Highlights from the SPIE Optical Engineering special section on education and training in optical instrumentation and lens/illumination design

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ABSTRACT

Over the past year, the authors have been editors on a special section of the SPIE peer-reviewed journal *Optical Engineering* focused on education and training of a global workforce in optical instrumentation and lens/illumination design. In this presentation, we seek to provide an overview of the selected papers in the special section and discuss the highlights of optics education innovation occurring at academic institutions around the world.

Keywords: Education and training, optical instrument design, lens design, illumination design, online education, software tools for education, workforce development, outreach

1. INTRODUCTION

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 (e.g., SPIE, Optica, and European Optical Society) 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.

To help address this need, the authors have been guest editors on the special section of the SPIE peer-reviewed journal *Optical Engineering* focused on education and training of a global workforce in optical instrumentation and lens/illumination design [1]. In this paper, we seek to provide an overview of the selected papers in the special section and discuss the highlights of optics education innovation occurring at academic institutions around the world.

We begin by summarizing the papers in the special section. We then described our approach for seeking authors to contribute to the special section. We lastly discuss difficulties that we encountered during the peer review process and how those were overcome.

2. SUMMARY OF PAPERS IN THE SPECIAL SECTION

One of the most important areas of optics education is course design and recognizing the current educational challenges both socially and economically. Kruschwitz et al. [2] share lessons learned from the Hybrid Optics Masters 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 [3] 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 [4]. Finally, Fuadi et al. addresses academic readiness

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for future optics careers by investigating the curriculum across several international high schools, highlighting challenges and differences in educational resources and government requirements [5].

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 [6]. In a similar fashion, Sasián discusses the structure and control of oblique spherical aberration and presents mitigation techniques to help guide students in reducing these types of aberrations in their own systems [7]. 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 [8].

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 [9]. Fabre et al. reviews 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 [10]. Similarly, Lukas et al. introduces 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 [11].

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 [12]. 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 [13]. 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 [14]. Finally, Marzoa and Vallmitjana presents an 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 [15].

This summary of papers in the special section is reproduced from the special section guest editorial [1].

3. LESSONS LEARNED FROM HOW WE RECRUITED AUTHORS

This special section had numerous submissions which has led to fourteen published papers. This large number of published papers reflects the many authors that were interested in submitting to our special section. While the primary credit for these submissions should go to the authors, without whose hard work the special section would not have been possible, we would also like to share some of the methods we used while soliciting contributions to this special section.

We began with standard approaches. We looked at conferences related to education, including the bi-annual Education and Training in Optics and Photonics (ETOP) (e.g., [16]), SPIE's Optics Education and Outreach (OEO) (e.g., [17]), and emailed authors that we thought would be interested. We looked at major optics education institutions, including well-known colleges and universities, and solicited papers from the faculty. We contacted educators that were teaching classes outside the universities, including at conferences like this one. We networked at conferences. We sent a lot of emails.

First author Nick Takaki personally found some other things to be helpful, too. When seeking authors, he received help and suggestions from many. Groot Gregory and Matt Posner, who were involved in a special section on *Education and Training in Quantum Sciences and Technologies* [18], gave useful advice. Tina Kidger, of Kidger Optics Associates and who remains involved in optics and lens design, was helpful in connecting him with potential authors. Members of SPIE's Education and Outreach Committee and people involved in Education Outreach at Optica also gave useful advice, as did faculty and students in his network that were associated with major optics institutions. These suggestions were enormously helpful.

Jungwirth found that the old-fashioned approach of scrolling through his digital Rolodex led to several papers. Prof. Zach Simmons [12] was his undergraduate physics research partner from the University of St. Thomas, a smaller liberal arts school in St. Paul, Minnesota, USA. Prof. Jose Sasián [7] taught him lens design in graduate school at the University of Arizona. He served on an SPIE Executive Committee with Cory Boone [8]. In short, personal connections can often lead to positive results.

In terms of paper focus, directly connecting with potential authors to discuss their proposed papers was of value. While not all these yielded submissions, by engaging with the potential authors directly, we could help better understand the current interests of the field and help tailor the submissions to fit withing the special section and to be more easily reviewed, especially for a special section where portions of the manuscript would be based somewhat on personal analysis and commentary. In short, we wanted to rely on the expertise of these potential authors to figure out what they thought would make a successful submission.

In addition to these steps, it was also paramount to stay organized. Spreadsheets were useful to collect potential authors, identify potential connections, and potential manuscript topics. The spreadsheets also allowed us to determine when it was necessary to follow up with potential authors to provide them with the most current information about the special section and to gauge their interest in participation.

4. LESSONS LEARNED DURING THE PEER REVIEW PROCESS, INCLUDING FINDING REVIEWERS

Successfully completing the peer review in general is an ongoing process with difficulties for authors, reviewers and editors. In this special section, we ran into a few unique challenges and had some specific solutions.

