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A comparison of two methods for online delivery of biorenewable resources and technology course content

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A comparison of two methods for online delivery of biorenewable resources and technology course content

by

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Major: Industrial and Agricultural Technology

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LIST OF TERMS

ABE	Agricultural and Biosystems Engineering
AGRON	Agronomy
BRT	Biorenewable Resources and Technology
CCEE	Civil, Construction, and Environmental Engineering
CBE	Chemical and Biological Engineering
GPA	Grade Point Average
HORT	Horticulture
ILS	Index of Learning Styles
IRB	Institutional Review Board for Human Subjects, Iowa State University
MBTI	Myers-Briggs Type Indicator
MDAP	Menu-driven Autotutorial Presentations Delivered via Flash
ME	Mechanical Engineering
NCES	U.S. Department of Education National Center for Education Statistics
SRWC	Short Rotation Woody Crops
VEC	Virtual Education Center

ABSTRACT

In 2007, a Virtual Education Center for Biorenewable Resources was initiated (Raman, Brown, Brumm, Anex, Euken, Nokes, Crofcheck, Van Gerpen, and He, 2006). The Center offered three courses through distance education, including Biorenewable Resources and Technology (BRT) 501 – Fundamentals of Biorenewable Resources and Technology. The main objectives for this study were to:

1. Determine if student learning in BRT 501 was influenced by course delivery method. Two methods were used – video lecture and menu-driven autotutorial presentations (MDAP) delivered via Flash. The influence of student major and gender on learning were also studied.
2. Assess student perceptions of the two delivery methods.
3. Compare instructor time commitment for classroom lecture, video lecture, and MDAP delivery methods.

Student learning experience was measured in the online course of BRT 501 at Iowa State University during spring semester 2010. Data were gathered from the WebCT grade book and student survey, which were supplemented by online research.

The sample size was 46 for delivery method, student major, and gender comparisons. Students were divided into two academically equal groups, one receiving lecture content in a video lecture format and the other in a MDAP format. We found that BRT 501 student learning was not significantly affected by the module delivery method. Students with agricultural majors were outperformed by students with non-agricultural majors, most of whom were engineering students, on the midterm and final exams, and course grade. Female

students scored significantly lower on biomass module first attempt quiz total than male students, but this difference was driven by a single low score and the small sample size. Furthermore, this difference between genders disappeared for the highest quiz score attempt total, and no other assessment showed a significant difference between scores achieved by female and male students.

Twenty students completed a survey of the qualitative aspects of student experiences in BRT 501. The biomass production module brought students without a farm background closer to the knowledge level of students with a farm background as demonstrated by students' self-assessed knowledge and their BRT 501 assessment scores. Students desired a stronger connection with the course instructor and peers, whether electronically or in-person.

The instructor time commitment for module development and delivery were gathered for classroom lecture, video lecture, and MDAP formats. These values were compared to determine the instructor time commitment of the three delivery methods. The study results indicate that a classroom lecture takes less instructor time commitment than a video lecture or a MDAP delivered online for the initial course offering. The video lecture and MDAP required coordination with the online delivery staff. The MDAP also took significantly longer to develop. For subsequent course offerings, both the video lecture and MDAP delivered online have the potential to take similar or less instructor time commitment than a classroom lecture.

For BRT 501, the best choice for content delivery appears to be online video lectures. The instructor needs to be visible on screen part of the time to fulfill student desires for a connection to the instructor and an opportunity for them to gather nonverbal cues. A hybrid course using video lectures and a limited number of classroom meetings (two to four per semester) also has the potential to fulfill the connection need (Mills and Xu, 2005-2006). Both formats would minimize instructor time commitment and offer a good learning environment for students. The MDAP took too much instructor time, some of which could be shifted to support staff. This shift would require significant support staff time to develop high quality presentations and would carry a significant cost. As instructional technology becomes easier to use and more powerful, the focus of online education will continue to shift from delivery technologies to successful student learning strategies.

CHAPTER 1. GENERAL INTRODUCTION

Introduction

Technology has been a driver in the advancement of distance education throughout its history, serving citizens with limited access to traditional educational programming. Distance education started in the 1700s in Europe as mail correspondence courses (Jeffries, 2010). It crossed the ocean and took root in the United States, taking off in the late nineteenth century when women found it a viable education option (Nasseh, 1997). University professors started recording lectures on phonograph records for distribution to students at distant locations in the early 1900s (Distance Education History, 2005). The next step appeared to be radio, but it never took off due to low enrollments (Jeffries, 2010).

Television was the next great technology advancement in distance education, with Iowa State University leading the way as the first university-owned station in 1950 that broadcast distance education courses (History of Iowa State, 2011). At its peak in the 1970s, 222 universities operated television stations (Jeffries, 2010). Telecasts reached citizens in remote areas with a lecture-style product very similar to that offered in university classrooms at the time. Satellite and fiber optic network systems followed that were a reasonable option for two-way communication between student and instructor (Jeffries, 2010; Distance Education History, 2005). Professors started to use the internet to supplement face-to-face courses in the 1980s with listserve resources and email (Jeffries, 2010). As bandwidth increased and high speed access has become more prevalent, technology has developed to take advantage of the Internet channel. Learning resources are now at a student's fingertips through the Internet.

The U.S. Department of Education's National Center for Education Statistics (NCES) (2008) reported that 66% of two-year and four-year degree granting postsecondary institutions offered at least one distance education course in 2006-07. The rate is higher for four-year public institutions at 89% for all types of continuing education courses and 88% for college credit courses (U.S. Department of Education, 2008). Distance education has room to grow through penetration within four-year higher education institutions. The number of students that now take at least one higher education course online has grown from 9.6% of total enrollment in fall 2002 to 31.3% of total enrollment in fall 2010 (Allen and Seaman, 2011). This was over 6.1 million students in 2010 (Allen and Seaman, 2011). Allen and Seaman (2011) also found that 65.5% of higher education chief academic officers considered online education important to their institution's long-term strategy.

Studies have found no significant difference in student learning between face-to-face and distance education environments (Bourne, Harris, and Mayadas, 2005; Chen and Jones, 2007). Bourne et al. (2005, p. 19) described the advantages and disadvantages of online distance education distribution systems, as paraphrased here:

Advantages

- *Students have had success learning online*
- *Students are satisfied with the online learning experience*
- *Increased flexibility and convenience for students*
- *Constructivist approaches work well online*
- *Delivery costs are comparable to face-to-face delivery*
- *Courses are more scalable*

Disadvantages

- *Social connectivity is reduced, if it is not handled well*
- *Students may struggle with differences in media*
- *Instructor time commitment may be greater*

In 2007, a Virtual Education Center for Biorenewable Resources was initiated (Raman, Brown, Brumm, Anex, Euken, Nokes, Crofcheck, Van Gerpen and He, 2006). The Center offered three courses through distance education, one being Biorenewable Resources and Technology (BRT) 501 – Fundamentals of Biorenewable Resources and Technology.

