The Use of Innovative Methods to Deliver Technology Education Laboratory Courses via Distance Learning: A Strategy to Increase Enrollment

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Introduction

Distance learning is not a recent innovation in education; correspondence courses having been used for over 150 years, but new interactive technologies are providing new opportunities and strategies for teaching at a distance (Smaldino, 1996). Several studies have compared face-to-face classrooms to distance classrooms in order to evaluate differences in student performance and quality of instruction. A meta-analysis of these studies showed that distance learning students performed equally well and some distance courses outperformed their classroom counterparts (Bernard et al., 2004).

This result has been consistent over many studies across many disciplines; advances in communication technology and innovative methods of delivery of instruction at a distance have challenged the idea that laboratory courses can only be delivered in a face-to-face laboratory setting. In engineering for example, Virtual Laboratories have been used to teach thermodynamics, electronic circuits, and other experimental courses as well (Baher, 1999, Griffioen, Seales, & Lumpp, Jr., 1999). Programs in nursing, engineering, technology, and other sciences are beginning to use different technologies and innovative methods to deliver courses via distance learning methodology in order to reach students in different locations and boost enrollment. A survey of online distance learning programs revealed a large increase in student enrollment (Carlson, 2004; Gayle, Cook & Kwanghee, 2003; Laughlin, 1997). The availability of distance courses has made it possible for some people to attend college because courses are accessible within their locality or the time of course delivery is convenient to them. This opportunity for learning has not been without critiques of the quality of such instruction, and rightly so with any form of instructional delivery.

Quality issues are a major concern for those who intend to pursue degree programs via distance learning, especially with the proliferation of distance learning programs. Although it is difficult for academics to agree on specific standards that constitute quality in distance learning, nonetheless, attributes such

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as accreditation standards for programs, evaluating students' experiences, teacher-student interaction, student-to-student interaction, learning resources for the learner, learner assessment and performance, instructional resources for faculty, faculty training, and learner satisfaction are valid criteria (Dahl, 2003; McIsaac, & Craft, 2003; Mann, 1998). These and many other factors can determine the quality of delivery of instruction in both distance and face-to-face classrooms.

The Problem

Enrollments in technology education at the college level have been declining (Daugherty, 1998; Hill, 1999; Isbell & Lovedahl, 1989). The declining enrollment has resulted in a shortage of technology education teachers across the country. Several years ago the projection was that by the year 2005, 13,089 technology education teachers would be needed to match the increasing enrollment of students in our secondary schools and the shortfall caused by teacher retirements (Ndahi & Ritz, 2002; Weston, 1997). Technology teacher educators need to investigate ways to increase the enrollments in their programs, or the profession may fail to provide technology teachers in the future (Ritz, 1999). Exploring alternative methods of delivery to reach prospective students at their place of work or in their locality will further meet the objective of providing education to all of society.

Technology education programs with a history of hands-on learning at the undergraduate level have been slow to implement distance learning techniques and strategies (Flowers, 2003). This study examines ways in which laboratory courses are delivered through the use of distance learning technology and other innovative methods.

Research Objectives

The objectives of the study were to:

1. Determine the extent to which laboratory courses are delivered via distance learning in technology and engineering programs,
2. Determine the laboratory courses offered via distance learning in technology and engineering programs,
3. Determine the types of distance learning technologies and innovative ways used to deliver laboratory courses in technology and engineering programs, and
4. Determine the support services provided to students and faculty using the distance learning technology.

Research Design and Methodology

This study used descriptive research in order to gain information as to how laboratory courses are taught via distance learning in technology and engineering programs. Quantitative and qualitative data were collected to provide for a balanced assessment and interpretation of current and developing practices. Data gathering involved a one-time collection of specific information

and a visit to one selected site for follow-up and data gathering through interviews and observation where necessary.

Population and Sample

The population for the study was drawn from universities in the United States and a university in the United Kingdom. A purposive sampling method was used to select these universities (Fraenkel & Wallen, 1993). The selected programs were delimited to mechanical engineering and industrial technology programs that offered distance learning courses, especially laboratory courses. The study sample comprised 75 department heads and program leaders from 64 selected universities in the United States that offer distance learning courses and have mechanical engineering and technology programs. One university in the United Kingdom was selected because it offered all its undergraduate engineering courses at a distance. The departments selected were the Environmental and Mechanical Engineering Department and the Department of Education and Language Studies: Center for Research in Teacher Education. The latter has a design and technology program similar to many technology education programs in the U.S.