Perhaps not uniquely, our first challenge was finding reviewers for the papers that were submitted. Most professionals requested to review are active participants in their academic or industrial careers and finding time to review papers could be arduous for most [19]. Since reviewing is typically not formally recognized by academic institutions and journals, the professional gains for reviewing seem diminishing. Moreover, literature suggests that lack of time is the principal factor in the decision to decline to review a paper irrespective of the reviewers are offered financial incentives for reviewing or not [20]. In other words, finding reviewers for journal articles is generally not easy, and from our experience becomes even trickier for papers that are not traditional original science articles but instead on innovations in education within a certain field.

We did a handful of things that helped me be successful. First, while searching for authors to submit to the special section, we also asked people if they wanted to be involved as reviewers. Consequently, when papers were being submitted, we already had a pool of people who were interested in being involved as reviewers and understood the scope of the special section. Second, we often considered authors of papers in the special section to be reviewers of other papers. These authors were necessarily familiar with the scope of the special section, and moreover were demonstrably qualified to be reviewers on papers on the topic of education. These strategies together meant that we often did not have to reach out to more than four potential reviewers for this special section. In contrast, in our experience as editors for *Optical Engineering* it is sometimes necessary to reach out to as many as eight or more potential reviewers for an ordinary submission. Of course, this success owes an enormous amount to the reviewers, and we extend great appreciation to those readers that reviewed a paper for this special section. Finally, when the list of potential reviewers was exhausted, we volunteered to review a few papers ourselves.

That said, we also had some difficulties during peer review that are specific to a special section on education. One question that came up more than once was what made a paper on educational topics suitable for publication in an archival journal, especially in the context of scientific merit [21]. Through the normal course of being editors for *Optical Engineering*¸ we have experience assessing reviewer comments on papers about engineering techniques, scientific contributions, or experimental results. When judging these sorts of papers, questions like “Will readers be able to reproduce the results if they follow these techniques”, “How do the results align with my understanding of the underlying physics”, “How do these results compare with industry-accepted metrics in this context?”, etc. are useful benchmarks.

In contrast, we did not begin this special section with extensive experience on reviewer comments for papers on educational topics. For example, how should one assess the novelty and impact of a paper describing a particular teaching technique? Unlike a novel metrology technique (say), which should in principle be universally reproducible if the underlying engineering and optical physics is done correctly, education depends strongly on contexts that cannot necessarily be practically reproduced between, say, a university in one country and an industry teaching course in another.

To this end, we found several guidelines to be helpful. Matthew Posner, who was a special section editor for *Optical Engineering* on a special section on *Education and Training in Quantum Sciences and Technologies* [18], provided a guidelines document that was created for their special section. These guidelines were a specialization of SPIE’s “10 simple steps for writing a scientific paper” to educational topics [22]. For example, these guidelines suggest how educational metrics can be separated into outputs (number of people attending, online resources produced, etc.), outcomes (attitudinal changes, increased understanding or enjoyment of the topic, etc.) and long-term impacts (increased capacity, instrumental impacts, etc.). In another example, these guidelines give recommendations on where to find literature on education, including the proceedings papers from the bi-annual Education and Training in Optics and Photonics (ETOP) (e.g., [16]), SPIE’s Optics Education and Outreach (OEO) (e.g., [17]), IOP’s Physics Education [23], IEEE Transactions on Education [24], or NSTA The Science Teacher [25]. Given that one very common piece of reviewer feedback was about how a submitted manuscript compared with other programs elsewhere, these recommendations are useful.

Another set of useful questions came from anonymous reviewers themselves. These are paraphrased or editorialized slightly, but the questions include:

- Are readers going to find this useful? How can other, future authors make use of the proposed work, either as a baseline or as context?
- How does the proposed methodology compare to other, similar offerings elsewhere? How is it better?
- What impact is being had, and what innovations are being offered to enhance the impact? Where is the data to substantiate these statements?
- How will this look five years from now? This question is particularly relevant when referencing specific software products, which can rapidly go out of date.

Of course, *Optical Engineering*’s guidelines for reviewers are also useful [21, 26].

Two other areas required special consideration during peer review. First, we received several manuscripts that discussed how a country or region’s specific culture and language influenced education. These papers were interesting and eye-opening to read, but also posed the challenge of finding reviewers with both sufficient optics knowledge and sufficient regional background knowledge. To this end, we found the database of potential reviewers that SPIE has collected was helpful for identifying potential candidates. Cross-referencing these candidates with university websites and their public resumes helped narrow down the search for reviewers with strong optics backgrounds and sufficient cultural exposure.

Likewise, reviewing the submission by Boone [8], which discussed the impact of short form content and its ability to expand optics education, required us to find reviewers who had experience with both optics as well as media production. In this case, we were able to leverage publicly available YouTube content and databases to find reviewers with professional industry training, academic careers, and experience with video content production.

5. CONCLUSION

In summary, over the past year the authors have been involved in a special section of SPIE’s *Optical Engineering*, focused on education and training of a global workforce in optical instrumentation and lens/illumination design. We have summarized the papers in the special section, described our approach for seeking authors to contribute to the special section, and discussed difficulties we encountered during the peer review process and how those were overcome.

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