The BRT 501 syllabus (Raman, 2010, p. 1) described the course as an introduction “to the science and engineering of converting biorenewable resources into bioenergy and biobased products.” Topics included: defining the resource base; physical and chemical properties of biorenewable resources; description of biobased products; methods of production for biorenewable resources; processing technologies for fuels, chemicals, fibers and energy; environmental impacts; and the economics of biobased products and bioenergy.

The primary lecturer for the course was Dr. D. Raj Raman, then Associate Professor, Department of Agricultural and Biosystems Engineering and Associate Director of Educational Programs, Bioeconomy Institute. Katrina Christiansen, then Graduate Research Assistant, Department of Agricultural and Biosystems Engineering, served as the graduate teaching assistant. Darren Jarboe, then Program Manager, Center for Crops Utilization Research and Ph.D. candidate, Industrial and Agricultural Technology, served as a special lecturer for the biomass production module, the section of the course during which the data for this study were collected.

Development and delivery of a biomass production module was selected because Jarboe had formal training in agronomy (B.S.), six years of commercial seed production experience, and over 10 years of agricultural research experience. Also, the biomass production module needed an upgrade to be more effective for students.

Dissertation Organization

The overarching purpose of this study was to determine the comparative learning experience from lectures distributed through two methods: video lecture and menu-driven autotutorial presentations (MDAP) delivered via Flash (see appendix A for examples). In this study, student learning experience was measured in the online course of BRT 501 at Iowa State University during spring semester 2010. Students were divided into two academically equal groups, one receiving lecture content in a video lecture and the other in a MDAP format. The major objectives for the study were to:

1. Determine if student learning in BRT 501 was influenced by course delivery method. Two methods were used – video lecture and menu-driven autotutorial presentations (MDAP) delivered via Flash. The influence of student major and gender on learning were also studied.
2. Assess student perceptions of the two delivery methods.
3. Compare instructor time commitment for classroom lecture, video lecture, and MDAP delivery methods.

To address the first objective, data were gathered from the WebCT grade book, a student survey, and an instructor time log, which was supplemented by online research. Qualitative aspects of student experiences with the two technology platforms were collected and analyzed, providing insight into student learning processes. Factors in the biomass production module that were explored include: student likes and dislikes about the delivery method used, student perceptions of the individual segments by biomass species, self-reported study time, student-instructor communication, and overall educational experience. The study also aimed to identify how learning styles influence student performance on assessments and self-assessed performance in BRT 501.

To address the second objective, supplemental videos of biomass production activities were provided as part of the biomass module. Students were queried about additional resources that would make the biomass production lectures more effective for student learning.

Finally, to address the third objective, the instructor time commitment for module development and delivery was gathered for content delivered through classroom lecture, video lecture, and MDAP formats. These values were compared to determine the instructor time commitment for the three delivery methods.

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CHAPTER 2. COURSE DELIVERY METHODS DO NOT APPEAR TO INFLUENCE STUDENT LEARNING IN BIORENEWABLE RESOURCES AND TECHNOLOGY

A paper to be submitted to the British Journal of Educational Technology

Darren H. Jarboe, D. Raj Raman, Scott McLeod, and Robert A. Martin

Abstract

In 2007, a Virtual Education Center for Biorenewable Resources was initiated (Raman et al., 2006). The Center offered three courses through distance education, one being Biorenewable Resources and Technology (BRT) 501 – Fundamentals of Biorenewable Resources and Technology, the subject of this study. The primary objective was to determine if course delivery method (video lecture format and the other in menu-driven autotutorial presentations (MDAP) delivered via Flash format), student major (agricultural and non-agricultural), and gender influence online student learning in BRT 501. Student learning experience was measured in the online course of BRT 501 at Iowa State University during spring semester 2010. Data were collected from the WebCT grade book, which was supplemented by online research. The sample size was 46 and students were divided evenly into two academically equal groups, one receiving lecture content in a video lecture format and the other in MDAP format. Student performance in BRT 501 based on online course delivery method (video lecture or MDAP), student major (agricultural or non-agricultural), and gender was analyzed. We found that BRT 501 student performance was not significantly impacted by module delivery method. Students with agricultural majors were outperformed

by students with non-agricultural majors, most of whom were engineering students, on the midterm and final exams, and course grade. Female students scored significantly lower on the biomass module first attempt quiz total. However, this was due to one female student's first attempt total score on the biomass quizzes, which had an impact due to the small sample size. This difference disappeared for the highest score attempt total for the biomass quizzes. All other assessments showed no significant difference between scores achieved by female and male students.

Introduction

Technology has been a driver in the advancement of distance education throughout its history, serving citizens with limited access to traditional educational programming. Distance education started in the 1700s in Europe as mail correspondence courses (Jeffries, 2010). It crossed the ocean and took root in the United States, taking off in the late nineteenth century when women found it a viable education option (Nasseh, 1997). In the early 1900s, university professors started recording lectures on phonograph records for distribution to students at distant locations (Distance Education History, 2005). The next step appeared to be radio, but it never took off due to low enrollments (Jeffries, 2010).

Television was the next great technology advancement in distance education, with Iowa State College (now Iowa State University) leading the way in 1950 by starting up the "first educationally owned and operated commercial station" to broadcast (History of Iowa State, 2011). Television peaked in the 1970s with 222 universities operating television stations (Jeffries, 2010). Telecasts reached citizens in remote areas with a lecture-style product very similar to that offered in university classrooms at the time. Satellite and fiber optic network systems followed that were a reasonable option for two-way communication between student and instructor (Jeffries, 2010; Distance Education History, 2005). Professors started to use the internet to supplement face-to-face courses in the 1980s with listserve resources and email (Jeffries, 2010). As bandwidth increased and high speed access became more prevalent, technology was developed to take advantage of the Internet channel and transition education delivery online.

The U.S. Department of Education's National Center for Education Statistics (NCES) (2008) reported that 66% of two-year and four-year degree granting postsecondary institutions offered at least one online education course in 2006-07. The rate was higher for four-year public institutions at 89% for all types of continuing education courses and 88% for college credit courses (U.S. Department of Education, 2008). The number of students that now take at least one higher education course online has grown from 9.6% of total enrollment in fall 2002 to 31.3% of total enrollment in fall 2010 (Allen and Seaman, 2011). This was over 6.1 million students in 2010 (Allen and Seaman, 2011). Allen and Seaman (2011) also found that 65.5% of higher education chief academic officers considered online education important to their institution's long-term strategy. Online education has room to grow through penetration at four-year higher education institutions.

