Distance Delivery Of A Laboratory Based Controls For Manufacturing Automation Course--A Success Story

Subramaniyan Kandasamy¹, Ramkumar S. Manian²

Abstract - Over the years, distance learning (DL) has proven to be very effective for many theoretical courses, but is challenging if courses include hands-on laboratory modules. Bringing students several times a quarter to campus and conducting lab sessions imposes inconvenience on the students. It also restricts the geographic locations of the student body that can benefit from this program. This was the case with the Electrical/Mechanical Engineering Technology program at the Rochester Institute of Technology (RIT). To overcome this issue, RIT has effectively utilized the web, multimedia techniques and simulation tools to bring the laboratory experience to DL students on demand. This paper discusses the stages in the evolution of a DL course and how a hands-on laboratory course is being successfully offered over the Internet, benefiting students far and wide.

Index Terms – Distance learning, Internet based learning, Programmable logic controller.

INTRODUCTION

Distance learning provides excellent opportunities for students to acquire degrees from remote locations. Providing access to lab from remote locations, however poses enormous challenges. RIT has been offering distance learning courses and programs for the past 11 years. RIT has shown a 95% course completion rate and 72% graduation rate in DL courses. Based on statistics provided by the National Center for Education, RIT has three times the faculty teaching courses through DL, when compared to 6% nationally. At RIT, 36 programs are currently offered through distance learning. One of the 36 programs is the multidisciplinary, Electrical/Mechanical Engineering Technology Program (E/MET). It provides students with core courses in electrical, mechanical, and manufacturing engineering technology. One of the mandatory, laboratory intensive course that is part of this program is Controls for Manufacturing Automation. RIT has successfully converted this course into a complete DL course, thereby improving its capability to impact students from various remote locations.

THE COURSE

The Controls for Manufacturing Automation course involves study of the principles and application of Programmable Logic Controllers (PLC). PLC is a device that is used for automated monitoring, controlling, and integration of manufacturing systems. Given the target audience for the E/MET program, this course has become a mandatory component of the degree. Topics include PLC hardware, PLC programming (ladder-logic), PLC troubleshooting, installation, and applications in an automated manufacturing environment. The course also introduces students to human machine interface and PLC networking.

Course work includes lectures, laboratory exercises, tests, and homework assignments. Laboratory sessions require the students to develop and test programs that control sensors, actuators, and automation equipment. After executing the program, it is important for the students to verify the program, by observing the system response, and troubleshoot if required. This requires the students to access the physical laboratory setups, which is a huge concern when offering the PLC course.

STAGES IN THE EVOLUTION OF THE COURSE

The PLC course was initially offered in-class. Demands by fulltime and part time students who were not located in the Rochester, NY area led to the course being offered as distance learning. Initially it was predominantly video based learning. To provide better student-teacher interaction, phone sessions combined with telewriters were included. With the popularity of web-based communications and other multimedia tools, the course is currently available for students totally over the Internet, thereby enabling true virtual learning. Figure 1 depicts the three stages of development in distance delivery of the PLC course.

Video Based Learning

As a first step in converting to DL, the course was offered through videos. A few community colleges in key regions of NY State were selected as satellite centers where students
would go to view lectures, take tests and perform lab work. Students were allowed to choose the center that would be easy for them to access.

Of the colleges selected only three had similar infrastructure as that of RIT, to support laboratory sessions. Some students therefore had to go through the anguish of traveling farther to perform their labs. This led to significant inconvenience and part time students did not have the flexibility they needed. This methodology also imposed a lag between the time they learnt a particular concept and when they actually implemented it in the laboratory session. Hence, there was no synchronous link between the lab and lecture sessions. An adjunct faculty was assigned at each satellite center, to oversee lectures, proctor exams, and guide students through their labs. To some extent the effectiveness of lectures depended on the adjunct faculty. The faculty at RIT did not have good control over the lab sessions. Students did not get a good opportunity to address issues and discuss real world problems since communication with RIT faculty was not direct. These problems led to the need for a better method to address student interaction and communication issues.

