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IMPROVEMENT OF PEDAGOGICAL LABORATORY BASED LEARNING: MULTIMEDIA ENHANCED INSTRUCTIONAL METHODS

A Thesis
Presented to
The Faculty of the Department of Architectural and Manufacturing Sciences
Western Kentucky University
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In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

By
Sumbul Khan

December 2013

IMPROVEMENT OF PEDAGOGICAL LABORATORY BASED LEARNING:
MULTIMEDIA ENHANCED INSTRUCTIONAL METHODS

Date Recommended 11/8/2013

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Dean, Graduate Studies and Research Date

I dedicate this thesis to my parents, Imtiaz & Qamar Khan, for their unconditional love and support. I also dedicate this work to my sisters and brother, for being my inspiration.

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Thank you to my thesis committee for your support, encouragement, and dedication in making this possible. Your guidance throughout all my endeavors in this program has made it very memorable and is sincerely appreciated.

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Sumbul Khan December 2013 80 Pages

Directed by: Dr. Greg Arbuckle, Dr. Mark Doggett, and Dr. Bryan Reaka

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In engineering technology and other scientific-based education, lab-based courses play a crucial role (Ma & Nickerson, 2006). Even though laboratory experience in student learning is crucial, it faces some problems. Due to insufficient laboratory conditions that lead to overcrowding and inability to view demonstrations, the effectiveness of hands on experience declines (Tiwari & Singh, 2011; Tuysuz, 2010). Considering the limitations that constrain lab experience, investigating and implementing alternatives to enhance pedagogical laboratory based learning becomes inevitable. This study investigates multimedia enhanced pedagogical teaching methods for delivering laboratory instruction to students.

The purpose of this study was to improve pedagogical laboratory based learning. First, this study implemented a multimedia enhanced pedagogical laboratory based instructional method. Second, this study evaluated the impact of multimedia enhanced instructional method on student learning outcomes to assess improvement in pedagogical laboratory based learning.

To evaluate the impact of multimedia enhanced instructional method on student learning outcomes, a student population was subjected to 1) traditional laboratory lecture and 2) video lecture. This study used two different assessment techniques to evaluate the instructional methods 1) surveys and 2) quizzes. The use of these different assessment techniques achieved two purposes. First, the surveys allowed the study to receive

students' evaluation on the lecture in order to compare the two types of instructional methods. Second, the quizzes allowed measuring the students' understanding of the demonstrations in order to evaluate the impact of multimedia enhanced instructional method on pedagogical laboratory based learning.

Survey results revealed that based on overall evaluations, students prefer traditional lectures in comparison to video lectures in terms of level of interest and engagement. Furthermore, quiz results revealed that multimedia enhanced instructional methods do not have an impact on pedagogical laboratory based learning.

Introduction

In engineering technology and other scientific-based education, lab-based courses play a crucial role (Ma & Nickerson, 2006). Engineering technology education requires understanding the relationship between theory and practice (Monroy, Calderon, & Miranda, 2005). In engineering technology laboratories, demonstrations enhance student learning and interest in the subject matter (Tuysuz, 2010). Laboratory demonstrations allow students to learn the relationship between a scientific principle and its practical use (Agrawal & Cherner, 2009). The idea of "learning by doing" (Bruner, 1990) dates long back. Based on this concept, hands-on experience in laboratories is essential for student learning. In general, engineering technology education over the decades has become more student-centered, active, challenge-based, self-directed learning, and problem based (Kybartaite, 2010). Since engineering technology is a discipline of applied science, laboratory application holds high importance in its education. In engineering, chemistry, and other applied science labs, students enhance their learning through seeing, observing, and performing (Tuysuz, 2010). Furthermore, hands-on laboratory courses hold a high level of importance in programs that want to develop technically proficient professionals.

In order to understand the underlying principles of complex systems, motions, and operation of machines in manufacturing technology education, students need to get a lot of practical and hands-on experience in the laboratories (Bal, 2012). Furthermore, experimental training in laboratories holds a high level of importance in many disciplines, as in advanced manufacturing/engineering technology in the present study (Kaplan et al., 2005). Laboratory experiences conducted during the year fulfill the need for this experimental training (Monroy, Calderon, & Miranda, 2005).

Statement of Need

Even though laboratory experience in student learning is crucial in engineering technology education, it faces some problems. Insufficient laboratory conditions and expensive equipment result in overcrowded groups that lead to lack of ability to see and observe the demonstrations (Tuysuz, 2010). Since laboratory equipment is very costly, only a limited amount of laboratory equipment is available and accessible (Kaplan et al., 2005). Many students have to share equipment in small laboratories that limits the laboratory experience due to overcrowding and creates an inability to view the demonstrations (Tuysuz, 2010). Even in cases where equipment is sufficient, students usually end up becoming spectators as instructors conduct experiments, due to large groups and overcrowding (Tiwari & Singh, 2011). Considering the limitations that constrain lab experience, investigating and implementing alternatives to enhance pedagogical laboratory based learning becomes inevitable. Amongst the possible alternatives, use of computers in accompanying laboratory methods can be a useful one (Tuysuz, 2010). A laboratory experience that could improve pedagogical laboratory based learning would be very beneficial (Bal, 2012).

Several researchers and educationalists in science education confirm that laboratory experience increases students' abilities as well as interest in the subject. Laboratory experience in students' learning has a significant role in the field of science education (Tuysuz, 2010). Some researchers even claim that "hands-on experience is at the heart of science learning" (Ma & Nickerson, 2006, p. 2). Therefore, investigating and implementing alternatives to improve laboratory instruction will enhance pedagogical laboratory based learning in a wide variety of fields related to applied science including

Computer Numerical Control (CNC), Robotics, Programmable Logic Controllers (PLCs), manual machining, nursing, biology, chemistry, and engineering technology laboratories as well.

The form of presented technologies and instructional methods in this study are not new. However, this study is different from previous studies conducted on multimedia enhanced instructional methods in several ways. First, the proposed instructional method aims to increase visibility of demonstrations by reducing overcrowding. Previous studies have aimed towards reducing costs, reducing the amount of faculty supervision, or saving time (Bal, 2012; Costa-Castello, Olm, Vargas, & Ramos, 2012; Genis, Brownlowe, & Kwon, 2006; Monroy, Calderon, & Miranda, 2005; Porteal, Huerta, Pastor, Alvarez, & Sanchez-Carrilero, 2009). Furthermore, past studies focused on replacing traditional laboratories for establishing a framework for distance learning (Bal, 2012; Tiwari & Singh, 2011). On the other hand, this study does not attempt to replace face-to-face, traditional laboratory demonstrations with distance learning. Conversely, this study uses a multimedia enhanced instructional method to enhance and improve existing, face-to-face laboratory lectures. Another difference is that this study aims to enhance hands-on laboratories that focus on transferring design skills to engineering technology students. Past studies have focused on mainly transferring conceptual skills to engineering students. In addition, this study does not add any complexity to the laboratory demonstrations by introducing new software or hardware that virtual/remote laboratories usually require (Bal, 2012; Gurocak, 2001). Therefore, the students do not need to learn any added software or hardware functions that might entail additional complexity.

One main difference that exists between the present and past studies is the methodology used to evaluate the impact of a multimedia enhanced instructional method on pedagogical laboratory based learning. Past studies have used two separate batches of students to collect results. These studies exposed batch A of students to a traditional laboratory and a different batch B of students to a multimedia enhanced laboratory to compare the two instructional methods. The present study utilizes the same batch of students to reduce bias. Furthermore, other studies have used the same batch of students and exposed them to two different instructional methods that demonstrate the same process for comparison purposes. However, this study exposes students to two different instructional methods that demonstrate different processes. Therefore, this study reduces bias associated with knowledge transfer between the two demonstrations. Additionally, the instructional methods demonstrate processes that entail a comparable level of difficulty.

Statement of Purpose

As noted, due to insufficient laboratory instruments that lead to overcrowding, the effectiveness of hands on experience declines (Tuysuz, 2010). The question is whether pedagogical laboratory based learning can be improved? Due to current advances in multimedia and technology, it is possible to enhance laboratory experience. This study investigates multimedia enhanced pedagogical teaching methods for delivering laboratory instruction to students.

The purpose of this study was to improve pedagogical laboratory based learning. This study implemented and evaluated a model that other universities could replicate as well. This study aimed to provide a basis for other institutions that are interested in implementing similar laboratories. This study targeted towards enhancing the learning experience of face-to-face students at Western Kentucky University in the Advanced Manufacturing/Engineering Technology labs. First, this study implemented an improved, multimedia enhanced pedagogical laboratory based instructional method. Second, this study evaluated the impact of multimedia enhanced instructional method on student learning outcomes to assess improvement in pedagogical laboratory based learning.

This study seeks to improve pedagogical laboratory based learning though a focus on five interlinked objectives: 1) increased visibility of laboratory demonstrations; 2) reduction of overcrowded groups in laboratories; 3) increased student interest and engagement in learning; 4) increased classroom productivity; and 5) reinforcement of classroom learning.

Limitations

Some influences on this study were beyond the control of the researcher. These limitations were as follows:

1. Multimedia and technology available to implement a multimedia enhanced instructional method.
2. Time needed to evaluate the impact of multimedia enhanced instructional method.
3. Space and labs available to implement an improved instructional method.
4. Population of students utilized for evaluating the impact of multimedia enhanced instructional method.
5. Bandwidth of Internet available to implement a multimedia enhanced instructional method.

Delimitations

This study did not analyze all laboratory instruction methods surveyed as a method of evaluation. The study was delimited only to the application of multimedia in pedagogical laboratory based learning.

This study was delimited to a manufacturing laboratory with lathe and milling machines at Western Kentucky University.

Assumptions

This study was based on the assumption that the student population utilized for evaluating the impact of multimedia enhanced instructional method had viewed the video lecture.

Hypothesis

The question is whether pedagogical laboratory based learning can be improved? Due to current advances in multimedia, it is possible to enhance laboratory experience.

H_0: Multimedia application in pedagogical laboratory instruction will not have an effect on pedagogical laboratory based learning.

H_1: Multimedia application in pedagogical laboratory instruction will have an effect on pedagogical laboratory based learning.

Definition of Terms

1. Pedagogical laboratory based learning: Hands-on experience in laboratory that focuses on application and implementation of theory to achieve design skills in order to develop technically proficient professionals.