Enrollment at postsecondary education institutions is expected to increase for all students 18 years old or more, creating an economic challenge to meet the needs of these students (Hussar and Bailey, 2011). Students 25 years old and older, many of them part-time, will make up 60% of the 2.5 million student increase by 2020 (Hussar and Bailey, 2011). Studies have found these students tend to need flexibility in time and location to attend courses, which is offered by online delivery. Arbaugh and Duray (2002) observed that non-traditional students face location and work schedule challenges that force them into online programs. Arbaugh (2005) noted that course flexibility was positively associated with student learning and satisfaction with the delivery medium. Online courses provide students with flexibility and better access to courses (O'Malley and McCraw, 1999). The remaining 40% of students also want flexibility in their educational experience. Mills and Xu (2005) observed that nearly all students preferred the online version of their statistics course.

Studies found no significant difference in student learning between face-to-face and online education environments (Bourne, Harris, and Mayadas, 2005; Chen and Jones, 2007) demonstrating educational quality can be maintained in this flexible environment. Bourne et al. (2005) described online learning advantages as student online learning success and satisfaction, greater flexibility and convenience for students, constructivist approaches work well, costs are comparable to classroom delivery, and courses are scalable. They found the potential disadvantages to be reduced social connectivity, media differences (i.e., various types of courseware with differing interfaces), and greater instructor time commitment.

In 2007, a Virtual Education Center for Biorenewable Resources (VEC) was initiated by Iowa State University, the University of Idaho, and the University of Kentucky (Raman, Brown, Brumm, Anex, Euken, Nokes, Crofcheck, Van Gerpen, and He, 2006). The VEC offered three courses through online education, including Biorenewable Resources and Technology (BRT) 501 – Fundamentals of Biorenewable Resources and Technology. BRT 501 was co-taught by faculty from all three institutions.

The BRT 501 syllabus (Raman, 2010) described the course as an introduction "to the science and engineering of converting biorenewable resources into bioenergy and biobased products." Course topics included defining the resource base; physical and chemical properties of biorenewable resources; descriptions of biobased products; methods of production for biorenewable resources; processing technologies for fuels, chemicals, fibers and energy; environmental impacts; and the economics of biobased products and bioenergy. This study took place during the methods of production for biorenewable resources, or biomass production, which covered production and economics for corn, soybean, hay and forages, and short rotation woody crops as well as a brief introduction to biotechnology.

The VEC aimed to explore the impact of two online course delivery methods on student performance. Due to the array of students in BRT 501, student performance in the course based on student major and gender was also examined.

Goal

The goal of this study was to determine if student learning in BRT 501 was influenced by course delivery method. Two methods were used – video lecture and menu-driven autotutorial presentations (MDAP) delivered via Flash. The influence of student major and gender on learning were also studied.

Materials and Methods

Dr. D. Raj Raman, then Associate Professor, Department of Agricultural and Biosystems Engineering and Associate Director of Educational Programs, Bioeconomy Institute, was the primary lecturer for BRT 501 and Katrina Christiansen, then Graduate Research Assistant, Department of Agricultural and Biosystems Engineering, served as the graduate teaching assistant. Darren Jarboe, then Program Manager for the Center for Crops Utilization Research and Ph.D. candidate in Industrial and Agricultural Technology, served as a special lecturer for the biomass production module, the section of the course during which the data for this study were collected. Jarboe and Raman developed the content for the biomass production module. The BRT 501 biomass production module content was delivered to students through WebCT using video lecture or MDAP (see appendix A for examples). Raman and Christiansen wrote all the exam and quiz questions, including for the biomass production module. Jarboe reviewed the biomass production module exam and quiz questions.

The Institutional Review Board for Human Subjects (IRB) (Investigator's Guide, 2010) at the Iowa State University Office for Responsible Research required submission of the study plan for review and approval prior to its start due to the involvement of live humans as subjects. The IRB determined the project was exempt from the requirements of federal human subjects regulations. All three Iowa State BRT 501 instructors successfully completed the Protecting Human Research Participants training offered by the National Institutes of Health Office of Extramural Research as required by the IRB. Students were made aware of the potential risks and benefits of participating in the study through a consent letter distributed via WebCT. Raman made an announcement in class about the research project in the class period prior to the start of the biomass production module.

The standard for online delivery of BRT 501 content was via video lecture with use of a tablet computer and pen to annotate, draw, and make calculations onscreen. The VEC was interested in exploring alternative content delivery methods and many were available. A Millward Brown (2009) survey conducted in December 2009 for Adobe Corporation estimated the Flash plug-in was on 99% of computers in mature markets, which included Australia, Canada, France, Germany, Japan, New Zealand, the United Kingdom, and the United States, representing 73% of the world's Internet users. Other media plug-ins with significant market share were Oracle Java (77%), Apple Quicktime Player (61%), Adobe Shockwave Player (52%), and RealOne Player (32%). Statowl.com (2010) showed the Adobe Flash plugin on 97% of computers, followed by Oracle Java (79%), Microsoft Windows Media Player (67%), Apple Quicktime Player (60%), and Microsoft SilverLight (55%). Flash was selected as the alternative delivery technology due to its widespread adoption.

Following course protocol, the biomass production lectures were released to students one at a time and the corresponding quiz was posted simultaneously. The quiz for each lecture remained available to students for two weeks. Students took BRT 501 quizzes using WebCT. Questions were in the form of true-false, multiple choice, matching, fill-in-the-blank, and calculation problems. In virtually all cases, the multiple choice and matching problems had randomized orders of responses, and the calculated problems had WebCT-generated parameter values so each student had a different set of numbers with which to work. The quizzes were graded by the software, scores were available to students immediately, and grades were posted to the WebCT grade book. Part I of the final exam, eleven questions, covered the material in the biomass production module. All grade data were downloaded from the grade book for analysis.

<u>Participants</u>

The Iowa State BRT 501 course had 51 students enrolled for spring semester, 44 on-campus and seven online. Four students, three on-campus and one online, dropped the course prior to the biomass production module. One on-campus student chose not to take the biomass production module quizzes and was dropped from the analysis. Students were enrolled as graduate students (42) and upper-level undergraduate students (4) from various majors, most of which were technical in nature (e.g., engineering, agronomy).

