Methods for Accelerated Delivery of Optics Workforce Development: Condensed Skill Building and Microcredentials

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ABSTRACT

The continuing shortage of trained optics technicians[1,2] has become a bottleneck for the precision optical manufacturing and assembly industry. The Optical Systems Technology (OST) program at Monroe Community College (MCC) has engaged with its industry partners to clarify the scope and timescale of training that will best address industry needs for qualified personnel. New modalities of instruction have been implemented to reduce the amount of time that employees and potential new hires are required to be at campus facilities to acquire core technical skills. In this paper, we present learnings from condensed laboratory training and plans for microcredential offerings to accelerate the certification process for optics technicians. These modalities have been applied to optical physics and manufacturing coursework.

Keywords: Accelerated learning, condensed study, microcredential, precision optics, optical manufacturing, workforce development, optics technician

1. INTRODUCTION

Standard methods of optics instruction remain central to the development of optical engineers and technicians. They provide students with comprehensive, concurrent instruction of both essential optical science concepts and hands-on skill development. The full semester over which this standard instruction occurs gives students the opportunity to interact with educators over a traditional two-year academic period, to reflect on the new knowledge and techniques being acquired and to seek supplemental support/tutoring.

Photonics companies require qualified employees to keep pace with briskly expanding business demands.[3] In the Finger Lakes region of New York State alone, there are more than 900 estimated annual job openings for optics technicians.[4] In spring 2024, the MCC OST program graduated 70 students (its largest class size to date), which is far short of the annual need.

This requires creative thinking about additional instruction methods that address the needs of both employers and students. Some of these many needs are the large number of open employment positions; the limited number of students graduating with degrees and certificates each year; the inability of employers to grant full-semester absences to their employees to build new skills; the increasing cost of full-degree certifications; the inability of non-local students to complete programming without relocating; and the need of students for regular income (full-time employment) while obtaining new certifications.

The MCC OST program maintains close relationships with numerous employers in the photonics industry. Many of these companies are members of the program's advisory board. Input from these partners – critical stakeholders of the program – is invaluable to set the direction for education of promising optics technician students. The voice-of-industry message is consistent and clear: standard modes of instruction are not meeting skilled workforce timeline needs. A shorter timeline to acquire hands-on skills to fabricate, assemble, and test optics is desired.

OST is implementing alternative teaching modalities to meet industry needs. This instruction involves significant hands-on experiential learning which is pervasive throughout the core curriculum. This paper describes the MCC optics technician instruction methods already in use and planned for the near future.

Optics Education and Outreach VIII, edited by G. Groot Gregory, Anne-Sophie Poulin-Girard, Proc. of SPIE Vol. 13128, 1312805 · © 2024 SPIE
0277-786X · doi: 10.1117/12.3027713

2. INSTRUCTION METHODS

Standard instruction

Optics technician certifications offered by OST include a one-year certificate and a two-year associate degree. The one-year certificate encompasses 27 credit hours of study (including 26 optics course credits) and the associate degree encompasses 61 credit hours of study (including 42 optics course credits). Courses are instructed over a standard 15-week semester. The OST curriculum includes optical manufacturing and optical physics learning. Both aspects involve a combination of in-class lectures and hands-on skill development. This modality of optics technician instruction has been in use at MCC since the inception of the OST program in 1963.

Thanks to grant funding from the Office of Naval Research[5], materials for remote instruction of most optics courses were developed for the OST program prior to 2020. The COVID-19 outbreak accelerated use of these materials for remote learning, with limited time on-campus for hands-on skill building. Worldwide advances in the infrastructure for remote communications, fiber Internet, and online sharing tools were critical enablers for this remote instruction. OST curriculum courses that do not require on-campus equipment continue to be offered 100% remotely, enabling students outside the geographic region of the college to complete these introduction courses without the need to come to campus. This has proven effective for four years and is expected to continue in coming years to increase the reach of the program to a greater number of students.