2. Educational technology: Technologies used for educational purposes in teaching and learning including audio/video recordings, DVDs, computers, and the Internet (Kybartaite, 2010).
3. E-learning: Electronic learning or e-learning is a comprehensive term used to describe any sort of teaching or learning that is enhanced or improved through the use of advancements in information communication technology (ICT) including audio/video recordings, DVDs, computers, Internet, etc. (Kybartaite, 2010).
4. Blended learning: An educational environment that combines face-to-face and e-learning methods (Ginnis & Ellis, 2006). This form of learning involves an application of educational technologies to face-to-face courses (Mora-Aguilar, Sancho-Bru, & Iserte-Vilar, 2009).
5. Virtual laboratories: Laboratories that use a software to replicate experiments (Schafer, Scott, Molina, Al-Kalaani, Murphy, Johnson, & Goeser, 2008). These labs utilize an interactive framework comprised of a dynamical model and basic tools that enable studying performance features while saving simulation development time (Costa-Castello, Olm, Vargas, & Ramos, 2012).
6. Remote laboratories: Laboratories that involve experimenting with actual devices, physically sited remote from the user, using Internet and local networks (Costa-Castello, Olm, Vargas, & Ramos, 2012). A remote laboratory allows students to carry out physical experiments through controlling the lab equipment from a distant location. Students in a remote laboratory can control experiments utilizing a web server and access to an interface (Schafer et al., 2008).

7. Distance/Internet/e-labs: Laboratories that control laboratory equipment at a physical lab from a remote, distant location while specifying parameters and retrieving results through live webcast via Internet. High speed Internet makes data and parameters accessible to the instruments at a remote site (Wu, 2011).
8. Videoconferencing: An instructional method that involves conducting class sessions utilizing Internet-based access to high-end video and test equipment in university's laboratories. Students participate in a real interaction with other students and become part of group discussions, share documents and collaborate while videoconferencing via Internet II that provides increased bandwidth compared to Internet (Genis, Brownlowe, & Kwon, 2006).
9. Video lectures: A multimedia enhanced instructional method that utilizes video camera to capture a lecture with narrative that the instructor could upload on the web for multiple viewing (Brecht & Ogilby, 2008).

Review of Literature

The most well-known instructional method involves traditional classroom learning in a lecture environment. During a lecture, knowledge transfer occurs from the lecturer talking in front of a large number of students who attempt to understand, listen, take notes, and retain information simultaneously. Traditional classroom lectures were based on printed books and learning material. There are many advantages pertaining to traditional classroom lectures such as enabling direct communication including question and answer sessions; allowing socialization amongst students; and making emotional involvement such as facial expressions and gestures possible (Kybartaite, 2010). Direct contact with the instructor during traditional lectures enhances motivation amongst students (Andersson & Dawoud, 2012). On the other hand, traditional classroom lectures also have several disadvantages including overcrowding, one-way communication, people having different rates of learning and understanding information, and students not meeting the pace of the lecture. Furthermore, a traditional lecture sometimes fails in effectively delivering knowledge since it becomes difficult for students to understand material while listening to the lecture and taking notes simultaneously (Kybartaite, 2010). Additionally, the overcrowded groups that result due to the high student/instructor ratio limit the instructor from attaining educational innovation (Mora-Aguilar, Sancho-Bru, & Iserte-Vilar, 2009). However, today the concept of using technologies for educational purposes has opened a wide range of opportunities in teaching and learning. Educational technology that includes audio/video recordings, DVDs, computers, and the Internet has all become a part of teaching methods (Kybartaite, 2010).

Educational Technology

Educational technology creates a fundamental basis for performing practice and research in teaching and learning. Research defines educational technology as “the study and ethical practice of facilitating learning and improving performance by creating, using and managing appropriate technological processes and resources” (AECT Definition and Terminology Committee, 2008, p.1). Educational technology is a goal-oriented approach to problem solving by applying techniques, methods, tools and theories from various knowledge realms in order to 1) design, develop, and evaluate resources in an efficient and effective manner to enable learning and, 2) transform educational institutions and methods to influence societal changes (Luppicini, 2005). Educational technology is a tool that is a broad term utilizing many innovations including portable CDs, DVDs, portable storage devices, personal computers, digital video cameras, iPods, MP3 players, etc. In broad terms, educational settings often implement any new technological innovation, related to either hardware or software (Kybartaite, 2010). Furthermore, educational institutions, including universities, are favoring the utilization of technology in education (Palmer & Devitt, 2007).

Computers and Internet are the main elements that boost advances in educational technology today (Kybartaite, 2010). Amongst the many alternatives for improving effectiveness of laboratory instruction, utilization of computers in accompanying laboratory methods can be a feasible one (Tuysuz, 2010). Studies reflect that using computer technologies in teaching and laboratory work is productive and has given the economics of engineering technology education a new direction (Bal, 2012). Education computer applications are capable of providing quick and direct feedback on performance measurement that improves the learning outcome, especially in distance learning. A new array of possibilities in the laboratory has opened up due to these computer applications. These new possibilities include remote control of instruments, automated data acquisition, simulation, rapid data analysis, and presentation. Experience shows that these applications positively affect the student's motivation and educational effectiveness level in comparison to the hands-on laboratory experience (Bal, 2012).

As an open network of data, the Internet allows access and sharing of knowledge and opens up many possibilities (Kybartaite, 2010). The Internet continues to gain new heights due to its flexibility as a learning and information-delivering tool in higher education (Gurocak, 2001). Today, Internet and the World Wide Web greatly enhance instruction and support existing classroom education (Jain, Gu, & Rizwan-Uddin, 2008). Furthermore, with the introduction of high-speed Internet, electronic communications have become an option for providing hands-on laboratory experience (Henry & Zollars, 2005). Internet is an excellent educational tool for communication, interactive learning, information exchange, and collaborative engineering technology education (Paterson, 1999). The application of multimedia and computers, along with World Wide Web and modern communication technologies are giving rise to new forms of learning and teaching (Grober, Vetter, Eckert, & Jodl, 2007). Furthermore, engineering technology education could gain great benefits from appropriate application of these capabilities (Paterson, 1999).

E-learning

Today, electronic learning or e-learning describes any sort of learning method that utilizes electronic technologies including computers, multimedia, etc. (Mora-Aguilar, Sancho-Bru, & Iserte-Vilar, 2009). E-learning is a comprehensive term used to describe any sort of learning that is enhanced or improved through the use of advancements in information communication technology (ICT) including audio/video recordings, DVDs, computers, Internet, etc. (Kybartaite, 2010). New trends in education that include e-learning, web-based tools and technology enhancements can greatly help instructors in solving the problem of overcrowded groups during lab sessions (Mora-Aguilar, Sancho-Bru, & Iserte-Vilar, 2009). The evolution of e-learning began with utilizing minicomputers and video networks until recently when the development of ICT linked with the Internet created web tools that are applicable to teaching and learning processes at various levels (Mora-Aguilar, Sancho-Bru, & Iserte-Vilar, 2009). E-learning is gaining popularity as an alternative to traditional laboratory lectures due to its many advantages that include flexibility, convenience accessibility; time and cost savings; a focus on active learning and participation; easy updating of content; and methods of measuring and testing the success of learning (Zhang, Zhao, Zhou, & Nunamaker, 2004). E-learning covers several processes and applications including virtual labs, remote labs, Internet labs, videoconferencing, blended learning, and video lectures (Kybartaite, 2010).

E-learning processes and applications. The use of e-learning can be integrated with traditional methods to provide a more effective learning experience as discussed in the following current alternatives to teaching laboratory sessions (Mora-Aguilar, Sancho-Bru, & Iserte-Vilar, 2009).

Two technologies that have drastically changed the nature of laboratories are remote and virtual labs (Ma & Nickerson, 2006). The main difference between a virtual lab and a remote lab is that the former is a model like a 3-D game that utilizes real world representations and actual data while the latter entails a physical laboratory (Wu, 2011). Virtual and remote laboratories continue to gain an increasing importance as teaching and learning instruments in higher education settings. This is because lower consumption of temporal, spatial, and human resources improves their outstanding performance in the context of continuous learning in comparison to traditional laboratories (Costa-Castello, Olm, Vargas, & Ramos, 2012). Virtual/remote laboratories replace the traditional laboratory with the help of ICT to create a facility where the Internet allows conducting experiments (Tiwari & Singh, 2011). The implementation of this type of laboratory creates an environment where the students select and control several parameters of the experiment. Furthermore, utilizing additional learning components and a graphical interface create the ‘feel’ of performing a real experiment (Tiwari & Singh, 2011).

Virtual/remote laboratories have a very similar application structure. Virtual laboratories utilize Easy JAVA Simulation (EJS) to build their application structure. EJS is a JAVA-based software tool that simulates physical settings. EJS allows developers to create a graphical user interface (GUI) that yields an interactive environment illustrating the frequency and time features of a system. A GUI is a graphical user interface that enhances the user’s understanding of the experiment and makes it more user-friendly through the use of figures, icons, indications, etc. (Tiwari & Singh, 2011). The virtual laboratory completely designs its structure in EJS utilizing a prevailing mathematical depiction of the plant and an EJS-designed GUI. Remote laboratories utilize EJS and Laboratory Virtual Instrumentation Engineering Workbench (LABVIEW). LABVIEW is an application manufactured by National Instruments (NI). Hence, very few differences exist between a virtual and remote laboratory’s interface since both environments use a similar design (Costa-Castello, Olm, Vargas, & Ramos, 2012). Studies note that both virtual and remote laboratories are recommendations only if it is not possible to gain experience in a real, traditional laboratory (Wu, 2011).

Virtual reality (VR). Current advances in computer graphics have made realistic visualization systems including Virtual Reality (VR) very viable in engineering technology laboratory training (Bal, 2012). Virtual labs create efficiency by simulating the activities of particular systems (Costa-Castello, Olm, Vargas, & Ramos, 2012). VR laboratories create an environment similar to three-dimensional (3D) computer games that students play (Wu, 2011). In a virtual laboratory, the experiment is replicated using software (Schafer et al., 2008).