Figure 2.1 shows that BRT 501 students were predominately from mechanical engineering (ME) (33%) and agricultural and biosystems engineering (ABE) (30%). Students from chemical and biological engineering (CBE) and agronomy/horticulture (AGRON/HORT) each made up 9% of students, and 4% of students were from civil, construction, and environmental engineering (CCEE). Seven students (15%) were from a major other than these five or undeclared. Graduate students with an engineering undergraduate degree made up 78% of the class. Ten students were female and 36 were male.

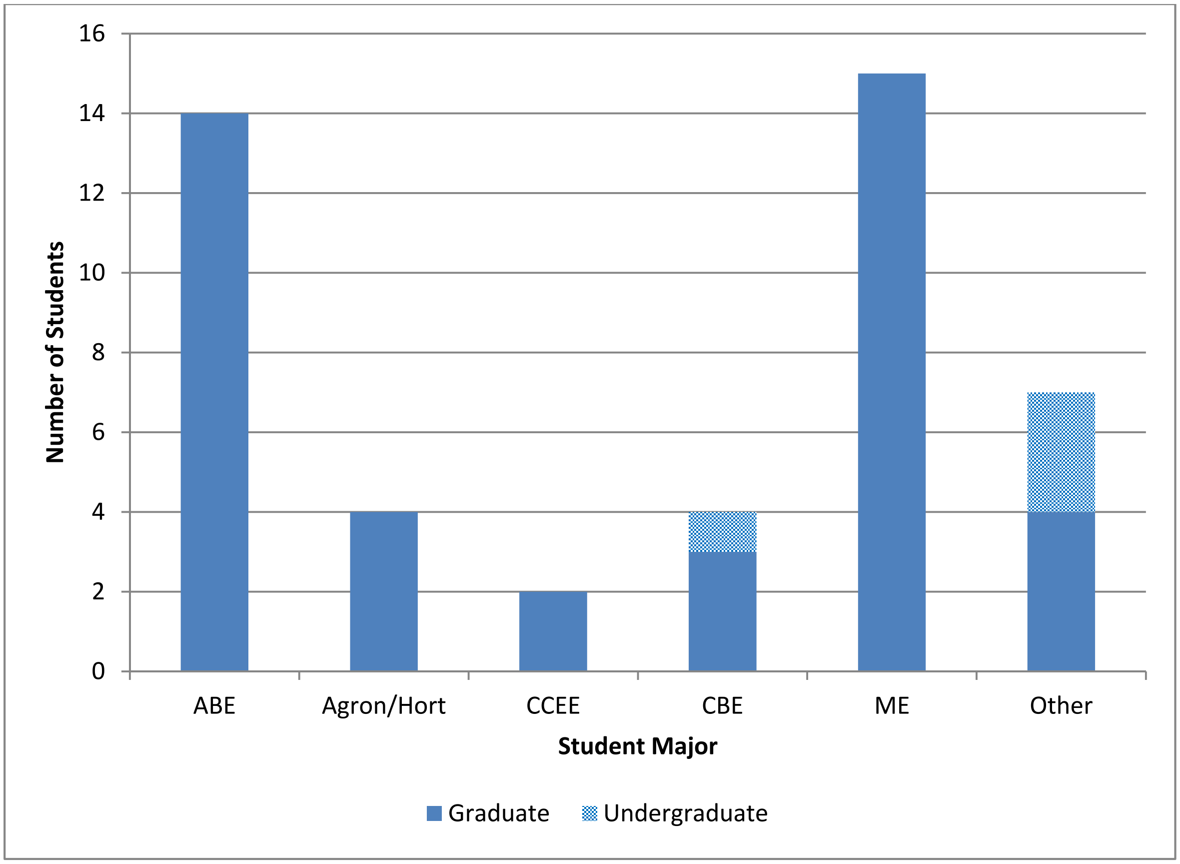

Figure 2.1. Distribution of BRT 501 student program majors. Abbreviations for student majors: ABE – Agricultural and Biosystems Engineering; AGRON/HORT – Agronomy/Horticulture; CBE – Chemical and Biological Engineering; CCEE – Civil, Construction, and Environmental Engineering; and ME – Mechanical Engineering.

After the course midterm exam, the 46 BRT 501 students were ranked based on academic performance in the first half of the class and then students were split into two groups based on their ranking. Students ranked 1, 4, 5, 8…were assigned to Group 1 while those ranked 2, 3, 6, 7… were assigned to Group 2. The serpentine method used is a form of ranking. Bohn and Wolfe (1992) found that using ranking was better for non-parametric methods of data analysis than simple random sampling. Adjustments to the groupings were made to balance for gender. A Wilcoxon rank-sum test was conducted on midterm exam scores to determine if the students in Group 1 (video lecture) and Group 2 (MDAP) had similar performance on assessment scores up to and including the midterm exam (Horn, 2012). The results indicated no significant difference, $z = 0.00$, $p < 1.00$. The mean ranks in Group 1 and Group 2 were each 23.5. Also, the two group's midterm exams were compared using a t-test and no significant difference was detected ($p < 0.81$).

Group 1 received the biomass production module through standard course video lectures and Group 2 received the MDAP. Both delivery modes contained nearly identical information presented as text, tables, and images. The video lecture content was delivered as a sequence of slides with voiceover and the MDAP content was delivered as slides through a menu driven Flash presentation with text. The written material was identical, but spoken words on the video may have provided additional content. Appendix A shows screenshots from a typical unit (hay and forages) of the video lecture and MDAP. PDFs of the slides for each lecture were available to all students. Furthermore, the slides included links to outside resources such as videos and animations, which were thus accessible to students in both groups.

<u>BRT501, the Course</u>

New online BRT 501 course video lectures and MDAP covering seven class periods were developed for the biomass production module. The content covered was:

- Production of herbaceous biomass
  - Corn
  - Soybean
  - Hay and forages
- Production of woody biomass
  - Coppices
  - Trees
- Transgenic plants

The following information was included in the lectures for each biomass crop:

- Crop history
- Plant and seed nomenclature
- Classification
- Crop composition
- Biomass production operations
- Land quality and value
- Crop rotation
- Calculating costs of production
- Challenges, advantages, and outlook

The biomass production content was delivered to students through WebCT starting in the ninth week of the semester and ending in the eleventh week. The presentations used slides with text, images, example problems, and internet videos. The videos demonstrated biomass production machinery and production practices. Ross, Siepen, and O'Connor (2003) found that video was useful as part of a learning package, but not stand-alone. The students in their study thought video of relevant subject matter was entertaining and enjoyable to watch. Their students (90%) thought the addition of video was more effective than using only books. Financial information for corn, soybean, and hay and forages production used the costs of production from *Estimated Costs of Crop Production in Iowa – 2010* (Duffy, 2009). Financial information for short rotation woody crops (SRWC) came from *Assessing the Economic Feasibility of Short-Rotation Woody Crops in Florida* (Langholtz, Carter, and Rockwood, 2007).