Figure 2 shows the number of students from the state of New York enrolled in the course. It is evident that there were no international students or students from other regions of the US enrolled in the course. This could be attributed to the requirement to travel to one of the satellite centers or RIT to complete the course requirements. The necessity to utilize satellite centers also restricted the access to students from only a few regions within New York State.

**Telewriter assisted Video Based Learning**

To improve communications with students, RIT started incorporating teleconference sessions with students. Students got together at the specified satellite sites and RIT faculty would be online to discuss their issues and questions.
In another attempt to improve student-teacher interaction, telewriters were introduced. This enabled the faculty to provide graphical representation of concepts during discussions. Teleconference along with the telewriter provided improved levels of communication, although it was only one way. Issues with travel still could not be avoided, as students had to go to the satellite centers for lectures and laboratory sessions. In addition, they also had to assemble for the teleconference sessions. This did not provide part time students the flexibility they required. This system did not make much of a change, as students still had to travel to complete all of the course formalities. Major restrictions on geographical locations could not be avoided and the faculty still did not have total control over the course.

As shown in figure 3, the number of students from other states did increase, but most of them were from Pennsylvania, Massachusetts, and New Jersey, which are states neighboring New York. Students from out of state assembled at RIT to complete their laboratory sessions. These students received individual videotapes of lectures and participated in the teleconference sessions, but had no way of viewing the telewriter. Their supervisors proctored the exams. The satellite centers selected still posed a constraint on the geographic dispersion of the student population. Students still had to cope with the lag between the lecture and the hands on laboratory experience.

As shown in figure 3, the number of students from other states did increase, but most of them were from Pennsylvania, Massachusetts, and New Jersey, which are states neighboring New York. Students from out of state assembled at RIT to complete their laboratory sessions. These students received individual videotapes of lectures and participated in the teleconference sessions, but had no way of viewing the telewriter. Their supervisors proctored the exams. The satellite centers selected still posed a constraint on the geographic dispersion of the student population. Students still had to cope with the lag between the lecture and the hands on laboratory experience. These restrictions on geographical locations could not be avoided, and the faculty did not have total control over the course.

As shown in figure 3, the number of students from other states did increase, but most of them were from Pennsylvania, Massachusetts, and New Jersey, which are states neighboring New York. Students from out of state assembled at RIT to complete their laboratory sessions. These students received individual videotapes of lectures and participated in the teleconference sessions, but had no way of viewing the telewriter. Their supervisors proctored the exams. The satellite centers selected still posed a constraint on the geographic dispersion of the student population. Students still had to cope with the lag between the lecture and the hands on laboratory experience.

As shown in figure 3, the number of students from other states did increase, but most of them were from Pennsylvania, Massachusetts, and New Jersey, which are states neighboring New York. Students from out of state assembled at RIT to complete their laboratory sessions. These students received individual videotapes of lectures and participated in the teleconference sessions, but had no way of viewing the telewriter. Their supervisors proctored the exams. The satellite centers selected still posed a constraint on the geographic dispersion of the student population. Students still had to cope with the lag between the lecture and the hands on laboratory experience.

### Internet Based Learning

Since Fall of 1999, RIT has been offering the PLC course totally over the web. Course information, lecture presentations, outlay for lab experiments and assignments are posted in RIT’s "mycourses" web portal. Lectures on DVDs have now replaced videocassettes. Students are provided individual lecture DVDs as part of the course material. They no longer have to travel to attend classes. Lecture presentations posted in “mycourses” highlight key points and provide a structure for the students to adopt. Students working in the industry do not have the necessity anymore to schedule onsite sessions for lectures or for labs. They have the flexibility to work whenever, and from wherever they can. Several students who need to travel on business have benefited tremendously from this method. Geographic location is no longer a barrier for students, since the need to commute to satellite centers has been completely eliminated. This has enabled a number of out of state and few international students to benefit from this program.

Figure 4 shows student enrollment in this course since the web based method was adopted. When compared to the previous methods of course delivery (figures 2 and 3), the success in providing opportunity for students far and wide is evident. In New York State, students now are from all regions of the state and are no longer from selected counties. Students from 21 other states throughout the United States have successfully taken this course through distance learning.

