field.

This special section of *Optical Engineering* is dedicated to optics education, with a strong focus on lens and illumination design, as well as optical instrumentation. The collected manuscripts aim to provide a valuable resource for educators designing optics curricula and professionals looking to enhance their optical engineering skills and knowledge.

One of the most important areas of optics education is course design and recognizing the current educational challenges both socially and economically. Kruschwitz, Brown, and Zavislan share lessons learned from the Hybrid Optics Master's Education Program, highlighting methods to foster connections between professors and students and discussing the challenges in providing in-person labs for working students with limited travel ability. Similarly, Aikens describes the formation of an online lens design course aimed at training students to become proficient optical designers, emphasizing mentorship and structured design exercises. Additionally, Vogt gives commentary on the structure, objectives, and methodologies of the Optics Systems Technology Program at Monroe Community College, which has seen growth of enrollment and graduation rates of optics technicians over the last several years. Finally, Fuadi, Ayop, and Nursulistiyo address academic readiness for future optics careers by investigating the curriculum across several international high schools, highlighting challenges and differences in educational resources and government requirements.

In addition to good course design, novel pedagogical approaches are important and can help with the understanding of fundamental and complex optical concepts. For example, Menard introduces a streamlined technique for performing ray-tracing of Gaussian laser beams that is based on classical ray-tracing and is described to be more intuitive than approaches that require computing and separating complex variables in matrix math. In a similar fashion, Sasián discusses the structure and control of oblique spherical aberration and presents mitigation

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techniques to help guide students in reducing these types of aberrations in their own systems. In contrast to these high-level topics, Boone addresses the importance of general optics outreach by focusing on short-form content creation, tailored for non-STEM audiences, which can be used to heighten public awareness and interest in optics.

While proper teaching techniques are critical in building a strong optics foundation, it is equally important to utilize computational tools to help with the visualization of these abstract ideas. Kruschwitz presents examples of computer-based simulation tools that can be an effective component in the teaching of aberrations, interferometry, and optical testing. Fabre et al. review the potential for immersive virtual reality, identifying situations where it can be used to support optics learning, such as the realistic training of using large equipment, both safely and under distraction. Similarly, Lukas et al. introduce the Extended Reality Twin Lab framework, a tool designed to facilitate remote learning on practical training and provides an example of the usefulness of this technology by describing a fully integrated remote-controllable Michelson interferometer.

Lastly, a fundamental component of any scientific curriculum is the usage of lab-based practicum that can augment strong foundational knowledge with invaluable intuition. Simmons discusses how various types of 3D printers utilize a variety of groundbreaking optics technologies and demonstrates how these printers can be used to produce cost-effective labs, such as phone-based microscopes, spectrometers, and optomechanical mounts. Kumar and Rani detail a cost-effective single-beam experimental setup for conducting a range of experiments related to the diffraction and interference of light, covering experiments such as diffraction patterns, the Poisson spot, and spatial frequency filtering. Marciniak describes a radiometry lab experiment that utilizes a Fourier-transform infrared spectrometer to collect and analyze spectral data of an unknown sample in order to teach students about instrument calibration, data collection, and data analysis. Finally, Marzoa and Vallmitjana present a experiment where students recreate Galileo's observations of Saturn by comparing image data acquired with a low-quality telescope against images acquired with an improved design, in order to illustrate how equipment can limit the quality and accuracy of scientific experiments.

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