WebCT had a feature that allowed content delivery to specific groups, which was used to provide the video lectures to Group 1 and the MDAP to Group 2. After the biomass production presentations were completed and all quiz attempts made, the content from both delivery platforms was available to all students.

Course assessments were WebCT-based quizzes, which reinforced student understanding of the course material and prepared students for exams, as well as the midterm and final exams. The biomass production module quizzes were given after the midterm exam so only the final exam contained biomass production questions. All course assessments were WebCT-based, timed, open-book, unproctored, and on the honor system. WebCT functions created unique assessments for each student as previously mentioned.

Data Collection and Analysis

Assessment and grade data were collected from the WebCT grade book for all 46 students. BRT 501 student assessment data were collected for: all quiz attempt scores, midterm exam score, and final exam score. Student grades were also gathered. These were selected because they are good measures of student performance (Angus and Watson, 2009; Smith 2007). The grade book also identified students as on-campus or online. Student classification as graduate or undergraduate; engineering or non-engineering major; and gender were also gathered from university records and information on the Internet.

Quizzes were developed and delivered to students to assess their acquisition of the biomass production module information presented. Frequent online assessments have been shown highly correlated with final exam or other summative assessment performance (Bonham, Deardorff, and Beichner, 2003; Smith, 2007). Christiansen developed the quizzes for all BRT 501 modules under the guidance of Raman. The biomass production module quizzes were generated by Christiansen with oversight from Raman and Jarboe. This was done to maintain consistency in question style and type of content selected for assessments. Quizzes were given through WebCT and students had two weeks to take each quiz until they were satisfied with their score. A total of 30 quizzes were given in BRT 501, six of which covered biomass production module content.

The final exam questions were developed by Christiansen and Raman and the biomass module questions were reviewed by Jarboe. Eleven questions on the final exam covered biomass production content and were worth 31% of the total points.

SAS Enterprise Guide 4.3 functions summary statistics, correlations, and t-test were used to analyze the data collected. The mean, coefficient of variation, median, and range were calculated to determine the central tendency and distribution for each variable (Bryman and Cramer, 2009). The Pearson's product moment correlation coefficients were calculated to identify positive (stronger as it approaches 1) or negative (stronger as it approaches -1) relationships between two variables (Bryman and Cramer, 2009; Introduction to SAS, 2010). A t-test was used to assess if there was a statistically significant difference between the means for two unrelated samples and the p-value from the t-test was used to indicate statistical significance (Bryman and Cramer, 2009). Confidence intervals at the 95% level were calculated for the two population means, giving the range in which the mean was expected to fall (Bryman and Cramer, 2009).

Table 2.1 shows the variables for which summary statistics were computed, which included the sample mean, coefficient of variation, median, and range. Correlations for these variables were also computed and analyzed. A t-test was conducted to determine if student performance on these variables was statistically different for three treatment classifications: delivery method, student major, and gender. Delivery method compared students in Group 1 and Group 2. Student major grouped students into those with an agricultural major (e.g., agricultural and biosystems engineering, agronomy) and those with a non-agricultural major (e.g., chemical and biological engineering, mechanical engineering). Students were also grouped by gender.

Table 2.1. Student performance variables for which summary statistics were computed.

Biomass module quiz total score first attempt
Biomass module quiz total score final
Remaining modules quiz total score first attempt
Remaining modules quiz total score final
All quiz total score first attempt
All quiz total score final
Midterm exam score
Final exam score
Course grade
Biomass production module final exam questions score

Results and Discussion

Data were broken into ten student variables that were calculated for all students taking BRT 501 (see table 2.1). These variables enabled comparisons among teaching modules, delivery technologies, student major, and gender.

Summary statistics calculated for each student variable are summarized in table 2.2. The table shows that the mean score for all students was of 395 points for the first attempt on the six biomass module quizzes out of a possible 510 points (77.5%). The median was 409 points with a range of 230 to 480 points. Students were allowed to retake all course quizzes until they achieved a score that satisfied them. The mean high score for biomass production

Table 2.2. Summary statistics for student scores for ten Biorenewable Resources and Technology 501 student variables (in points unless otherwise noted).

Student Variables	Mean	Mean (%)	Coefficient of Variation (%)	Median	Range: Minimum	Range: Maximum	Total Possible
Biomass module quiz scores							
First attempt total	395	77.5	14.9	409	230	480	510
Highest attempt total	506	99.2	3.6	510	390	510	510
Score on remaining modules quizzes							
First attempt total	1,509	80.3	11.3	1,562	1,135	1,820	1,880
Highest attempt total	1,842	98.0	3.4	1,860	1,472	1,880	1,880
Score on all quizzes							
First attempt total	1,905	79.7	11.1	1,904	1,408	2,300	2,390
Highest attempt total	2,348	98.3	2.8	2,370	1,968	2,390	2,390
Midterm exam score	85.3	85.3	12.1	89.0	65.0	100.0	100.0
Final exam score	90.6	90.6	8.8	93.2	59.7	99.8	100.0
Biomass module final exam question score	29.9	96.5	6.7	31.0	22.4	31.0	31.0
Course grade	3.57	89.3	15.1	3.67	1.33	4.00	4.00

n = 46.

module quizzes that students accepted was 506 points (99.2%) with a median of 510 points and a range of 390 to 510 points. Figure 2.2 shows the distribution of student scores for the biomass module quiz score total on the first attempt. All but one student scored 96% or more for the high score total on the biomass module quizzes.