RIT has developed an interesting way for the students to perform their laboratory sessions over the web. Figure 5 shows the procedure for performing laboratory experiments over the Internet. The requirements and description for the laboratory sessions are posted in “mycourses”. This gives students a chance to think and prepare a logic that they can refer to while programming. To assist them further, a real video demonstration of what the expected final outcome is also provided through "mycourses". For lab sessions to be performed over the Internet, students need access to the software. Some have access to the software at their work. Students requiring the software, purchase a student version of it from RIT along with the rest of the course material. Students install it at their remote sites and can develop and download programs to the lab setup at RIT. The laboratory setup at RIT is equipped with a computer, “Control Host” connected to a network of PLCs, serving as the gateway. This control host is also connected to the Ethernet. The physical experimental setups for appropriate lab exercises are also connected to the PLC. Students are provided an IP address.
address that allows the communication software on their computers to find the gateway within the laboratory. The laboratory setup is available 24/7 providing access to students all ten weeks of the quarter. The students develop their program, within the stipulated deadline, and test it by communicating with the PLC in the laboratory, over the web.

While executing the program, the students need to verify that the system responds in compliance with the lab requirements. They have to watch, for example, motors run, or lights go on or off at the right time as expected. For this, a web camera is setup in the lab, focusing on the physical experimental setup. The web camera is live and streams real video 24/7 through a “Real Video Streaming Host”, for the entire quarter. A URL is provided to students to view the laboratory setup in media player. This allows the students to execute their program, watch the experimental setup respond to their program and troubleshoot if required. Location of a student with respect to RIT is not a consideration anymore. A student can perform his/her laboratory exercise from anywhere in the world. Students now are totally independent, and have full control over their programming exercises.

The message board in "mycourses" greatly enhances the student teacher and student-student interactions. Students post their questions on line and get responses from the faculty, and also opinions from fellow students. This provides a classroom like environment, where a question by one student is beneficial to the whole class and communication is no longer one way. To further improve interactions, teleconferences are held once a week, throughout the quarter, when students can talk with the instructor, discuss problems and share ideas. Tests and assignments are posted on the web, giving every student equal opportunity to start and stay ahead of others in completing course formalities.

Table 1 compares the three learning models with respect to specific factors. The factors considered include course control, student-teacher interaction, course flexibility, travel requirements, and synchronization of lectures and laboratory exercises.

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>CONTROL</th>
<th>INTERACTION</th>
<th>FLEXIBILITY</th>
<th>TRAVEL NEEDS</th>
<th>SYNCHRONIZATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL MODEL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIDEO BASED</td>
<td>L</td>
<td>L</td>
<td>VL</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>TELEWRITER ASSISTED</td>
<td>L</td>
<td>M</td>
<td>L</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>INTERNET BASED</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>VL</td>
<td>VH</td>
</tr>
</tbody>
</table>

Figure 6 summarizes the student distribution for all the three methods of course delivery discussed. In the former methods of delivery, there were more than one satellite center involved. The satellite centers collectively had greater capacity and could handle more students than RIT. Therefore the enrollment numbers were high in 1999 and 2000. Also, till 1999, the course was offered once in two years, but from the year 2001, it is being offered every year. The result is therefore reduced student enrollment (bars 3, 4, 5, 6) when compared to years 1 and 2 (1999 and 2000 respectively) in the figure.

**CONCLUSION**

Internet based delivery of the Controls for Manufacturing Automation course has proven to be really successful. The student's ability to do lectures and labs from remote locations, flexibility in accomplishing course requirements, and other advantages of this method have helped overcome restrictions on geographic locations. Performing laboratory sessions through the web has attracted students from across the world. Student dispersion across the US has tremendously increased, with students enrolling from 21 states other than NY. Table 2 summarizes the states and countries from which students were involved in each term the course was offered as DL.
The two main barriers in offering the PLC course through distance learning were the geographic location of the student and inability to provide laboratory experience. Effective use of the web and multimedia tools, have enabled RIT to successfully overcome these barriers, taking Distance Learning to a whole new level.

REFERENCES