Instrumentation and Data Collection

The survey instrument developed by the researcher to achieve the objectives of the study was modeled from the Ndahi & Ritz (2002) study that analyzed distance learning in industrial and technical teacher education programs. Both open and close-ended questions were asked. In order to determine its face and content validity, the instrument was reviewed by a panel of three professors for appropriate wording and clarity. The instrument was then administered to faculty engaged in distance learning from five institutions. As a result, one question on the survey was re-worded to elicit a more direct answer.

Heads of departments and program leaders from the selected universities were mailed a questionnaire with a self-addressed return envelope. A follow-up questionnaire was sent electronically to department chairs and program leaders who did not respond to the initial survey. The initial return was 49%, but after the follow-up questionnaire was sent, it rose to 58.6% (41 department chairs and program leaders).

Data Analysis

Descriptive statistics in the form of frequencies and percentages were used to analyze the quantitative data. The open-ended data were coded and organized based on questions on the survey (Stainback & Stainback, 1988). A narrative summary of the responses explained the data. Information not relevant to the study was deleted.

Extent of Laboratory Courses Taught Via Distance Learning

To determine the extent to which laboratory courses were taught via distance learning, the researcher looked at the number of departments of engineering that offer courses via distance learning. Although all the universities

selected for the study offered distance learning courses in other programs, not all offered distance learning courses in their mechanical engineering and technology programs, especially laboratory courses.

Based on the responses, the data indicated that 20 departments of engineering and technology, representing 48.8%, offered distance learning courses. Further analysis of the data revealed that 15 departments (36.6%) offered non-laboratory courses, and only 5 departments (12.2%) offered laboratory courses (see Table 1).

Table 1
Extent to Which Laboratory Courses Are Taught Via Distance Learning (n=40)

Item	n	%
Technology and Engineering Departments offering distance learning courses	20	48.8
Non-laboratory courses	15	36.6
Laboratory courses	5	12.2

Laboratory Courses Offered Via Distance Learning in Technology and Engineering Programs

Of the five programs that offered laboratory courses via distance learning, four departments offered such instruction at the graduate level. Course titles included network management, information technology, and digital communication. Only one department offered courses at both graduate and undergraduate levels.

At the UK-selected university, the following courses were offered in the departments of Mechanical Engineering and Materials Engineering:

> Engineering Mechanics - Solids; Introduction to Thermofluid Mechanics; Environmental Monitoring; Modeling and Control; Engineering Mechanics - Solids and Fluids; Heat Transfer - Principles and Applications; Manufacturing Technology; Failure of Stress Materials; Inside Electronic Devices; and Engineering in Action.

Most of these courses have extensive laboratory hands-on activities.

Distance Learning Technologies and Innovation in Laboratory Course Delivery

The five departments that offered laboratory courses via distance education used combinations of a variety of instructional technologies. The technologies most used were Interactive Microwave TV, (two-way audio and video), compressed video, Internet, CD's, computer software (virtual software), and video tapes.

At the selected University in the UK, interviews were conducted on site with faculty and staff. Teaching materials, student portfolios, and a secured Web site were observed. In addition to the Internet, CD's, and video, the university used the following innovative ways to deliver laboratory courses:

Residential and Summer Schools. Residential and summer schools serve a similar purpose; the difference is the duration. The summer school is one week long and combines labs, lectures, and problem sessions. In general, these schools provide four key features, providing the opportunity for students to:

1. undertake experimental work considered too hazardous for a student working at home.
2. undertake lab work using more sophisticated equipment, or equipment too expensive to provide at home.
3. undertake assessed lab-work.
4. work together.

Some courses even arranged to take students on a study trip, perhaps to a company with special processes, or to a geographic site of interest.