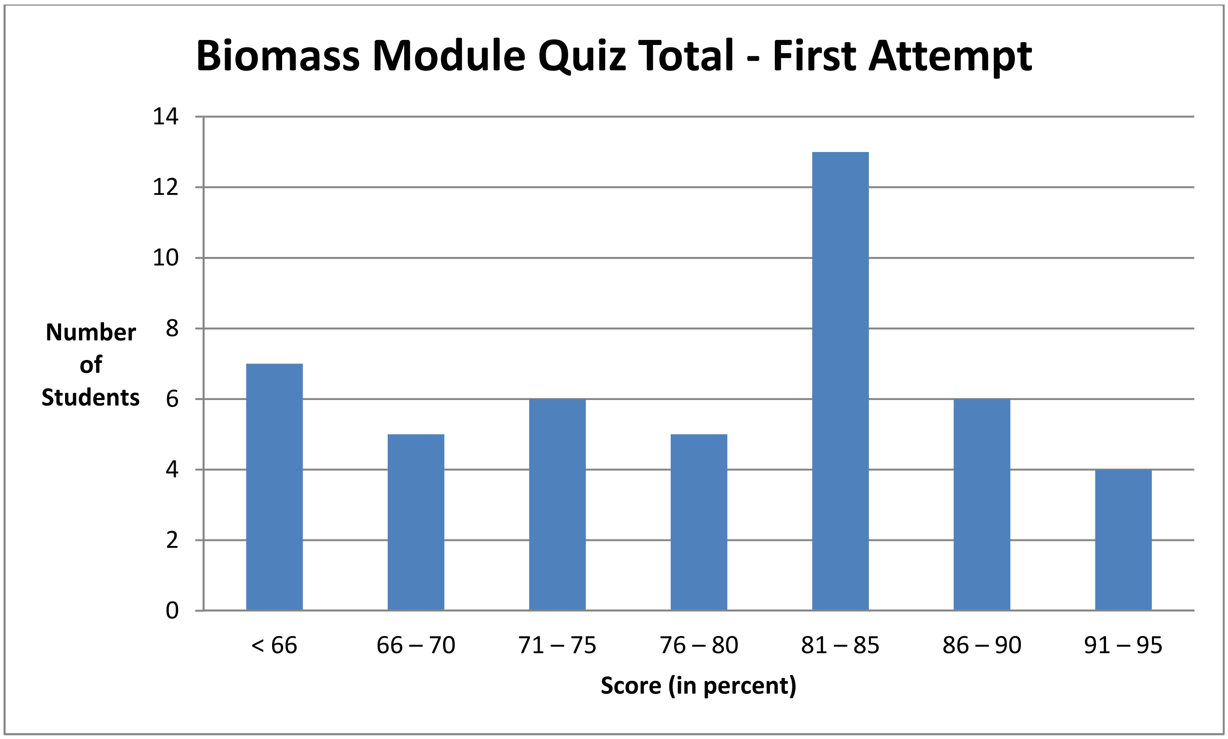

Figure 2.2. Distribution of student total scores for the first attempt on biomass production module quizzes.

The mean score for the first attempt on the 24 remaining course module quizzes was 1,509 points out of a possible 1,880 points (80.3%) with a median of 1,562 points and a range of 1,135 to 1,820 points. Students had a mean score of 1,842 points (98.0%) on the 24 quiz scores they accepted. The median was 1,860 points with a range of 1,472 to 1,880 points. Figure 2.3 shows the distribution of student scores for the remaining modules quiz score total on the first attempt. For the high score total on the remaining modules quizzes, 43 of 46 students scored over 96% and two additional students scored over 91%. One student scored under 80%.

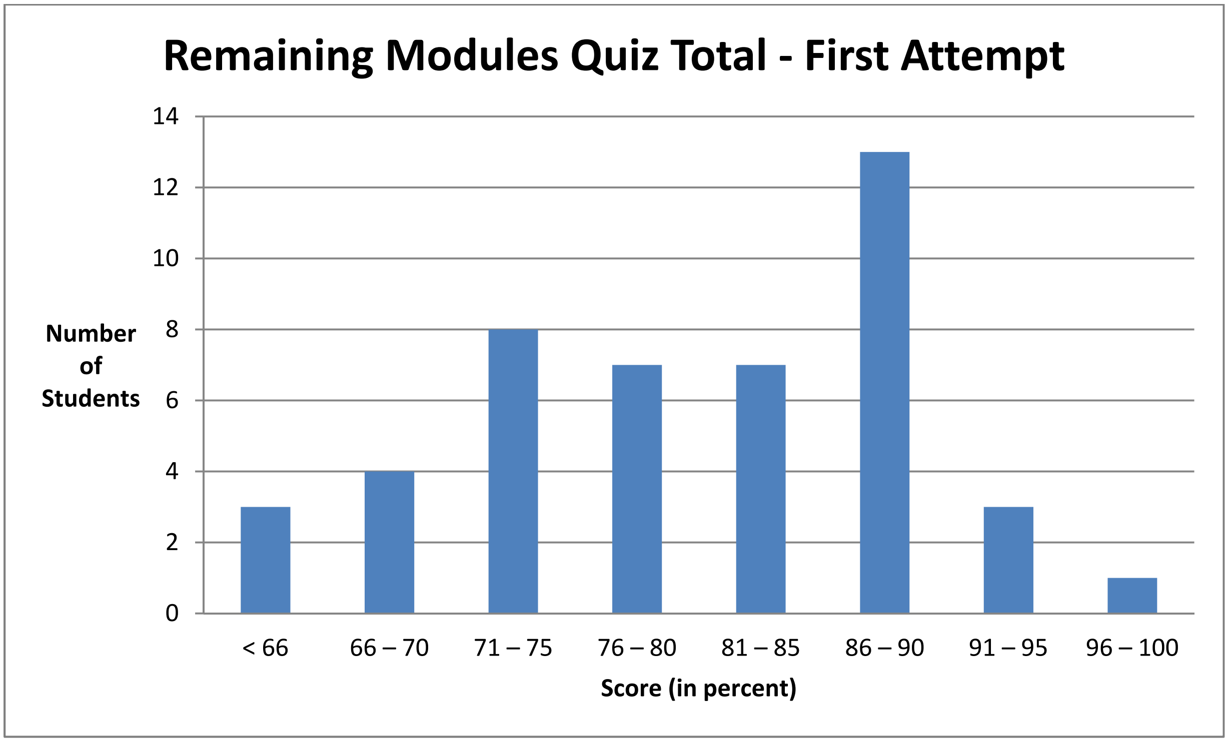

Figure 2.3. Distribution of student total scores for the first attempt on the remaining modules quizzes.

The first attempt quiz score mean for the biomass module was lower than for the remaining course modules (77.5% vs. 80.3%). This was reversed for the highest attempt quiz score mean, which was higher for the biomass module than for the remaining course modules (99.2% vs. 98.0%). The material was likely new for the majority of the class and may have affected the first attempt scores.

The mean score for the first attempt on all 30 quizzes was 1,905 points out of a possible 2,390 points (79.7%) with a median of 1904 points and a range of 1,408 to 2,300 points. Students had a mean score of 2,348 points (98.3%) on the 30 quiz scores they accepted. The median was 2,370 points with a range of 1,968 to 2,390 points. Figure 2.4 shows the distribution of student scores for the all modules quiz score total on the first attempt. Only four students scored less than 96% for the high score total on all module quizzes. Three of these students scored 91% or more and the other student scored over 80%.

