Curricular Structure for Teaching Ethical and Professional Conduct in Optics and Photonics

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Abstract: A full course focused on ethics and professional practice has been developed to complement technical coursework and provide comprehensive training for engineers studying optics. Related frameworks for ethical enculturation are under study.

1. Focus on Ethics

Professional organizations, funding agencies, and academics increasingly recognize the need to include explicit training in ethics and professional practice within STEM education; however, implementation of such training is varied.[1] The need is underscored by high-profile lapses in professional practice, including plagiarism, falsification, and fabrication, conflict of interest or commitment, failure to disclose, and violation of export- and international trade regulations.[2] Ethics frameworks help professionals understand the origin of rules, which may improve compliance, and provide a foundation for making good judgements when explicit rules are unavailable, as arises naturally with new technologies, like facial recognition, AI, and gene editing.[3]

In 2014, CREOL launched the BS in photonic science and engineering, exceeding ABET standards by positioning ethics and professional development front and center in the curriculum (Fig. 1). Topics are threaded throughout coursework, labs, and capstone activities, and anchored in *Frontiers in Optics*, a required course dedicated entirely to ethical and professional practice.

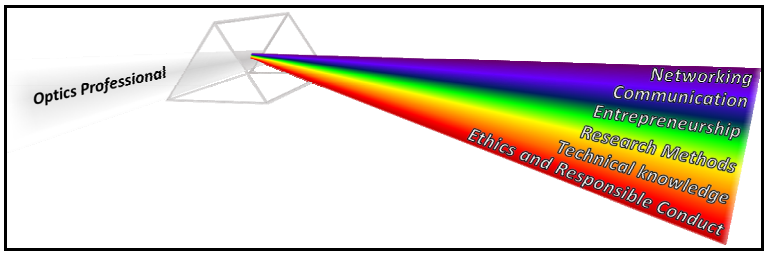

Fig. 1. Logo positioned prominently on the course homepage of *Frontier in Optics* to emphasize that successful optics professionals excel in a broad spectrum of skills.

Fig. 2. Students in *Frontiers in Optics* learn from outside experts. (***Left***) Dr. Jason Eichenholz (CEO & co-Founder, Luminar) explains the value of building social capital. (***Right***) Jennifer McKinley and Dr. Kathleen Richardson (co-founders, IRradiance Glass) teach students about entrepreneurship.

2. Structure of *Frontiers in Optics* Course

Frontiers in Optics includes modules in 1) ethics and responsible conduct; 2) history and societal impact of optics; 3) structure of the industry; 4) networking; 5) intellectual property and entrepreneurship; 6) literature methods; 7) critical analysis of literature; 8) written and spoken communication; 9) preparation and use of multimedia

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materials; and 10) origins of the scientific method. Students explore topics and demonstrate mastery through wide ranging activities. Each module includes traditional and non-traditional learning methods. As an example, Table 1 summarizes the *Ethical and Responsible Conduct* module, listing learning outcomes, measures, activities, and assessments. Students complete readings drawn, when possible, from industry sources like *Optics and Photonics News*, *SPIE Professional* magazine, *Physics Today*, *IEEE Spectrum*, and others. Students answer questions about readings in discussion threads that promote peer-to-peer learning,[4] and they hear from invited speakers (Fig. 2), visit local companies, and interact directly with local industry leaders.

Table 1. *Ethical-and-Professional-Conduct* module, structured to exceed ABET standard: *"Graduates have an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts."*

Learning Outcome	Instructional Resources	Interaction	Assessments
Measure 4.1 "A passing student must be able to demonstrate knowledge of the ethical issues regarding publications and the peer review process, work credit sharing allocations, data management and reporting, citations and plagiarism." ***Measure 4.2*** "A passing student must be able to recognize ethical and professional conduct by being well informed about global, economic, environmental & societal issues as an engineering solution is realized."	***Readings*** • C. Jansseens, "Let's clarify authorship in scientific publications," *Chron. Higher Ed.* (2014). • S. T. Corneliussen, "Paper retractions begin reawakening press skepticism about science," *Physics Today* (2015). • M. Bertolotti, "The Misfortune (or Fortune) of Gordon Gould," in *History of the Laser* (2005). ***Dynamic Interaction*** • Discussion of case-studies. • Workshop led by ethicist J. Beever, Ph.D. ***Multimedia*** • CITI responsible-conduct training program. • Florida Photonics Cluster webpage. ***External links*** • "On being a scientist: A guide to responsible conduct in research," Natl. Acad. Sci. (2009). • UCF research-misconduct policy, 4-211.	***Student-to-Content*** • Research • Presentations • Readings • Videos / podcasts ***Student-to-Self*** • Reflective writing • Self-assessments • Practice quiz ***Student-to-Student*** • Group discussion • Group project • Peer review ***Student-to-Instructor*** • Announcements • Assignment scoring • In-class discussion • Meetings	• Participation • Scaffolded writing • Group project • Research paper • Presentations • Quizzes & exams

Students completes scaffolded assignments that develop communication and professional skills. Some are done in small groups, focused on an independent research topic. These include creating technical and non-technical abstracts, a citation library, research paper, and a multi-media presentation. They also develop a resume and LinkedIn profile and deliver an elevator speech. By semester's end, each student has a dossier that showcases their understanding of communication skills, interdisciplinarity, and how their technical field connects to manufacturing, sustainability, health and safety, economics, and social needs. All assignments require students to use ethical frameworks and to develop professional connections within the class and to external contacts. The success of the method is evinced by overwhelmingly positive comments appearing in *Student Perception of Instruction*.

3. Study of Ethics Enculturation

Funded by NSF (grant no. 2024296), the authors are investigating how frameworks like *Frontiers in Optics* affect students' training in STEM and whether students' personal values are reflected within, refracted by, or reciprocally shaped through disciplinary frameworks. Models will be developed to understand how relationships between individual values and normative frameworks affect the "Three Rs:" Recruitment, Retention, and Responsibility.

4. Acknowledgements

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5. References

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