Many researchers support the use of Virtual Reality (VR) in education enhancement. VR creates a real world environment while making it experimental. Furthermore, its interactive learning environment utilizes simulations and animations that enhance students' understanding (Tuysuz, 2010). Interactive VR labs enhance active student learning instead of passive memorization of information (Agrawal & Cherner, 2009). Application of VR allows students to observe physical processes in detail, analyze constraints associated with parameters, and acquire information from virtual experiments to conduct a detailed analysis and compare results to actual operational conditions (Agrawal & Cherner, 2009). VR creates a real-life environment with computer-generated images and secondary devices (Porteal, Huerta, Pastor, Alvarez, & Sanchez-Carrilero, 2009). Virtual labs create an interactive framework comprised of a dynamical model and basic tools that enable studying performance features while saving simulation development time (Costa-Castello, Olm, Vargas, & Ramos, 2012). Theoretical calculations form the basis of VR labs and do not involve real experiments (Tiwari & Singh, 2011).

Virtual laboratories utilize an industrial plant model to evaluate the time evolution of the system. The framework portrays the plant as a geometric arrangement. The virtual setting introduces the students to the system features and functions as a tool for critical calculations (Costa-Castello, Olm, Vargas, & Ramos, 2012). Application of virtual reality in engineering technology education includes creating a virtual world where learners interact with 3D representations, multiple frame-of-reference and perspectives, and simultaneous visual and auditory feedbacks (Bal, 2012). These capabilities can increase motivation and concentration levels in students to master complicated materials. VR uses computer modeling to replace laboratory equipment by simulating behaviors of systems or processes under study. This gives the additional advantage of being able to repeat the experiment several times while comparing the results with the model-based findings (Bal, 2012). Electronic circuits, thermodynamics, among other types of laboratory courses use VR as an instructional method (Ndahi, 2006).

Using VR solves a few problems encountered in traditional laboratory instruction while allowing students to attain the learning objectives. Educational demonstrations using VR provide theory and practice on real experiments while reducing time and costs (Porteal, Huerta, Pastor, Alvarez, & Sanchez-Carrilero, 2009). Complex data provided to students is made easier through the use of technology in VR while allowing the students to learn by doing (Tuysuz, 2010). Another advantage of VR is that it allows students to carry out experiments that might be dangerous to conduct in the traditional lab. VR's many advantages include new interaction possibilities along with more realistic and enjoyable learning environments. VR-based education creates a real environment that gives the sense of being in the actual setting. Existing applications of VR include computer-aided design (CAD), manufacturing, automation, control, manufacturing assembly planning, robotics, manufacturing system visualization and simulation.

Empirical data collected reveals that use of VR is successful in terms of instructional effectiveness, along with transferring skills to the real world (Bal, 2012). Furthermore, a large number of students can use a VR laboratory at the same time (Tiwari & Singh, 2011). VR offers various advantages that include the students focusing on comprehending basic concepts instead of performing extensive wiring and measurements, decreasing the number of failures due to incorrect settings, minimizing the laboratory staff support, focusing student time on effective discussions and observations, and reducing repeating measurements (Bal, 2012).). Although a virtual lab's design does not present any practical limitations, it could be challenging to create a VR lab that has the feel of a real experiment (Tiwari & Singh, 2011).

Josephsen and Kristensen (2006) acknowledged that students using the SimuLab computer-based learning environment greatly enhanced their experience and retained the demonstration longer. Hence, using VR as an alternative to traditional lab sessions creates a positive attitude in learning (Tuysuz, 2010). The question is whether a simulation such as VR can provide the effective learning outcomes as traditional labs. Kerr, Rynearson, and Kerr (2004) conducted studies that revealed there were no differences between the achievement scores of students conducting the experiment in a traditional lab compared to distance students conducting the experiment via VR.

Furthermore, some studies also showed that VR is more effective in comparison to traditional lab sessions (Tuysuz, 2010).

Despite its advantages, the use of VR has been limited due to the high computer knowledge and operational skills required (Bal, 2012). Furthermore, students are not eager to communicate in a virtual environment since they presume that students will not be willing to provide prompt feedback. Utilizing a virtual system imposes additional disadvantages, requiring expert software skills and time (Kybartaite, Nousiainen, & Malmivuo, 2010). Other limitations of VR labs include high costs and the time required to implement the necessary VR lab hardware (Agrawal & Cherner, 2009).

Remote laboratories. While virtual and remote laboratories are homogenous settings for laboratory application, remote laboratories allow the likelihood of experimenting with actual devices, physically sited remotely from the user, through the use of Internet and local networks (Costa-Castello, Olm, Vargas, & Ramos, 2012; Tiwari & Singh, 2011). A remote laboratory allows students to carry out physical experiments through controlling the lab equipment from a distant location. A web server and access to an interface allow controlling experiments in remote labs (Schafer et al., 2008). In this setting, an experimental setup is always in place (Tiwari & Singh, 2011). Various applications have utilized remote monitoring via World Wide Web. Remote laboratories are gaining importance in universities since they are an inexpensive way of introducing concepts to students. Furthermore, these laboratories allow students to interact with machinery such as robots, electronics, microscopes, and control applications (Monroy, Calderon, & Miranda, 2005).

A desirable characteristic of remote laboratories is its use of real-time video and audio feedback that enhances the remote student's laboratory experience. The use of webcams in remote labs allows students to view the on-going experiment and trace the various parameters while collecting their own data online (Grober, Vetter, Eckert, & Jodl, 2007; Schafer et al., 2008; Tiwari & Singh, 2011).

The remote laboratory provides a framework where it is feasible to work with equipment that is located at a distance. Remote laboratories utilize GUI in the same manner as virtual laboratories (Costa-Castello, Olm, Vargas, & Ramos, 2012). However, the remote laboratory integrates the physical plant's graphic representation with the plant's video streaming. The framework also compensates for video transmission delays by including an augmented reality display option in which the laboratory places the simulation model over to the plant's camera view. The remote laboratory functions in the manual and automatic mode. The manual mode allows the student to perform open loop experiments and become familiar with the time and frequency characteristics as well as disturbances of the plant. On the other hand, the automatic mode allows conducting closed loop experiments with various controllers. This allows the student to witness the different limitations to the control techniques of Proportional Integral Derivative (PID) and Integral Model Principle (IMP). The laboratory's framework designs experiments in a way that represent the restricted performance of PID control for the dismissal of unstable interruptions and show the benefits IMP provides by the use of repetitive control and resonators (Costa-Castello, Olm, Vargas, & Ramos, 2012).

Studies that have implemented remote laboratories reveal that learning outcomes achieved are similar to those obtained from on-site, traditional laboratories (Schafer et al., 2008). Ogot, Elliott, and Glumac (2003) conducted a study to compare student learning outcomes between traditional on-site students and remote laboratory students. Results revealed that there was no difference between student learning outcomes of remote students and local students who performed the experiment on site.

Studies revealed that remote laboratories entail other disadvantages as well. On the downside, malfunctioning of equipment at remote sites can be very frustrating for students. Other problems include delays in data feedback, slow communication between the remote and local sites, and non-beneficial data (Henry & Zollars, 2005). Furthermore, studies that implemented remote labs uncovered negative learning outcomes, in some cases. In comparison to virtual laboratories, students in remote laboratories were able to identify some non-idealities in the experiment results (Schafer et al., 2008).

Internet laboratories. An Internet-based laboratory permits students to control laboratory equipment at a physical lab from a remote, distant location. The students at remote sites along with students at the local site have the capability to control the processes. Remote as well as local students monitor and note the same experimental data. Furthermore, students can utilize high speed Internet to retrieve data from the physical site. The use of high speed Internet makes data and parameters accessible to the instrument and students at a remote site. The student can conduct the experiment at the local site while specifying parameters and retrieve results through live webcast. Studies refer to this type of laboratory as an Internet laboratory, distance laboratory, i-lab, e-lab, or web lab (Wu, 2011).

The main difference between a remote lab and an Internet lab is that the latter enhances remote labs by creating additional audio-video links between the remote and local sites such as conference calling, audio transmission with webcams, and interactive TVs (Gurocak, 2001; Jain, Gu, & Rizwan-Uddin, 2008). Internet labs utilize two-way live video and audio connections that link the local laboratories with students at a remote location. The experiments that users conduct at the remote laboratories are also webcasted live (Wu, 2011). The Internet lab encompasses four components including a local lab, LabVIEW, webcams, and a remote client. The local lab is the actual local site where the personnel is conducting the experiment (Edwards et al., 2006).

Internet labs utilize LabVIEW to allow signal acquisition, analysis, data display, display signals, automate instruments, and control devices (Edwards et al., 2006; Wu, 2011). This software also enables live webcast of data in graphical format. Furthermore, it allows communication between the remote and local users and grants complete access to the experiment (Edwards et al., 2006; Jain, Gu, & Rizwan-Uddin, 2008). This software uses variables, data types, sequence structures, and loops. One of the greatest benefits is that it utilizes up-to-date tools for collecting, analyzing, and delivering measured data (Jain, Gu, & Rizwan-Uddin, 2008). The LabVIEW applications and digitizer make the experimental procedures simpler while minimizing tiresome manual recording of data (Wu, 2011). Virtual Instruments is a term used to refer to all windows or interfaces in LabVIEW.

Virtual Instruments (VI) are basic building blocks and enable modularization of the code for efficient use. Every VI is comprised of a front panel and a block diagram. The user creates the front panel indicators and controls via drag and drop software from the VI’s interactive input and output terminals. Controls include push buttons, dials, switches, knobs, and other input devices. The indicators include various displays such as graphs and LEDs. Each indicator has a terminal on the block diagram. The block diagram is a graphical representation of the source code. Furthermore, the block diagram has structures and functions from built-in VI libraries. The block diagram displays the flow of information through interconnected of nodes including indicators, control terminals, functions, and structures. As the student runs VI, the block diagram takes effect and the data passes from one function/indicator to the next (Jain, Gu, & Rizwan-Uddin, 2008).

Software named Universal Library (UL) for LabVIEW comes with data acquisition devices. This software enables the development of customized LabVIEW applications that are congruent with the Data Acquisition (DAQ) hardware. For instance, a USB-TEMP is a data acquisition device that users can utilize in experiments to measure the temperature. UL for LabVIEW allows the development of customized LabVIEW applications congruent with USB-TEMP. For instance, users could modify a program (e.g., TinScan.VI) that comes along with the UL package to read the temperature inputs through LabVIEW. This program reads a temperature input range and displays the temperature. The program broadcasts the output and has the capability of presenting it graphically as well (Jain, Gu, & Rizwan-Uddin, 2008).