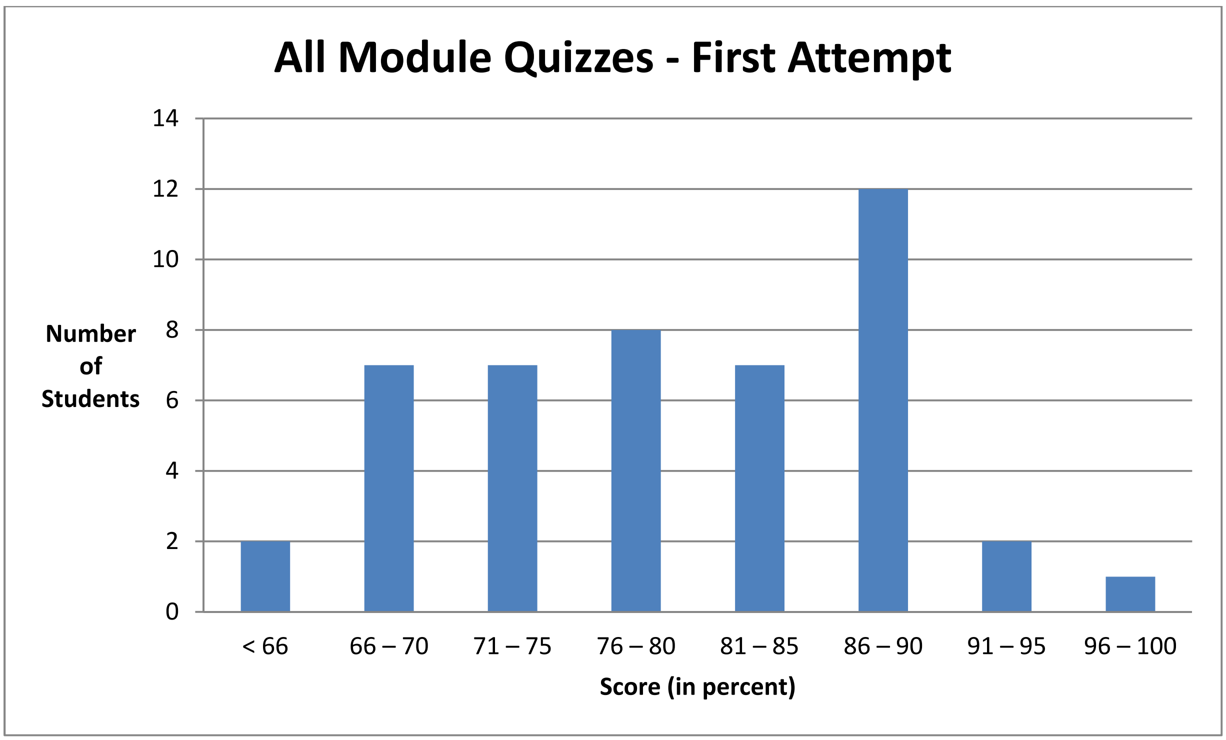

Figure 2.4. Distribution of student total scores for the first attempt on all module quizzes.

The median scores for the biomass and remaining modules highest quiz score totals indicate that a majority of students had extremely high scores, 99.2% and 98.0%, respectively. Very few students scored poorly on the total quiz score used for the course grade. This indicates that students were competitive and willing to do the work necessary to increase their score and improve their course grade.

The midterm exam was taken in week 8, which was prior to the biomass production module, and the final exam was taken in week 16. Midterm exam scores by students had a mean of 85.3 points and a median of 89.0 points out of 100 possible points. The range for the midterm exam was 65.0 to 100.0 points. Student final exam scores averaged 90.6 points and had a median of 93.2 points out of 100.0 possible points. Scores ranged from 59.7 to 99.8 points. Figures 2.5 and 2.6 show the midterm and final exam score distributions for students, respectively.

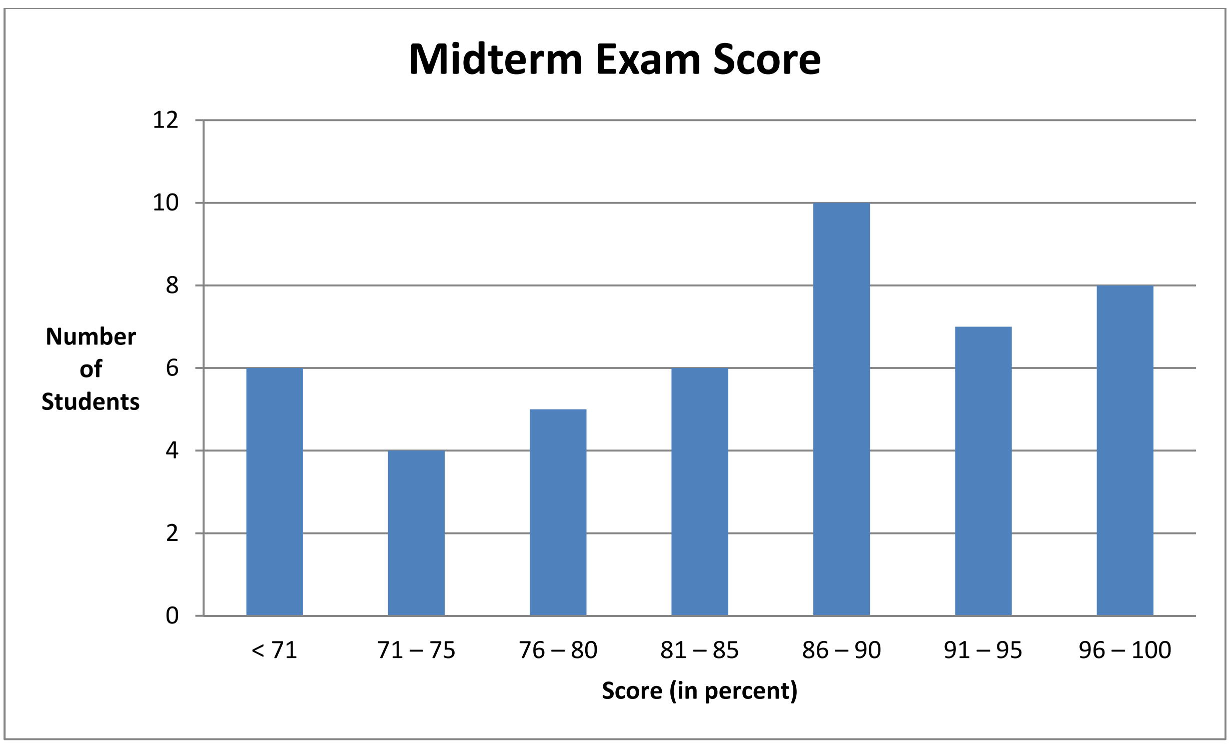

Figure 2.5. Distribution of student midterm exam scores.