The Learning Kit. A specialized Learning Kit enables students to learn the basic techniques and terminology of the subject being taught. The activities introduced in the Learning Kits are designed to be undertaken in the "average family kitchen." Students are advised about any equipment they need to purchase for themselves (the University has rules specifying the upper limit of expenditures). Other equipment such as a soldering iron, a volt meter, pliers, etc. is provided to students. Carefully prepared notes or instructions guide students through measurement and construction activities such as how to create an electronic circuit. The notes specify things that might go wrong and how to correct them. Computer software may also be used to perform some lab activities by means of simulation in a virtual environment.

Demonstration Laboratory. The demonstration laboratory introduces students to the work they are going to undertake, illustrating how to proceed, how to make particular types of measurements, etc. It also covers topics considered too dangerous for students or situations in which the equipment is not available at the residential school. Many of these demonstrations are recorded on video to control both the process taught and the quality of the teaching across numerous groups of students at different centers.

Support Services Provided to Faculty and Students Engaged in Distance Learning

All the departments that offer distance learning courses offer support services to students and faculty. The support services include e-mail systems, graduate assistants, course Websites, proctors, telephone conferencing, electronic library materials, and instructional designers to work with faculty to design and develop courses. At the selected university in the UK, however, interviews with instructional designers and faculty revealed the significant role played by instructional designers. Although they are not the content experts, they advise faculty, for example, on how information is presented on a Website or the format in which the information is presented. The purpose is to maintain a standard format and quality in print materials, including electronic resources.

The selected university in the U.K also provides a support service to faculty that is unique from other institutions in this study: *Staff tutors* who are regionally based to provide the link between the university faculty and students within the regions. The staff tutors have a key role in quality assurance, especially in facilitating effective teaching of the university faculty's courses, and are responsible for the selection, monitoring, and staff development of part-time Associate Lecturers. They contribute to faculty research and the development and presentation of courses. The staff tutors are highly qualified in their fields, and as such, bridge the distance gap between the university faculty and students at different locations.

Results

This study sought to identify courses that have hands-on lab activities and are delivered via distance learning in technology and engineering programs. Data were collected and analyzed from degree programs (BS, MS, and PhD) in engineering and technology. While the survey return of 58.6% is acceptable for reporting, the results cannot be generalized to technology and mechanical engineering departments beyond those sampled in this study. However, the results can serve as a basis for further investigation with a more comprehensive sample.

Laboratory Courses Offered Via Distance Learning

It is important to determine the nature of the laboratory courses and the extent to which they are delivered via distance learning in technology and engineering programs in order to learn from the experiences of institutions and programs. Although the results show that 15 departments of technology and engineering programs (48.78% of respondents) are offering distance learning in non-laboratory courses, only 5 departments (12.19%) are offering laboratory courses. Most of the non-laboratory courses are being offered at the graduate level.

At the selected university in the U.K, all courses in the departments of Mechanical Engineering and Engineering Materials are being offered via distance learning. Some of the courses require intensive, hands-on laboratory activities while some do not. When laboratory activities are part of the course requirements, the faculty decides whether to use a learning kit or demonstration lab or to invite students to the residential or summer school. This decision is made during the planning and development of the course. To maintain quality standards for all courses, faculty must have an intended course peer-reviewed by faculty from institutions teaching similar courses in a non-distance setting. Generally, when courses do not receive a favorable review they are not taught. It takes between two and three years for faculty to get a course accepted for distance delivery by the university.

Technology and Innovative Ways Used to Deliver Laboratory Courses

The investigation did not uncover new technology to deliver laboratory courses. Instead, these courses were delivered using the same methodology for

distance learning courses in general. This included mainly television, the Internet, printed materials, video tapes, and compressed video. What departments are doing differently is combining various technologies and using other innovative ways to deliver courses. The university in the UK used most of the instructional technology mentioned, but also employed other innovative methods such as the Residential and Summer Schools, Learning Kits, Field Trips, and the Demonstration Laboratory. The combination of these innovative methods with the numerous technologies available enabled the university to deliver all its laboratory courses in engineering at a distance.

Support Services Provided to Faculty and Students

Support services to faculty and students can make a difference in the effectiveness of both the teaching and learning process of distance education. The support services included the availability of electronic communication systems, telephone conferencing, proctors, graduate assistants, and instructional designers. Most of the departments that responded to the survey provided similar support services. The UK university has one unique support service which was the use of tutors to facilitate teaching and learning for the students and to serve as a link between the university and the students. The tutors are also responsible for selecting, monitoring, and developing the skills and knowledge of part-time lecturers and they contribute to the research, development, and the delivery of courses.