Additionally, a feature named *remote front panels* enables remote students to view and control the VI front panels from a distance using a web browser without any further programming. The student could measure different quantities simultaneously and switch between displays. A remote student could also run the application and view progress via web. Furthermore, multiple students can monitor live updates of the front panel through the use of any browser (Jain, Gu, & Rizwan-Uddin, 2008).

In order to provide both the local and remote students with an identical laboratory experience, data webcasting involves displaying measured data in a digitized manner on the monitors of computers. GUI allows both remote and local students to experience identical data acquisition through various methods including screen sharing. Considering that some experiments use analog signals to measure and represent data, students could use a digitizer to convert analog signals to digital data that creates a basis for displaying and recording data for convenient sharing between remote and local sites (Wu, 2011).

Internet labs consist of webcams to provide a streaming video of the experiment that personnel are carrying out at the local site. The remote client is any distant student that connects through the Internet. Integrating these components together calls for software and hardware compatibility. For instance, data acquisition hardware should be able to communicate with LabVIEW through a data acquisition driver. Mostly, LabVIEW applications are specific to the experiment. In order to webcast the data live, the student must link LabVIEW to the Internet. Internet labs create several audio-video links between the local and remote sites such as conference calling or audio transmission with webcams (Jain, Gu, & Rizwan-Uddin, 2008). In some studies, this technology combines Internet and interactive TV (Gurocak, 2001). Software and hardware connections with the Internet make it possible to establish the Internet lab at the local site. The students at a distant location are able to program and control the experimental equipment in the Internet lab through the use of Internet while utilizing the interactive TV for watching and hearing the experiment live (Gurocak, 2001).

One of the greatest advantages of Internet lab is that it eliminates physical distances by overcoming space-bound limitations. These laboratories enable students at a remote location to conduct experiments via high speed Internet (Wu, 2011). Results from past studies revealed that Internet labs generate positive learning environments (Gurocak, 2001). On the other hand, this technology also has many disadvantages. For example, Internet labs are very time consuming to develop and implement. Furthermore, it is also complicated to keep the software updated on the remote computers (Gurocak, 2001). Although the lab experience for remote students is very realistic, the accuracy of a traditional lab experience is not the same for local and remote students (Wu, 2011).

Videoconferencing. Fully interactive videoconference teaching is another type of distance learning method. Videoconferencing involves conducting class sessions utilizing Internet-based access to high-end video and test equipment in university's laboratories. Students participate in a real interaction with other students and become a part of group discussions, share documents and collaborate while videoconferencing via Internet II. This type of teaching method is capable of delivering real-time interactive instruction to distance students that have subscribed to Internet II services using Internet Protocol (IP) networks that provide high-speed transmission, real-time communications, and assures bandwidth (Genis, Brownlowe, & Kwon, 2006). The main difference between a remote lab and videoconferencing is that the latter is broadly applicable to other educational courses in addition to laboratory instruction and focuses on creating more interaction possibilities between face-to-face and distance students (Genis, Brownlowe, & Kwon, 2006; Kybartaite, Nousiainen, & Malmivuo, 2010).

Videoconferencing is gaining acceptance in higher education as well. This technology provides more opportunities for dialogue that leads to effective learning instead of students learning in isolation (Kybartaite, Nousiainen, & Malmivuo, 2010).

Videoconferencing offers great flexibility in program delivery and widens student's horizons. It allows distance as well as face-to-face students to become a part of the same educational and training process. Videoconferencing allows students in other universities to take the same courses. This method reduces the shortage of trained specialists needed in laboratories. Videoconferencing allows for remote operation through which expensive equipment is accessible to institutions that cannot afford it or do not have faculty with sufficient expertise. Another advantage is that this method does not require constant supervision of faculty (Genis, Brownlowe, & Kwon, 2006).

Videoconferencing allows for sending a set of information to many recipients at once. Institutions utilize fully interactive videoconferencing during laboratory sessions to create the same laboratory experience for face-to-face students present in the lab and distant students. The personnel control the equipment while a computer conducts output data analysis. LabVIEW structures the experiments. Furthermore, this software transfers data collected from the experiment to the computer. This data is stored for further analysis and processing. Application of videoconference teaching also utilizes cameras to monitor the laboratory experiments. These web cameras send images back to remote users that provide visual feedback. Videoconferencing usually utilizes webcams that have pan/tilt/zoom features available. Students can access the webcams through Microsoft Internet Explorer by typing in the IP address of the camera. This password-protected camera features two modes: demonstration mode and complete access mode. Pan/Tilt/Zoom features are unavailable in the demonstration mode (Genis, Brownlowe, & Kwon, 2006).

Blended learning. E-learning usually implies distance education instead of face-to-face learning. Furthermore, this expression involves teaching and learning methods that utilize web-based services via Internet (Mora-Aguilar, Sancho-Bru, & Iserte-Vilar, 2009). Many higher education institutions today adopt e-learning platforms for their courses. This environment does not only influence online courses but affects face-to-face courses as well that continue to integrate e-learning technologies as useful tools. Literature refers to this type of educational environment as blended learning (Ginnis & Ellis, 2006). Blended learning is described as a learning system that integrates various delivery methods as well as uses various event-based activities including face-to-face classrooms, self-paced learning, and live e-learning (Georgouli, Skalkidis, & Guerriero, 2008). This form of learning facilitates higher education while adding multiple forms of communication to meet certain learning goals (Garrison & Kanuka, 2004). Selecting the appropriate blend of optimal delivery methods depends on the course objectives. The delivery methods generally fall into four categories: offline individual work including books, workbooks, manuals, DVDs, etc.; face-to-face delivery methods including presentations, lectures, coaching; online methods utilizing the web; and non-web based Computer Based Technology including chats, audio conferencing, video conferencing, application sharing, etc. (Georgouli, Skalkidis, & Guerriero, 2008).

Blended learning enhances higher education through reflective thinking and critical discourse by integrating asynchronous written and synchronous verbal communication, (Garrison & Kanuka, 2004). The degree that blended learning applies online educational technologies to face-to-face courses varies (Mora-Aguilar, Sancho-Bru, & Iserte-Vilar, 2009). The optimal way of determining the use of these e-learning tools depends on the course. Literature is constantly studying the process of integrating e-learning tools with face-to-face courses. However, a pedagogical and methodological analysis of blended learning is crucial (Kelly, Ponton, & Rovai, 2007).

The greatest advantage of blended learning is that blended learning approaches are consistent with ideals of traditional higher education (Mora-Aguilar, Sancho-Bru, & Iserte-Vilar, 2009). Results from studies that have implemented e-learning tools for blended learning reveal that it provides learner-centered factors while improving the learning quality (Georgouli, Skalkidis, & Guerriero, 2008). Research showed that a mix of elements in hands-on experiments is better than implementing a virtual/remote/Internet laboratory alone (Ma & Nickerson, 2006). Blended learning meets the values of higher education, facilitates complex, creative, and critical thinking skills while providing an effective and efficient learning experience (Garrison & Kanuka, 2004)**.**

Video lectures. Video based lectures are one of the most influential and informative forms for distance education (Debevec, Safaric, & Golob, 2008). Amongst the greatest benefits of video lectures is their ability to provide an extremely realistic environment and enhance flexibility in choosing the learning pace and time (Kybartaite, Nousiainen, & Malmivuo, 2010). Video lectures allow students to work at their own pace, which has a positive impact on student confidence (Andersson & Dawoud, 2012). One benefit is it is able to provide information that is hard to attain verbally, graphically, or through text (Whatley & Ahmad, 2007). Video lectures are an excellent educational tool for transferring knowledge that is difficult to deliver (Kybartaite, Nousiainen, & Malmivuo, 2010). Video lectures are an application of multimedia with substantial potential for learning and teaching in higher education (Whatley & Ahmad, 2007).

Another advantage of video lectures is that they provide a more traditional classroom environment instead of a studio-based environment (Kybartaite, Nousiainen, & Malmivuo, 2010). Zoom-pan capabilities and large screen monitors used in broadcasted video could possibly offer a more useful laboratory experience in comparison to a passive environment at the very end of a crowded laboratory. Furthermore, utilization of multimedia features and interactive simulations in broadcasted videos allow students to understand various concepts that enhance active learning. These capabilities give broadcasted videos an advantage over other distance labs such as remote/virtual laboratories (Jain, Gu, & Rizwan-Uddin, 2008).

This method allows students to focus on learning while not being distracted by simultaneously taking notes in classroom (Agrawal & Cherner, 2009). The technology enables repetitive viewing of demonstrations and meets varying learning needs (Agrawal & Cherner, 2009; Thurnquist, 2003). It is also easy for instructors to implement and deliver without any complex equipment or assistance (Agrawal & Cherner, 2009). Some video lectures use software to record all movements of the pen on the screen simultaneously with the lecturer's audio voice. The delivery can also be enhanced through the use of a webcam that shows the instructor delivering the lecture (Agrawal & Cherner, 2009).

Said and Khan (2004) conducted a study on using multimedia lectures in which lectures were videotaped and then made available to students online. The model used video lectures as a supplement to existing traditional lectures. Surveys revealed that 80% of the students agreed that these video lectures were helpful. Furthermore, 70% of the students said that video lectures helped them in understanding the course material better.

In addition, students preferred a combination of both traditional and video lectures with more traditional, hands-on activities. Furthermore, students regarded traditional lectures as interactive and helpful for a detailed understanding of the emphasized material.

Kybartaite (2010) conducted a similar study in which 67% of the students preferred traditional lectures in comparison to other multimedia enhanced instructional methods. However, the students indicated that video lectures were helpful because they allowed repetitive reviewing of the course materials. Furthermore, students preferred face-to-face communication with the instructor in class in comparison to video lectures because traditional lectures allowed more interaction and gave them the chance to ask questions. This study also assessed final exam results that revealed no difference in scores across traditional lecture students, video lecture students, or virtual classroom students.

Studies showed that video lectures are an effective learning tool, with no impact on student performance level in comparison to traditional lectures (Andersson & Dawoud, 2012). Advantages of video lectures is that they create a realistic environment by including the speaking persons, examples, discussion, questioning, gestures, humor, and explanations through writing and drawings on the board. These components in teaching environments enhance understanding of the material by reducing complexity (Fritze & Nordkvelle, 2003). Furthermore, incorporating audio communication prevents an overload of visual information while increasing effectiveness of the learning process (Mayer, 2005).