Condensed laboratory instruction

OST initiated asynchronous laboratory instruction for optical manufacturing and optical physics courses in 2023, to facilitate employee participation in apprenticeship programs.[6,7,8] Students receiving this instruction take all classroom instruction remotely during standard semesters and defer hands-on experiences to the end of the semester. All course-required skill building activities and assignments are completed at MCC campus in an intensive session. The schedule piloted for courses has been a 1-to-2-week period with 6-8 hours of daily instruction, matching the number of standard instruction hours. Lab practical exams confirming competence and retention are also included.

MCC is not the only optics education center making use of this condensed hands-on instruction. The Hybrid Optics Master's Education (HOME) MS Program at the University of Rochester Institute of Optics is one example of efforts at other universities.[9]

Students participating in this mode of instruction at MCC are assisted with logistics such as transportation and (on-campus) lodging. The same professors that instructed the course during the semester provide the post-semester instruction. This provides as consistent a learning experience as possible between these asynchronous learners and their classmates. Since this instruction option was developed to support apprenticeship programs, participants have had prior on-the-job experience manufacturing precision optics albeit at skill levels that vary from student to student. On average, these students have been more focused in approach to their studies than the general population of students.

Pilot class sizes have been limited to 1-3 students with full-time faculty providing instruction. (The intense schedule is more challenging for adjunct faculty to support given busy work schedules.) This more intimate environment has resulted in a higher level of engagement, with students asking more questions during instruction and receiving individualized attention. The asynchronous nature of hands-on instruction versus classroom learning has not been observed to have a significant impact on student performance. Participation in remote lectures during the regular semester has proven to provide the proper knowledge and context needed for the post-semester hands-on sessions. In the case of the manufacturing courses, students were often able to remotely see equipment they would be working with, increasing their familiarity with the equipment prior to arriving on campus. For the optical physics courses, it was found helpful to have a teaching assistant present – particularly someone who had just completed the semester-long version of the lab course and who could act as an experienced lab partner for the condensed lab students.

Results from the initial pilots of this instruction method have been positive. One associate degree graduate and two certificate completers received 100% of their optics coursework via this instruction method. Compared to classmates who received standard instruction (100% on-campus, synchronous learning), condensed-lab students exhibited higher grades, submitted more-detailed reports, and demonstrated stronger comprehension of key skills and concepts. These early successes give OST confidence that this form of training can be expanded to increase enrollment of students nationwide to graduate higher numbers of trained optics technicians.

No significant logistical or financial aid issues arose in the to-date pilots of this instruction method. This is due to addressing several issues in advance of instruction. Grant funding for low-enrollment instruction permitted standard university class size requirements to be circumvented. The course catalog was modified to include special condensed-lab class sections whose enrollment was tightly controlled by the faculty. Equally essential, employers provided both encouragement and job bandwidth forgiveness for their employees to receive the training. Enabling factors like these examples are an important part of the planning when offering non-standard learning methods.

Instructor perception is that the condensed-lab method maintains high consistency with standard instruction in the scope and equipment used. Nevertheless, opportunities remain to strengthen this instruction method. Representative examples of these opportunities include:

- **Sequencing:** The ordering of laboratory exercises used for standard instruction may not always be optimal for the condensed lab experience. Lab activities during a full semester are scheduled to coincide with lecture pacing and content and are sequenced to mitigate student workload collisions with other courses. These are non-issues for post-semester instruction, which permits exercises to be reordered to emphasize narrative, critical technique repetition, and additive reinforcement in a brief period of time.
- **Flexibility:** Expectations on student bandwidth, level of attention, and mood during a condensed lab schedule warrant careful monitoring and adjustment. It is potentially unreasonable to expect students to operate at 100% for 6-8 hours of hands-on instruction every day. If the student has an off day, it is critical to adjust instruction to ensure student success. When possible, a backup lab offering period should be negotiated in case the instructor and/or students face unexpected illness, emergency, or travel problems. Post-lab workload likewise needs to be managed carefully. Full-semester students are given a full week or more to complete a lab packet. With a condensed schedule, there is need to either leave time during the week to accommodate lab write-ups or to ease the burden on the student by minimizing work needed outside of the daily instruction period.
- **Completeness:** Taking shortcuts during condensed lab sessions should be avoided, to ensure mastery of critical lab techniques. As an example, if an experimental opto-mechanical setup is used across multiple labs in a sequence, it may be more efficient to build the system once and leave it ready to go for all lab needs. However, if students need to build proficiency in the techniques and equipment involved, the assembly should be taken down and put away after each use, then rebuilt and realigned for each lab so that the student develops proper mastery.
- **Technology:** To build familiarity with lab equipment and methods, it is desirable to have learning environments equipped with advanced audio-visual equipment. This enables students participating in remote classroom learning sessions to better view and understand the operation of key equipment they will use in their condensed laboratory sessions. The ability to record lab sessions during standard instruction provides remote students with the option to observe equipment in use by their classmates (while skipping past dead time to minimize viewing time). MCC is in the midst of upgrading its laboratory environments with such equipment.

(a)

(b)

Figure 1. Examples of training and equipment involved in condensed-laboratory optics technician instruction at Monroe Community College. (a) An optical manufacturing apprenticeship student receiving condensed-lab instruction. (b) A fabrication station in the advanced optical manufacturing lab equipped with a digital camera to permit viewing of hands-on manufacturing by remote students that will perform hands-on activities asynchronously from their classmates.

Optical manufacturing microcredential instruction

MCC is preparing initial pilots of microcredential course offerings for optics technicians. This training requires students to pass a three-course sequence in optical manufacturing. Each of the three courses is presented in consecutive five-week periods. The sequence completes in a single 15-week semester, preparing students for immediate employment as precision optics manufacturing technicians.

This mode of instruction provides a key service to workforce development. Microcredential graduates that do not desire to continue their education beyond this core level of training are qualified to begin a career operating precision manufacturing and testing equipment. This fills a key gap in the workforce landscape: employers need new hires that can operate manufacturing equipment without lengthy training that reduces the bandwidth of seasoned technicians; students wish to begin employment with reduced impact on personal finances and time required to complete longer-term degree programs.

For this instruction method to be successful, it must not compete with the resources allocated for other degree programs and instruction methods. MCC is renovating a parallel set of manufacturing laboratories that contain the equipment needed to run microcredential sequences in parallel to other courses offered through the OST department.

Qualified instructors are another critical resource essential to offer microcredential certification. A diverse population of adjunct professors must be cultivated. This is challenging. The intensive nature of microcredential instruction ideally requires teachers to be available for all-day sessions, making it difficult to take on instruction duties around commitments to employers. Should this training pathway prove popular, it is desirable to continuously run multiple sequences for higher graduation rates. This would require the hiring of multiple full-time faculty members, which will be assessed as pilots are conducted and enrollment is evaluated. The first microcredential sequence is anticipated for Fall 2025.

Pre-apprenticeship program instruction

The MCC OST department has also begun development of a pre-apprenticeship program in optical manufacturing. Apprenticeship programs provide employees with a combination of classroom and on-the-job experiences needed to progress to higher levels of capability and responsibility; pre-apprenticeship programs provide unskilled persons with core skills sufficient to obtain entry-level employment – and one day to participate in an apprenticeship program. MCC is located in Rochester, New York which has the employer base and the population base to warrant pre-apprenticeship training for the optical manufacturing sector. The 2022 poverty level in Rochester was approximately 28% which is well above the national average of 11.5%.[10,11] More than 120 optics/photonics companies are located in this region[12], offering life-changing employment opportunities for residents.

MCC pre-apprenticeship training is to be offered in a state-of-the-art facility accessible to the greater metropolitan population. This facility, the Finger Lakes Workforce Development (FWD) Center[13], offers training in several areas of technical study as a pipeline to train residents for challenging careers in the key regional employment sectors – including optics and photonics.

