Delivering Advanced Technical Education Using Online, Immersive Classroom Technology

Vacuum and thin film technologies are critical to advanced manufacturing industries that produce virtually all electronic devices including computer microprocessors and memory chips, flat panel displays, and communications devices. To maintain and troubleshoot the complex systems that produce this enabling technology, vacuum technicians must have an understanding of math and science along with a blend of hands-on skills and higher-order thinking skills. As vacuum systems have become more complicated, there is a need for formal vacuum education in many areas of the U.S; but the demand for vacuum technicians in most of these areas is not great enough to support a formal educational program. Vacuum-reliant industries often must turn to expensive and limited short courses or on-the-job training for vacuum technicians.

In 1996, several companies near Minneapolis, Minnesota, formed a consortium with Normandale Community College (CC) in Bloomington, MN, to develop a formal program of study in vacuum technology. The Vacuum and Thin Film Technology Associate of Applied Science (A.A.S.) degree program consists of 60 credits including general education courses, required math and science courses, and several supporting technical courses. The college also offers two certificates in vacuum technology. Over 500 students have completed vacuum technology courses at Normandale CC since 1998. Many earn a certificate and/or an A.A.S. degree in the program; some transferring to four-year institutions to complete bachelor degrees.

After successfully responding to the needs of local industries, Normandale CC has begun to address the challenge of providing a formal technical education in vacuum technologies to students throughout the U.S. through a grant from the National Science Foundation's Advanced Technological Education (ATE) program. The goal is to develop a cost-effective program that can reach economies of scale and provide business and industry with highly skilled technicians

in a critical enabling technology via a telepresence instructional model. This article discusses the successes and challenges encountered during the first two years of Project *ReVAMP: Revising Vacuum Technology, an Advanced Manufacturing Program* (DUE #1400408).

Objective 1: Use the latest video conferencing technology to enhance interactions between remotely located students, local students and the instructor.

Before Project ReVAMP, Normandale CC faculty members taught distance learning courses in vacuum technology by pairing mostly online course work with short, on-campus labs. But, instructors found that real-time interaction with students is critical since vacuum technology is a unique subject with unfamiliar terminology. Faculty members began searching for an effective way to connect with remote students. At the same time, new teleconferencing technology, often called telepresence, based on high-speed Internet access was becoming available. Telepresence seemed like the best solution to connect Normandale CC instructors with remotely located students in a way that nearly matches the experience of all participants being in the same room. The Educational Technology Engineer at Normandale CC designed a custom telepresence system for a classroom, which consists of three large high definition monitors, one of which is a touch screen, three high definition cameras, and high performance microphones and speakers. The system is controlled by an instructor's touch pad.

Benefits: To date, the telepresence technology at Normandale CC has delivered high quality video and audio feeds with no discernible delays even when connected internationally. Because of the high definition large monitors, the Normandale CC instructor can easily read the body language and facial expressions of remote students, enabling the instructor to respond to student concerns even if they are not actively voiced. Likewise, the seamless, high-quality audio connection allows remote and on-campus students to interact as if they were in the same room.

In course evaluations, both on-campus and remote students expressed very few concerns about learning with the telepresence technology.

Challenges: The costs associated with installing telepresence systems are a barrier to scaling the delivery of vacuum technology courses. The price for telepresence equipment and installation has dropped since Project ReVAMP began in 2014, but telepresence systems still cost tens of thousands of dollars. Other costs include allocating or re-designing a classroom and providing technical support. In its third year, the Project ReVAMP team will explore how to deliver vacuum technology courses over ITV or other web-based systems that are compatible with telepresence systems.

Objective 2: Establish partnerships with institutions in regions where the demand for vacuum technology courses is too low to justify the costs of delivering local courses but whose students or employees can benefit from a formal education in vacuum technology.

Normandale CC is partnering with educational institutions and private industry to achieve this objective. Through June 2016, Normandale instructors have delivered two academic terms of remote classes and a third is underway – all with industry partners who have telepresence technology available at their worksite. In Fall 2016, Normandale CC will offer remote classes to industry partners and to one educational institution.

Benefits: Establishing industry partnerships is proving to be easier than anticipated. An incentive for industry is that employees receive academic credit and, eventually, certification for completing vacuum technology courses. Industry partners encourage their employees to enroll in Normandale CC classes and reimburse the costs. Further, many companies already have telepresence systems, so their start-up costs are minimal.

Challenges: Partnering with two- and four-year educational institutions has been complicated. Some institutions do not have facilities equipped for telepresence. Also, any benefit that institutions might derive from offering courses to a new audience are offset by the need for Normandale CC and each institution to establish policies for cost sharing, granting credits by each institution, enrollment details, and student recruitment. In many cases, the start-up costs for partnering with other educational institutions to offer vacuum technology courses are prohibitive. Given these challenges, the Project ReVAMP team is exploring how to efficiently and effectively accomplish Objective 2 during the final year of the grant.

Objective 3: Implement active learning practices through the use of an online learning management system to provide access to learning opportunities outside classroom hours.

The three core courses in the Normandale CC Vacuum and Thin Film Technology program are "Introduction to Vacuum Technology," "Vacuum Analysis and Troubleshooting" and "Thin Film Deposition." The grant covers adapting the first two core courses for telepresence delivery. The Instructional Designer at Normandale was critical in helping rewrite the curriculum for the introductory class to reflect the principles of active learning and flipped classrooms. Most of the course materials are available via the Normandale CC LMS.

Benefits: There have been several benefits to adopting an active learning approach. Project evaluation activities in the third year of the project will identify areas of success, but Normandale CC instructors have observed the following: online quizzes encourage students to study course materials before a class session; study guides paired with each class session encourage focused note-taking in-class; and, demonstrations and activities using vacuum equipment and components increase student engagement with the content.

Challenges: The challenge for Project ReVAMP has been to sequence the course content appropriately to effectively develop students' understanding of vacuum technologies. For example, in the “Intro to Vacuum Technology” course, math and science concepts are now covered in the first part of the semester, and applications are addressed later in the semester.

Objective 4: Explore techniques to provide hands-on hardware learning experiences using a custom training system made available to remotely located students.

The need for hands-on experiences in the classroom has been strongly emphasized by the Project ReVAMP Industry Advisory Group. To address this, a hardware vacuum training system with components similar to those in industrial applications was designed to allow students to construct and operate a simple vacuum system. Four copies of the system are being built and will be sent to off-site students so they can perform demonstrations and experiments along with the instructor and on-site students in the telepresence classroom.

Benefits: Initial student feedback indicates that hands-on experiences contribute significantly to the effectiveness of the class. The system has been successfully shipped over a thousand miles. It was re-assembled and fully operational within a half hour of arriving.

Challenges: It is still to be determined how to price the vacuum training system as Project ReVAMP scales in the third year of the project. We will explore whether distance partners will be willing to pay a rental fee to use the equipment at their site.

Next Steps

With the vacuum technology curriculum completed and courses being delivered via telepresence, the Project ReVAMP team will continue to refine the online portions of the courses and the hands-on activities while documenting and evaluating the process of successfully partnering with another educational institution to deliver vacuum technology education.