Other advantages of video lectures include engaging students' attention, providing information that can be easily absorbed, helping students understand difficult phenomena, and providing flexibility of learning speed and time. Furthermore, video lectures can provide a variety of equipment and gadgets for learning and allow students to develop into self-sufficient learners by reinforcing concepts repeatedly. Additionally, other advantages include allowing students to enrich their lecture notes through the videos and presenting students with an opportunity to start, stop, or rewind the video to meet their particular needs (Kybartaite, Nousiainen, & Malmivuo, 2009). On the downside, video lectures could become dull, and students are not able to have a direct contact with the instructor when watching the video (Kybartaite, Nousiainen, & Malmivuo, 2009).

Methodology

Selection of Video Lectures

This study implemented video lectures as the selected instructional method. By video lectures, the study employed a multimedia enhanced instructional method that utilized video camera to capture a lecture with narrative that the instructor could upload on the web for multiple viewing. The video lectures utilized were single streaming videos with educational material such as demonstrations with narrated step-by-step instructions on using laboratory equipment.

The criteria for selecting a multimedia enhanced instructional method for improving pedagogical laboratory based learning considered several objectives. The selection criteria included both educational objectives of laboratory learning as well as objectives of this project.

Educational objectives. In order to create a standard for comparing and selecting a multimedia enhanced instructional method for improving pedagogical laboratory based learning, this study redefined educational objectives and aims of pedagogical laboratory based learning in terms of engineering technology (ET) laboratories. The study retrieved a standard for educational objectives and goals of engineering technology education from the Association of Technology, Management, and Applied Engineering (ATMAE).

ATMAE defined engineering technology as a “field concerned with the application of basic engineering principles and technical skills in support of engineers engaged in a wide variety of projects” (Wright, 2008, para. 4). Accreditation boards and industries identified critical thinking and problem solving as core competencies for this program (Scott & Boyd, 2008; Waldrop & Jack, 2012). Furthermore, the goal/student outcome is not only knowledge transfer, but also enabling students to apply that knowledge in various contexts (Scott & Boyd, 2008). In order to achieve these student outcomes, ATMAE mandated that ET programs should have experiences that emphasize problem-solving activities (Scott & Boyd, 2008). Instilling problem-solving and design skills requires presenting students with real-life problems and redesign solutions (Waldrop & Jack, 2012). ATMAE required ET instruction to focus on problem-solving activities that incorporate industrial application (Dyrenfurth & Newton, 2012). Furthermore, both ATMAE and the Accreditation Board for Engineering and Technology (ABET) require ET courses expose students to design skills while incorporating concepts (Scott & Boyd, 2008).

Therefore, institutions should design engineering technology laboratories in a manner that emphasizes design skills, professional skills and conceptual understanding (Ma & Nickerson, 2006). Enhancing these competencies requires presenting students with real life examples that involve problem solving during laboratory sessions. Acquisition of these competencies allows students to achieve the overall ET outcome of applying basic engineering principles and technical skills to various projects in the industry.

Project-based objectives. When selecting a method for improving pedagogical laboratory based learning, the study considered several factors. Two main factors were the study's purpose and the students' perception of an improved laboratory experience. From the students' point of view, the laboratory experience should allow them to attain hands-on experience, enhance understanding through improved visibility of demonstrations, and allow them to take notes and retain information simultaneously. Literature reviewed showed that video lectures (VL) generate a setting where the students are able to view and simultaneously take notes from their seats without the need to crowd around laboratory equipment during a demonstration (Jain, Gu, and Rizwan-Uddin, 2008; Thurnquist, 2003). VL establishes an environment where students are capable of viewing demonstrations with increased visibility due to zoom in and out features of video cameras. Therefore, this study utilized video lectures to create a realistic, traditional classroom environment.

The aim of this study was to improve pedagogical laboratory based learning with multimedia application. Effective multimedia application focuses on the important aspects of experiments and demonstration in terms of video, audio, and ‘real’ feel of conducting the experiment. The literature revealed that video lectures demonstrate hands-on experiments, enhance understanding through improved visibility of demonstrations, provide important information such as stepwise instructions on conducting the experiments, and deliver video/audio of the demonstration in process (Agrawal & Cherner, 2009; Jain, Gu, & Rizwan-Uddin, 2008). Additionally, video lectures enhance existing laboratories with multimedia (video cameras and audio) to create a laboratory where students conduct hands-on experiments in a traditional manner while sustaining the feeling of a real laboratory experience (Kybartaite, Nousiainen, & Malmivuo, 2010). These components enhance the basic understanding and content of the demonstrations. Furthermore, these factors improve pedagogical laboratory based learning. For attaining this goal, the video lectures were most suitable.

Methodology Overview

The methodology section of this study consisted of a practical part as well as an evaluative part. The first part that was practical, involved implementing video lectures for an enhanced laboratory. The second part that was evaluative, involved utilizing methods for evaluating the impact of video lectures based on student feedback.

By video lectures, the study implied a multimedia enhanced instructional method that utilizes video camera to capture a lecture with narrative that the instructor could upload on the web for multiple viewing. The video lectures utilized were single streaming videos with educational material such as demonstrations with narrated step-by-step instructions on using laboratory equipment. The methodology specifically addressed the effectiveness of this technology in lectures and its impact on student learning outcomes. The second part that was evaluative answered the question of whether utilizing technology such as video lectures in instructional methods can improve pedagogical laboratory based learning.

The form of presented technologies and instructional methods in this study were not new. However, this study was different from previous studies conducted on multimedia enhanced instructional methods in several ways. One main difference that exists between the present and past studies is the methodology used to evaluate the impact of a multimedia enhanced instructional method on pedagogical laboratory based learning. Past studies have used two separate batches of students to collect results. These studies exposed batch A of students to a traditional laboratory and a different batch B of students to a multimedia enhanced laboratory to compare the two instructional methods. The present study utilized the same batch of students for to reduce bias. Furthermore, other studies have used the same batch of students and exposed them to two different instructional methods that demonstrated the same process for comparison purposes. However, this study exposed students to two different instructional methods that demonstrated different processes. Therefore, this study reduced bias associated with knowledge transfer between the two demonstrations. Additionally, the instructional methods demonstrated processes that entailed a comparable level of difficulty.

Setting

The Advanced Manufacturing program at Western Kentucky University consists of several labs including PLC lab, electronics lab, materials lab, machining lab, robotics lab, hot metals lab, Computer Integrated Manufacturing (CIM) lab, CNC lab, and a manufacturing lab with lathe and milling machines. Although the study did not utilize all these laboratories, institutions could use the model, processes, and procedures learned in this study to adapt to other laboratories as well in the future. This study used the manufacturing lab with lathe and milling machines. This lab uses both traditional and advanced manufacturing equipment and methods utilized in current industries.

Methodology: Practical

The practical approach involved utilizing methods for implementing the multimedia enhanced laboratory. This approach dealt with the hardware and software components required for implementing the multimedia enhanced laboratory.

Project scope overview. The work scope described a flexible, turnkey recording and broadcasting system for instructional purposes in a manufacturing lab to demonstrate aspects of specific machines during the process of machining a part to length on a mill. The instructor stored the video lectures on the web. Additionally, the instructor made these video lectures accessible to students who could view the lecture multiple times.

HD Handycam Camcorder: specifications and functional description. The system consisted of a Sony HD Handycam Camcorder model HDR-SR1 that captured the demonstration in process. The audio specifications included a built-in microphone that recorded in Dolby Digital 5.1ch surround sound. A 10X optical zoom and 80X digital zoom for enhanced details and clear focus during demonstrations. The camcorder had on screen zoom buttons that allowed capture of the demonstrations from various angles at different levels of detail with ease. The pan, tilt, zoom in and zoom out capabilities allowed utilizing the camcorder for a variety of demonstrations. The optics/lens features included a Carl Zeiss Vario-Sonnar T lens with 4 megapixel (MP) resolution and provided a sharp and vivid video (Sony Electronics Inc., 2013).

The camcorder recorded high definition video straight to the device's 30 gigabyte (GB) hard disk drive. A USB 2.0 interface connected the Handycam Camcorder's hard disk drive to a computer for video transfer. The camcorder came with a software called Picture Motion Browser version 1.0 that saved the video in an (.mts) file format. The software was compatible with Microsoft Windows 2000, Windows Home, and Windows Professional (Sony Electronics Inc., 2013).

In order to upload the video lectures on the web, the videos were re-encoded using a software named Freemake. The software converted the files from .mts file format to .avi format without altering the video quality. The instructor uploaded the video lecture to Tegrity. Tegrity is a web-based application that captures lecture and makes it accessible on the web server.

Methodology: Evaluative

The purpose of this study was to improve pedagogical laboratory based learning. In order to test the impact of multimedia enhanced instructional methods on student learning outcomes, the researcher assessed student feedback. Previous studies regarded student feedback as one of the most critical factors in teaching assessment (Holmes & Brown, 2000). This form of assessment provides information useful for improving learning and teaching environments in the future. One common method of receiving student feedback is through questionnaires (Kybartaite, 2010). Questionnaires can attain student feedback and record the experience in a systematic manner. One pitfall with using questionnaires is that studies have regarded them as routine, simple, and convenient and therefore students do not take them too seriously (Richardson, 2005). Therefore, another form of student feedback to assess student learning outcomes is to include a quiz and this was utilized as well.

Population under study. The population was the students in AMS 227 Introduction to Manufacturing Methods. This course is comprised of a lecture and a laboratory component. During the course, students worked with machine and hand tools. A course objective is to attain a basic understanding of hand-operated machinery utilized in manufacturing. The course was comprised of 19 students.

Research design. The students viewed a live demonstration on machining a part to length on a lathe in a traditional laboratory lecture. The professor also posted a video lecture on machining a part to length on mill. The same day, students were informed verbally in class regarding the video lecture that quizzes and surveys would be conducted on both the in-class demonstration as well as the video lecture the following class meeting. The instructor expected the students to watch the video lecture in their available time. The study selected both these processes because, although different, they demonstrated basic principles related to machining and entailed a comparable level of difficulty.

Traditional lathe lecture. The traditional lecture demonstrated machining a part to length on the lathe. The duration of the demonstration was approximately two hours. Before the lecture started, the instructor gave students handouts that graphically represented the workpiece along with its final dimensions. At the start of the lecture, the instructor described all the parts of the lathe along with its functions. During the lecture, the instructor demonstrated machining the part to length on the lathe in a detailed, step-by-step manner. The instructor engaged the students during the lecture by asking questions and discussing related concepts. The instructor also discussed possible solutions to problems that the instructor and students encountered during the process. At the end of the lecture, the instructor asked the students to verbally summarize the process step-by-step. Figure 1 shows the lathe machine used.