The optical manufacturing pre-apprenticeship program will provide two tiers of training in basic optical science, optics cleaning and handling, precision optics manufacturing, and optical inspection and metrology.[14] Each level will include 15-20 hours of direct instruction, including hands-on exercises to build the basic eye-hand coordination skills and to understand standard optics manufacturing techniques. At the completion of this instruction, participants will be prepared to obtain an entry-level optics technician position and will be ready to enter MCC OST certificate/degree programs if they so desire.

Table 1. Comparison of standard and accelerated learning methods for precision optics and optical manufacturing education.

Method	Credit Hours	Optics Hours	Study Scope	Delivery Mode
Dual Enrollment	3-4	3-4	Intro to Optics or Geometrical Optics	One-semester or full-year course instructed in high school.
Certificate – Standard	27	26	Intro to Optics, Math Skills in Optics, Geometrical Optics, Photo Science, Career Communications, Optical Fab & Metrology, Advanced Optical Fab & Metrology	2 semesters. Weekly 3-hour lectures and 3-hour labs over 15-week semester. Most taken on-campus, some may be taken remotely.
Certificate – Condensed Labs	27	26	Same as Certificate – Standard	2 semesters. Weekly 3-hour lectures over 15-week semester; daily 6-to-8-hour lab sessions over 1-2 weeks after semester.
Associate – Standard	61	42	Same as Certificate – Standard plus Optical Instruments and Testing, Wave Optics, Optical Systems, Photonics	4 semesters. Weekly 3-hour lectures and 3-hour labs over 15-week semester. Most taken on-campus, some may be taken remotely.
AAS – Condensed Labs	61	42	Same as Associate – Standard	4 semesters. Weekly 3-hour lectures over 15-week semester; Daily 6-to-8-hour lab sessions over 1-2 weeks after semester.
Microcredential	12	12	Optical Fab & Metrology, Advanced Optical Fab & Metrology, Optical Systems	15 weeks. 3 back-to-back courses instructed in daily 8-hour sessions over 5 weeks each.
Pre-Apprenticeship	-	-	Basic Optics and Manufacturing, Cleaning/Handling/Inspection, Optical Metrology	2 weeks. 2 levels of hands-on instruction at special training facility. (Non-credit bearing.)

3. SUMMARY

Rapid workforce development has become an essential element to addressing the worldwide shortage of qualified optics technicians. Several instruction methodologies fit into this category of education delivery, including condensed laboratory instruction, microcredential sequences, and pre-apprenticeship training. They are a valuable options for efficient, condensed skill building for employment growth in the optics and photonics industry.

This paper has summarized the instruction methodologies being implemented by the Optical Systems Technology program at Monroe Community College in Rochester, New York. They are considered an important supplement to standard modalities of instruction that cater to the time constraints and financial needs of many who seek to enter this marketplace. For those seeking a compelling career as optics technicians, these more rapid methodologies for hands-on instruction are anticipated to continue to increase in importance. Such programming reduces financial and time barriers for new students to enter the optics and photonics workforce. It likewise enables existing employees to enhance their skills with less impact on work schedules and commitments. Some of the methods described facilitate reaching students not located near an academic center of optics education, allowing them to spend less time away from work and families and enabling the growth of optics technicians across a greater geographic region.

To learn more about the Optics Systems Technology program and various certification pathways for rapid workforce development, please contact Alexis Vogt, PhD, avogt4@monroecc.edu, (585) 292-2685.

ACKNOWLEDGEMENTS

This material is based upon work supported by the National Defense Education Program (NDEP) for Science, Technology, Engineering, and Mathematics (STEM) Education, Outreach, and Workforce Initiative Programs under Grant No. HQ00342310006. It is also supported by the County of Monroe Industrial Development Agency (COMIDA). The views expressed in written materials or publications, and/or made by speakers, moderators, and presenters, do not necessarily reflect the official policies of the Department of Defense or the County of Monroe, nor does mention of trade names, commercial practices, or organizations imply endorsement by the U.S. Government or New York State Government.

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