Discussion

If technology education programs are confronting dwindling enrollment and a shortage of teachers, it is fair to say that the profession or departments preparing technology education teachers should consider options that have boosted enrollment in other fields. Certainly, we can close the teacher shortage gap in the future if student enrollment in our programs increases. Increasing enrollment, though, is not easy considering the difficulty of attending college for some adults because of geographic location, work schedules, and personal responsibilities (Newman, 1997). It is imperative that administrators and instructors in our programs consider alternative methods of delivery of instruction, using alternatives to the traditional, face-to-face classroom approach.

Among the many strategies that can help increase student enrollment in technology education is to take the program to the prospective students instead of the students going to the program. It is true that a big obstacle to delivering technology education laboratory courses is teaching the hands-on activities. Programs in science and engineering are facing the same problem: it is difficult to conduct experimental work because the scope of many experiments is limited by issues of safety for students and the cost and complexity of instruments and devices required for laboratory activities (Dunne, Farrel, McDonald, & O'Dowd 1999; Gustafsson, 2002). This study clearly indicated the limited extent to which technology and engineering programs are delivering laboratory courses via

distance learning. Nonetheless, the efforts made in delivering non-laboratory courses are encouraging.

Advances in communication technology have made it possible to deliver laboratory courses in technology and engineering (Liou, Soelaeman, & Leung, 1999; Hodge, Hinton & Lightner, 2001; Alessandro, Milano, & Vincenzo, 1999). Although, some of the technologies are very effective in delivering some courses, others are not (Joler & Christodoulou, 2001). Combining different technologies with other innovative ways has worked well for some institutions. The UK university, by using innovative strategies such as the Residential and Summer Schools, Field Trips, Learning Kits, and Demonstration Laboratories in combination with other technologies, is able to teach all its laboratory courses via distance learning to its nearly 200,000 students within and outside the UK. Distance learning is not meant to replace a face-to-face classroom, but it is one major way to make education more accessible to society. As advances in communication and digital technology continue, residential or demonstration labs may someday be replaced with comparable experiences provided through distance education.

Concerns raised by academics and the general public about distance education continue to surface, often relating to the quality of the courses. Institutions engaged in distance learning have methods for evaluating the quality of their instruction. There are no universal standards to measure the quality of distance education delivery; institutions generally set their own criteria (Dahl, 2003; McIsaac, & Craft, 2003; Mann, 1998). At the selected university in the UK, between two and three years are spent in preparation, evaluation, and testing of a course before it is finally delivered to students. Ironically, perhaps, most face-to-face courses do not undergo such rigor, even though both delivery methods might use the same instructional technology.

Support services are an integral and essential component in distance teaching. The fact that students are at a distant location means they will require services that will bridge the gap between them and their instructor. These services could include any medium of communication or human assistance that is accessible to students. For example, one concern with laboratory courses is safety. In a face-to-face class, the instructor may observe practices that can cause injury to students and take corrective action before any harm is done. To circumvent this issue, some distance classes are using computer simulations and virtual laboratories, while in others computers are being used to control or manipulate the required equipment at a distance.

Support services such as telephone conferencing, e-mail, proctors, graduate assistants, and digital libraries are other ways to link students with the faculty. This connection is critical to students in any form of distance learning situation, regardless of the technology used. The staff tutor used in the UK and mentioned earlier seems to be a unique and effective way to link the students and faculty. The person serving in this manner is highly qualified in content of the course and is therefore able to provide informed assistance at any time to a student.

As the advances in communication technologies and instruction continue, more and more laboratory courses will be delivered via distance learning.

Although great strides have not been made in teaching laboratory courses, it is encouraging to note that nearly half of the responding departments of technology and engineering are engaging in distance delivery of their courses. More importantly, some of these departments are combining different technologies and other innovative methods to deliver hands-on laboratory courses. To reiterate, distance learning is not meant to replace face-to-face classroom instruction, as many skeptics have assumed, but to provide an alternative means of learning for the large population of non-traditional students. This reform in education deserves the attention of teacher educators in general as well as those involved in technology education.

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