Figure 1. Lathe machine

Video mill lecture. The video lecture demonstrated machining part to length on mill. The lecture comprised of four separate videos. The total duration of the video lecture was approximately 40 minutes. The instructor provided the students with a handout that graphically represented the workpiece along with its final dimensions. The beginning of the video lecture discussed the basics of the milling machine along with its various parts and functions. During the video lecture, the instructor narrated the process of machining part to length on mill in a detailed step-by-step manner. The zoom in and zoom out features of the video provided the students with a closer look at specific aspects of the process. Furthermore, the video utilized the zoom in feature to demonstrate the more important aspects of the machine on a larger scale. The instructor actively engaged the students during the lecture by asking questions, discussing related concepts and providing solutions to problems that occurred during the process. The greatest advantage of the video lecture were that the students could use the video to comprehend the process at their own pace, could view the video multiple times, and easily take notes while viewing the demonstration. Figure 2 shows the milling machine used.

Figure 2. Milling machine

Assessment techniques. This study used two different assessment techniques to evaluate the instructional methods: 1) a survey conducted after each laboratory lecture and 2) a quiz conducted after the laboratory lecture to measure students' understanding of the demonstrations. The use of these different assessment techniques achieved two purposes. First, the surveys received the students' evaluation on the lecture in order to compare the two types of instructional methods. Second, the quizzes measured the students' understanding of the demonstrations in order to evaluate the impact of multimedia enhanced instructional method on pedagogical laboratory based learning.

Survey questions. The survey consisted of seven questions. The questions on the survey asked students to evaluate the following: 1) their perception of the lecture in terms of interest and engagement during the demonstration, 2) their level of understanding the process, 3) visibility or their ability to see the process, 4) their level of understanding on the design of the process, 5) their ability to follow the steps, 6) retention of the demonstration, and 7) their overall learning experience. Students answered questions on a Likert scale from 1 to 5 in which 1 was very poor and 5 was very good. Appendix A shows the survey for machining a part to length on the lathe and the survey for machining a part to length on a mill.

Quiz questions. After the instructor completed the lectures, the students received a quiz on each lecture that measured their understanding of the demonstration based on course objective in order to evaluate the impact of multimedia enhanced instructional method on pedagogical laboratory based learning. The instructor formulated the quiz for each demonstration in the same manner. Each quiz consisted of a random series of steps in setting up the lathe and the mill to get a work piece to initial length. The quiz expected the students to reorder the steps in a chronological order. Appendix B shows the quiz on the lathe machine and the quiz on the mill machine.

Quiz and survey administration. After the demonstrations, at the next class meeting, the students received a survey for each demonstration to evaluate the lecture. Once the students completed the surveys, the instructor administered the quizzes randomly. Some students took the lathe quiz first and some took the mill quiz first. Once the students completed the first quiz, the instructor administered the second quiz. Random administration of the quizzes reduced the bias associated with all students initially receiving the same quiz and not focusing on the second quiz or vice versa. These quizzes measured the students' understanding of the demonstrations in order to evaluate the impact of multimedia enhanced instructional method on pedagogical laboratory based learning.

Data Analysis

The study analyzed data collected by conducting a t-test utilizing Excel: Two-Sample Assuming Equal Variance with an alpha of 0.05. First, the study used a two-tailed t-test on the variation between survey results from the traditional lathe lecture and the video mill lecture. Second, the study used a two-tailed t-test on the variation between quiz results from the traditional lathe lecture and the video mill lecture. T-test analysis evaluated the impact of multimedia enhanced instructional method on student learning outcomes to assess improvement in pedagogical laboratory based learning. Analyzing the data tested the following hypotheses:

H_0: Multimedia application in pedagogical laboratory instruction will not have an effect on pedagogical laboratory based learning.

H_1: Multimedia application in pedagogical laboratory instruction will have an effect on pedagogical laboratory based learning.

Threats to Validity

In order for the study to evaluate the impact of multimedia enhanced instructional method on pedagogical laboratory based learning, the study expected students to watch the video lecture in their available time. However, the study did not utilize measures to confirm that students watched the video lecture. Additionally, since the traditional lathe lecture allowed more direct communication including question and answer sessions, its duration was longer than the video mill lecture. This lack of confirmation and difference between the durations of the traditional lathe lecture and video mill lecture, add bias to survey results that the study used to compare the two types of instructional methods. Furthermore, these threats to validity also add bias to quiz results that the study used to measure the students' understanding of the demonstrations.

Furthermore, the study lacked traceability measures for linking individual student surveys to quiz scores. Utilizing these measures would add validity and assist in studying any direct correlations between individual quiz results and survey results.

Findings or Results

Surveys

The students received surveys to evaluate both lectures in order to compare the two types of instructional methods. The students rated the lectures based on a Likert scale of 1 to 5 where 1 = Very Poor; 2 = Poor; 3 = Average; 4 = Good; 5 = Very Good. The surveys allowed students to evaluate the traditional lathe lecture and the video mill lecture on the following criteria:

1. Level of interest and engagement in the process
2. Level of understanding the process
3. Ability to see the process
4. Ability to understand the design of the process
5. Ability to follow the steps in the process
6. Ability to retain the demonstration
7. Overall learning experience

Appendix C lists the raw survey results and Appendix E outlines the descriptive analysis of the survey results.

The first criterion for evaluation was the level of interest and engagement in the process. Table C1 in Appendix C shows the survey results on the level of interest and engagement during the two lectures. Table E1 shows the descriptive analysis from a t-test on the difference between the level of interest and engagement during the two lectures. There was a significant difference between the means on level of interest and engagement during the two lectures, ($t(36) = 2.078$, $p = 0.45$). Based on the results, the students preferred traditional lectures (TL) in comparison to video lectures (VL) in terms of level of interest and engagement. Furthermore, 63% of the students said that the level of interest and engagement in the traditional lathe lecture was better in comparison to video mill lecture.

The second criterion for evaluation was the level of understanding the process. Table C2 shows the survey results on the level of understanding the process during the two lectures. Table E2 shows the descriptive analysis from a t-test on the difference between the levels of understanding the process during the two lectures. There was no significant difference between the mean on the level of understanding the process during the two lectures.

The third criterion for evaluation was the ability to see the process. Table C3 shows the survey results on the ability to see the process during the two lectures. Table E3 shows the descriptive analysis from a t-test on the difference between the ability to see the process during the two lectures. There was no significant difference between the means on the ability to see the process during the two lectures.

The fourth criterion for evaluation was the ability to understand the design of the process. Table C4 shows the survey results on the ability to understand the design of the process during the two lectures. Table E4 shows the descriptive analysis from conducting a t-test on the difference between the ability to understand the design of the process during the two lectures. There was no significant difference between the mean on the ability to understand the design of the process during the two lectures

The fifth criterion evaluated was the ability to follow the steps in the process. Table C5 shows the survey results on the ability to follow the steps in the process during the two lectures. Table E5 shows the descriptive analysis from a t-test on the difference between the ability to follow the steps in the process during the two lectures. There was no significant difference between the mean ratings on the ability to follow the steps in the process during the two lectures.

The sixth criterion was the ability to retain the demonstration. Table C6 shows the survey results on the ability to retain the demonstration during the two lectures. Table E6 shows the descriptive analysis from a t-test on the difference between the ability to retain the demonstration during the two lectures. There was no significant difference between the means on the ability to retain the demonstration during the two lectures.

The seventh criterion for evaluation was the overall learning experience. Table C7 shows the survey results on the overall learning experience during the two lectures. Table E7 shows the descriptive analysis from a t-test on the difference between the overall learning experience during the two lectures. There was no significant difference between the mean ratings on the overall learning experience during the two lectures. Figure 3 shows the mean ratings of TL and VL for all criteria.

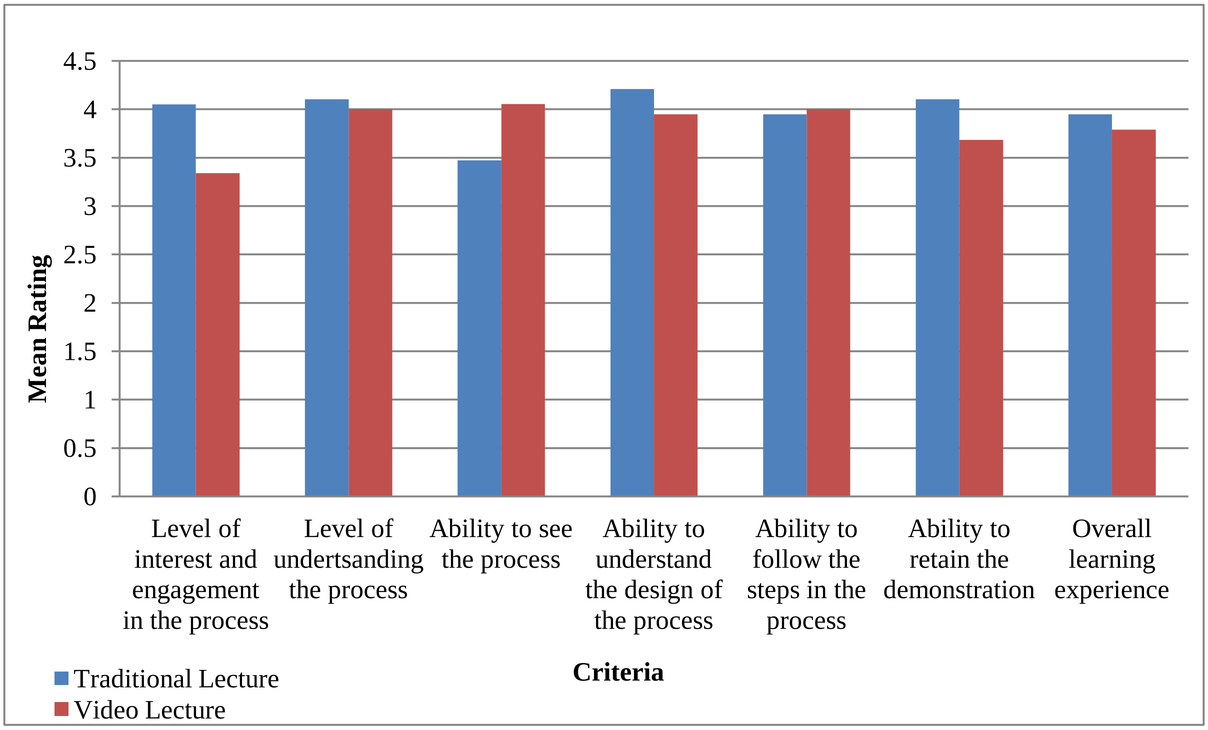

Figure 3. Mean ratings of TL and VL

Overall, the traditional lathe lecture rated significantly higher in terms of level of interest and engagement. There was no significant difference between the mean ratings for the traditional lathe lecture and video mill lecture in terms of level of understanding the process, ability to see the process, ability to understand the design of the process, ability to follow the steps in the process, ability to retain the demonstration, and overall learning experience.

After the instructor had administered the surveys and quizzes, the instructor asked the students for further feedback and additional comments on both the instructional methods. The students said that both TL and VL have their own advantages. The students said that one of the greater advantages of VL was that it allowed for repetitive viewing.

Quizzes

The students received quizzes that allowed measuring the students' understanding of the demonstrations in order to evaluate the impact of multimedia enhanced instructional method on pedagogical laboratory based learning. The quizzes asked the students to place the process steps in a chronological order from 1 (first step) to 8 (last step) to get the workpiece to initial length on the mill as well as on the lathe. The instructor graded the quizzes based on the number of steps ordered correctly. Appendix D lists the raw quiz results and Appendix F outlines the descriptive analysis of the quiz results.

Table F1 shows the descriptive analysis from conducting a t-test on the difference between quiz results from the traditional lathe lecture and the video mill lecture. There was no significant difference between the quiz results from the traditional lathe lecture and the video mill lecture.

Quiz results showed that the students scored an average of 26% on the video mill lecture with a standard deviation of 28. The minimum score was 0% and the maximum was 100%. Furthermore, the students scored an average of 22% on the traditional lathe lecture with a standard deviation of 18. The minimum score was 12.5% and the maximum was 75%.

Descriptive analysis showed that there was no significant difference between the quiz results from the traditional lathe lecture and the video mill lecture. There is no difference between the students' understanding of the demonstrations from the traditional lathe lecture and the video mill lecture. Therefore, multimedia enhanced instructional methods do not have an effect on pedagogical laboratory based learning.

Conclusion

Surveys

Similarities with previous studies. Survey results showed that students prefer TL in comparison to VL in terms of level of interest and engagement. This preference aligns with previous studies that also revealed that students preferred TL over VL due to the level of increased interaction and engagement (Said & Khan, 2004). The result that 63% of the students said that the level of interest and engagement in the TL was better in comparison to VL aligns with previous studies. Literature reviewed showed that the greatest advantage of TL is direct communication with the instructor such as question and answer sessions that enhance motivation amongst the students (Andersson & Dawoud, 2012; Kybartaite, 2010).

Although survey results showed no significant difference between the means on the ability to see the process during the two lectures, there was a slight preference for VL in comparison to TL. This preference aligns with previous studies that also revealed that VL increases visibility and generates a setting where students are able to view the demonstration without the need to crowd around (Agrawal & Cherner, 2009; Jain, Gu, & Rizwan-Uddin, 2008; Thurnquist, 2003).

Qualitative response results from students indicated that VL adds the advantage of repetitive viewing. Other studies supported this finding by presenting similar results in which students found video lectures helpful because it allowed reviewing the course materials, re-emphasizing the lecture, and made repetitive viewing possible (Agrawal & Cherner, 2009; Kybartaite, 2010; Said & Khan, 2004).

Differences with previous studies. Some survey results contradicted previous studies. Survey results showed that students do not have a preference between TL and VL in terms of level of understanding the process, ability to understand the design of the process, and overall learning experience. However, previous studies revealed that VL enhances student learning, increases effectiveness of the learning process, and provides a more effective learning experience (Agrawal & Cherner, 2009; Andersson & Dawoud, 2012; Jain, Gu, & Rizwan-Uddin, 2008; Kybartaite, Nousiainen, & Malmivuo, 2009; Mora-Aguilar, Sancho-Bru, & Iserte-Vilar, 2009). Contradiction of survey results with previous studies could be due to the small population size this study utilized.

Links within study. Results revealed no link between the level of interest and engagement in the process with other criteria that included level of understanding the process, ability to see the process, ability to understand the design of the process, ability to follow the steps, ability to retain the demonstration, and overall learning experience. Therefore, an increased level of interest and engagement did not have an impact on the other criteria.

Quizzes

Although survey results indicated that students preferred TL due to an increased level of interest and engagement in the process, the quiz results did not link to this finding. Since there was no difference between the quiz results from the TL and VL, there is no difference between the students' understanding of the demonstrations. Therefore, although TL increases the level of interest an engagement in the process, it does not necessarily increase students' understanding of the demonstration in comparison to VL.

Similarities with previous studies. These quiz results supported most previous studies. Studies conducted on VR and RL showed that there was no difference amongst the achievement scores of students conducting experiments in a multimedia enhanced laboratory or a traditional laboratory (Kerr et al., 2004). Furthermore, students attained the same learning objectives and achieved the same learning outcomes in multimedia enhanced laboratories and TL (Ogot, Elliot, & Glumac, 2003; Tuysuz, 2010). Kybartaite (2010) conducted a similar study that revealed no difference in scores across TL students, VL students, and virtual classroom students. Similar studies showed that video lectures are an effective learning tool, with no impact on student performance level in comparison to TL (Andersson & Dawoud, 2012). Similarly, data from the present study showed that there was no difference between the quiz results from the TL and the VL. Hence, there is no difference between the students' understanding of the demonstrations from the TL and VL. Therefore, the null hypothesis is accepted that multimedia enhanced instructional methods do not have an effect on pedagogical laboratory based learning.

Differences with previous studies. The quiz results contradicted one previous study. Brecht (2012) conducted a study that showed that exam grades from students that utilized VL as a supplement to TL were better in comparison to exam grades from TL students.

Data Interpretation

Many explanations are present for varying viewpoints on utilizing video lectures as an instructional method to enhance pedagogical laboratory based learning. However, one prominent explanation results from the literature reviewed and this study. All the studies focused on various disciplines including computer programming (Said & Khan, 2004), biomedical engineering (Kybartaite, 2010), mathematics (Andersson & Dawoud, 2012), financial accounting (Brecht, 2012), or engineering technology as in the present study. All the studies agreed that video lectures are an effective learning tool, increase educational effectiveness, allow repetitive viewing, allow revising course material, and add flexibility to the learning process (Andersson & Dawoud, 2012; Bal, 2012; Brecht, 2012; Kybartaite, 2010; Said & Khan, 2004). However, while some studies implemented video lectures as a stand-alone instructional method, others implemented it to enhance existing traditional laboratories in a blended learning format. Utilization of video lectures as a stand-alone instructional method versus in a blended learning format explains the diverging viewpoints on this instructional method's impact on student surveys and quiz results. Altogether, VL allows repetitive viewing and reinforcement of course material to absorb complex topics while TL allows for interaction possibilities.

In conclusion, this study revealed no difference between the quiz results from the TL and VL. Hence, there was no difference between the students' understanding of the demonstrations from TL and VL. Therefore, the following null hypothesis is accepted:

H_0: Multimedia application in pedagogical laboratory instruction will not have an effect on pedagogical laboratory based learning.

Literature reviewed and this study also showed that VL allows repetitive viewing and reinforcement of course material to absorb complex topics while TL allows for interaction possibilities and an increased level of interest and engagement. Therefore, this study recommends that future studies should integrate TL with VL in a blended learning environment and evaluate the combined impact on pedagogical laboratory based learning in the field of engineering technology.

Suggestions for Further Study

Although there was no difference between the quiz results from the traditional lecture and video lecture, the standard deviation for VL was very large with a value of 28. A closer analysis of individual VL student scores reflects that the minimum score was 0% and the maximum was 100%. Additionally, 26% of the students scored 0% and the scores were extremely dispersed. Therefore, no knowledge transfer occurred in these cases possibly because the students did not view the video lecture. This study recommends that future studies require students to watch the video lecture in class to eliminate the bias associated with students not watching the lecture in their available time.

This study lacked traceability measures for linking individual student surveys to quiz scores. This study recommends utilizing a confidential form of tracing student surveys to corresponding student quiz scores. Doing so will allow studying any links or correlations between individual quiz and survey results.

Finally, this study revealed that both TL and VL have their own advantages. Therefore, this study recommends evaluating the impact of blended learning that utilizes TL and VL, as a multimedia enhanced instructional method on quiz results to assess its impact on pedagogical laboratory based learning in engineering technology.

Appendix A: Surveys

Machining Part to Length on Lathe

Rate the traditional lathe lecture on machining part to length based on the following criteria. Use a scale of 1 to 5 where: 1 = Very Poor; 2 = Poor; 3 = Average; 4 = Good; 5 = Very Good

1. Level of interest and engagement in the process……………………1 2 3 4 5
2. Level of understanding the process…………………………………1 2 3 4 5
3. Ability to see the process……………………………………………1 2 3 4 5
4. Ability to understand the design of the process…………………….1 2 3 4 5
5. Ability to follow the steps in the process……………………………1 2 3 4 5
6. Ability to retain the demonstration………………………………… 1 2 3 4 5
7. Overall learning experience…………………………………………1 2 3 4 5

Machining Part to Length on Mill

Rate the video mill lecture on machining part to length based on the following criteria. Use a scale of 1 to 5 where: 1 = Very Poor; 2 = Poor; 3 = Average; 4 = Good; 5 = Very Good

1. Level of interest and engagement in the process……………………1 2 3 4 5
2. Level of understanding the process…………………………………1 2 3 4 5
3. Ability to see the process……………………….…...……………1 2 3 4 5
4. Ability to understand the design of the process…………………….1 2 3 4 5
5. Ability to follow the steps in the process……………………………1 2 3 4 5
6. Ability to retain the demonstration………………………………… 1 2 3 4 5
7. Overall learning experience…………………………………………1 2 3 4 5

Appendix B: Quizzes

Lathe Machine

Instructions: Place the following steps in chronological order from 1 (first step) through 8 (last step) to get workpiece to initial length on the lathe. Please note steps are missing from the process.

1. ____	a. Center drill second end
2. ____	b. Face off to length
3. ____	c. Center drill first end
4. ____	d. Cut workpiece off from raw stock
5. ____	e. Measure for length
6. ____	f. Face one end to square end
7. ____	g. Adjust RPM of machine
8. ____	h. Make sure spindle is turning in proper direction

Milling Machine

Instructions: Place the following steps in chronological order from 1 (first step) through 8 (last step) to get workpiece to initial length on the mill. Please note steps are missing from the process.

1. ____	a. Measure for length
2. ____	b. Check direction of spindle turning
3. ____	c. Turn workpiece around in vice
4. ____	d. Cut workpiece off from raw stock
5. ____	e. Face off to length
6. ____	f. Face one end to square end
7. ____	g. Adjust RPM to correct amount
8. ____	h. Face second end

Appendix C: Raw Survey Results

Table C1.

Survey results for the level of interest and engagement during the two lectures.

Criteria	Rating: Traditional Lecture (TL)	Rating: Video Lecture (VL)
Level of interest and engagement in the process	3	2
	3	5
	4	3
	5	5
	5	5
	4	3
	4	2
	4	4
	5	4.5
	3	1
	4	3
	5	2
	5	3
	3	4
	5	4
	5	3
	3	4
	2	3
	5	3
Mean Rating	**4.05**	**3.34**

Table C2.

Survey results for the level of understanding the process during the two lectures.

Criteria	Rating	
	Traditional Lecture (TL)	**Video Lecture (VL)**
Level of understanding the process	4	3
	4	4
	5	4
	5	5
	4	5
	4	4
	4	3
	5	5
	4	5
	3	3
	4	4
	4	3
	5	4
	4	2
	3	5
	5	4
	5	5
	3	4
	3	4
Mean Rating	**4.11**	**4.00**

Table C3.

Survey results for the ability to see the process during the two lectures.

Criteria	Rating	
	Traditional Lecture (TL)	**Video Lecture (VL)**
Ability to see the process	3	4
	4	5
	2	3
	3	5
	4	4
	5	4
	4	3
	3	3
	5	5
	2	5
	5	4
	3	5
	2	2
	3	4
	3	4
	5	5
	3	5
	4	3
	3	
Mean Rating	**3.47**	**4.06**

Table C4.

Survey results for ability to understand the design of the process during the two lectures.

Criteria	Rating	
	Traditional Lecture (TL)	**Video Lecture (VL)**
Ability to understand the design of the process	3	4
	3	5
	5	4
	5	5
	4	5
	5	5
	5	4
	4	3
	5	5
	3	4
	4	3
	4	1
	5	4
	4	2
	3	4
	5	3
	4	5
	4	5
	5	4
Mean Rating	**4.21**	**3.95**

Table C5.

Survey results for the ability to follow the steps in the process during the two lectures.

Criteria	**Rating**	
	Traditional Lecture (TL)	**Video Lecture (VL)**
Ability to follow the steps in the process	4	4
	3	5
	4	4
	5	5
	5	5
	5	5
	5	3
	4	3
	5	5
	3	4
	4	3
	4	2
	1	4
	3	4
	4	4
	5	3
	3	5
	4	5
	4	3
Mean Rating	**3.95**	**4.00**

Table C6.

Survey results for the ability to retain the demonstration during the two lectures.

Criteria	**Rating**	
	Traditional Lecture (TL)	**Video Lecture (VL)**
Ability to retain the demonstration	3	3
	3	5
	5	4
	5	5
	4	4
	5	4
	4	3
	4	4
	4	5
	3	1
	4	3
	5	3
	5	3
	4	3
	3	4
	5	3
	4	5
	4	5
	4	3
Mean Rating	**4.11**	**3.68**

Table C7.

Survey results for the overall learning experience during the two lectures.

Criteria	Rating	
	Traditional Lecture (TL)	**Video Lecture (VL)**
Overall learning experience	4	3
	3	5
	4	4
	4	5
	5	4
	5	4
	4	3
	4	3
	5	5
	3	2
	4	3
	4	2
	3	4
	3	3
	4	5
	5	4
	4	5
	3	4
	4	4
Mean Rating	**3.95**	**3.79**

Appendix D: Raw Quiz Results

Table D1.

Raw quiz scores from the two lectures.

	Quiz Score (%)	
	Traditional Lecture (TL)	**Video Lecture (VL)**
	12.5	12.5
	12.5	75
	12.5	0
	12.5	100
	12.5	0
	12.5	75
	12.5	25
	12.5	0
	25	0
	75	12.5
	12.5	0
	25	25
	12.5	25
	25	25
	25	37.5
	62.5	12.5
	37.5	25
	12.5	25
	12.5	25
Average	**22.4**	**26.3**
Standard Deviation	**17.96**	**28.23**

Appendix E: Descriptive Analysis of Survey Results

Table E1.

Descriptive analysis on the difference between levels of interest and engagement during the two lectures.

t-Test: Two-Sample Assuming Equal Variances		
	Traditional Lecture (TL)	*Video Lecture (VL)*
Mean	4.052631579	3.342105263
Variance	0.941520468	1.279239766
Observations	19	19
Pooled Variance	1.110380117	
Hypothesized Mean Difference	0	
df	36	
t Stat	2.078289923	
P(T<=t) one-tail	0.022435575	
t Critical one-tail	1.688297714	
P(T<=t) two-tail	0.044871149	
t Critical two-tail	2.028094001	

Table E2.

Descriptive analysis on the difference between levels of understanding the process during the two lectures.

t-Test: Two-Sample Assuming Equal Variances	*Traditional Lecture (TL)*	*Video Lecture (VL)*
Mean	4.105263158	4
Variance	0.543859649	0.777777778
Observations	19	19
Pooled Variance	0.660818713	
Hypothesized Mean Difference	0	
df	36	
t Stat	0.399114063	
P(T<=t) one-tail	0.34608349	
t Critical one-tail	1.688297714	
P(T<=t) two-tail	0.69216698	
t Critical two-tail	2.028094001	

Table E3.

Descriptive analysis on the difference between ability to see the process during the two lectures.

t-Test: Two-Sample Assuming Equal Variances		
	Traditional Lecture (TL)	*Video Lecture (VL)*
Mean	3.473684211	4.055555556
Variance	1.040935673	0.879084967
Observations	19	18
Pooled Variance	0.962322473	
Hypothesized Mean Difference	0	
df	35	
t Stat	-1.803345114	
P(T<=t) one-tail	0.039974273	
t Critical one-tail	1.689572458	
P(T<=t) two-tail	0.079948545	
t Critical two-tail	2.030107928	

Table E4.

Descriptive analysis on the difference between ability to understand the design of the process during the two lectures.

t-Test: Two-Sample Assuming Equal Variances	*Traditional Lecture (TL)*	*Video Lecture (VL)*
Mean	4.210526316	3.947368421
Variance	0.619883041	1.274853801
Observations	19	19
Pooled Variance	0.947368421	
Hypothesized Mean Difference	0	
df	36	
t Stat	0.833333333	
P(T<=t) one-tail	0.205075904	
t Critical one-tail	1.688297714	
P(T<=t) two-tail	0.410151807	
t Critical two-tail	2.028094001	

Table E5.

Descriptive analysis on the difference between ability to follow the steps in the process during the two lectures.

t-Test: Two-Sample Assuming Equal Variances		
	Traditional Lecture (TL)	*Video Lecture (VL)*
Mean	3.947368421	4
Variance	1.052631579	0.888888889
Observations	19	19
Pooled Variance	0.970760234	
Hypothesized Mean Difference	0	
df	36	
t Stat	-0.16464639	
P(T<=t) one-tail	0.435071668	
t Critical one-tail	1.688297714	
P(T<=t) two-tail	0.870143335	
t Critical two-tail	2.028094001	

Table E6.

Descriptive analysis on the difference between ability to retain the demonstration during the two lectures.

t-Test: Two-Sample Assuming Equal Variances		
	Traditional Lecture (TL)	*Video Lecture (VL)*
Mean	4.105263158	3.684210526
Variance	0.543859649	1.116959064
Observations	19	19
Pooled Variance	0.830409357	
Hypothesized Mean Difference	0	
df	36	
t Stat	1.42413799	
P(T<=t) one-tail	0.081508709	
t Critical one-tail	1.688297714	
P(T<=t) two-tail	0.163017417	
t Critical two-tail	2.028094001	

Table E7.

Descriptive analysis on the difference between overall learning experience during the two lectures.

t-Test: Two-Sample Assuming Equal Variances		
	Traditional Lecture (TL)	*Video Lecture (VL)*
Mean	3.947368421	3.789473684
Variance	0.497076023	0.953216374
Observations	19	19
Pooled Variance	0.725146199	
Hypothesized Mean Difference	0	
df	36	
t Stat	0.571500572	
P(T<=t) one-tail	0.285605777	
t Critical one-tail	1.688297714	
P(T<=t) two-tail	0.571211554	
t Critical two-tail	2.028094001	

Appendix F: Descriptive Analysis of Quiz Results

Table F1.

Descriptive analysis on the difference between quiz results from the two lectures

t-Test: Two-Sample Assuming Equal Variances		
	Traditional Lecture (TL)	*Video Lecture (VL)*
Mean	22.36842105	26.31578947
Variance	322.5511696	796.7836257
Observations	19	19
Pooled Variance	559.6673977	
Hypothesized Mean Difference	0	
df	36	
t Stat	-0.514285714	
P(T<=t) one-tail	0.305097563	
t Critical one-tail	1.688297714	
P(T<=t) two-tail	0.610195126	
t Critical two-tail	2.028094001	

Appendix G: IRB Approval

WKU

INSTITUTIONAL REVIEW BOARD
OFFICE OF RESEARCH INTEGRITY

DATE:	September 11, 2013
TO:	Sumbul Khan
FROM:	Western Kentucky University (WKU) IRB
PROJECT TITLE:	[512215-1] Improvement of Pedagogical Laboratory Based Learning: Multimedia Enhanced Instructional Methods
REFERENCE #:	IRB 14-045
SUBMISSION TYPE:	New Project
ACTION:	APPROVED
APPROVAL DATE:	September 11, 2013
EXPIRATION DATE:	December 15, 2013
REVIEW TYPE:	Expedited Review

Thank you for your submission of New Project materials for this project. The Western Kentucky University (WKU) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a *signed* consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of December 15, 2013.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Paul Mooney at (270) 745-2129 or irb@wku.edu. Please include your project title and reference number in all correspondence with this committee.

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