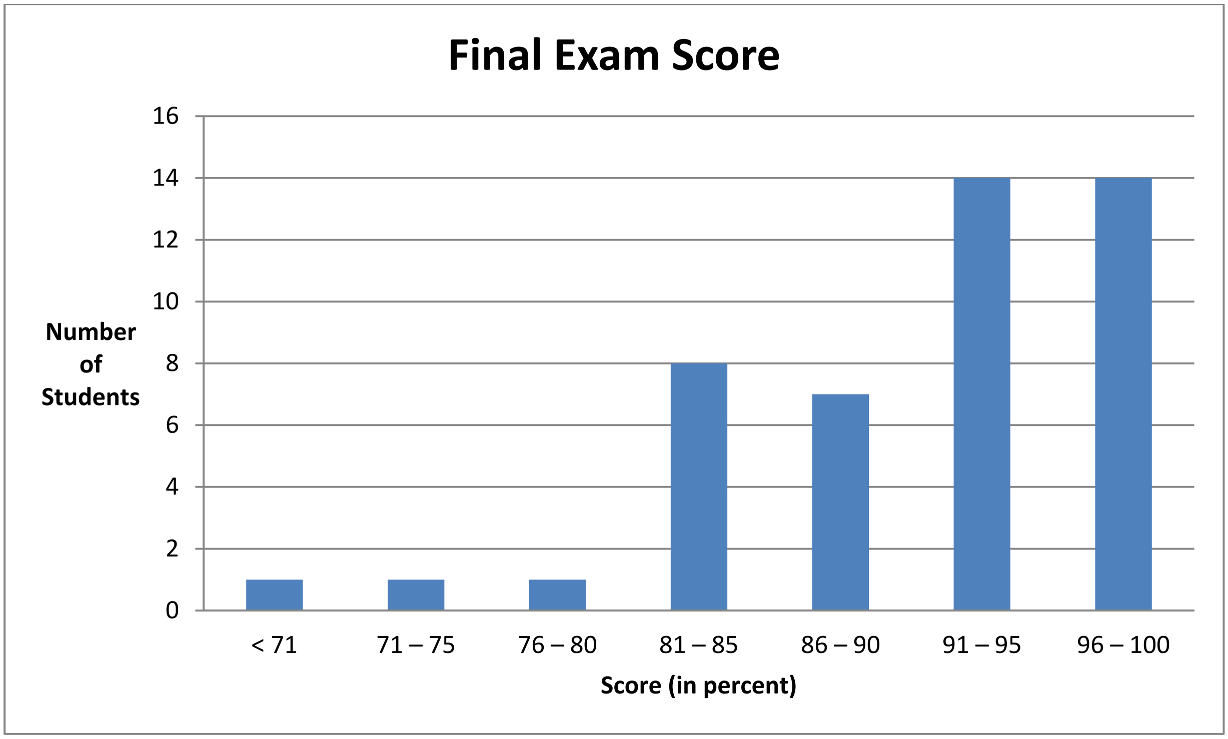

Figure 2.6. Distribution of student final exam scores.

The mean score for the biomass production module final exam questions total score was 29.9 of a possible 31 points (96.4%) with a range of 22.4 to 31. The distribution of student scores on the biomass module final exam questions is shown in figure 2.7.

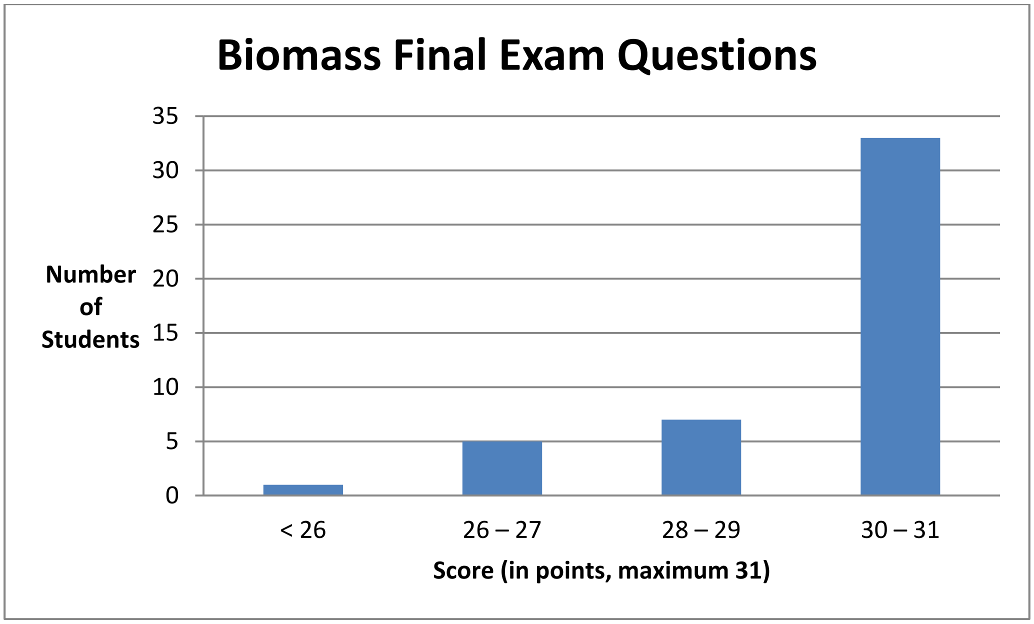

Figure 2.7. Distribution of student scores on the biomass module final exam questions.

The course grade students received was derived from weighted assessment scores on quizzes (15%), project (20%), midterm exam (30%), and final exam (35%). The grading scale is shown in table 2.3. The mean student grade was slightly under an A- (3.57/4.00) and the median was an A- (3.67/4.00). Figure 2.8 shows the distribution of student grades. Student performance on assessments was extremely high, with a few exceptions. This was expected in a survey course like BRT 501 where one major goal of the course is to expose students to the entire biorenewable resources and technology system. The modules do not go into such great depth that graduate students cannot understand the material, yet students are informed about ways they can integrate their research with other disciplines. The statistics for these factors are summarized in table 2.2.

Table 2.3. The course grading scale for Biorenewable Resources and Technology 501 from Raman (2010).

Grade	Score (in percent)
A	95 – 100
A-	90 – 95
B+	85 – 90
B	80 – 85
B-	75 – 80
C+	70 – 75
C	65 – 70
C-	60 – 65
D+	55 – 60
D	50 – 55
D-	45 – 50
F	< 45

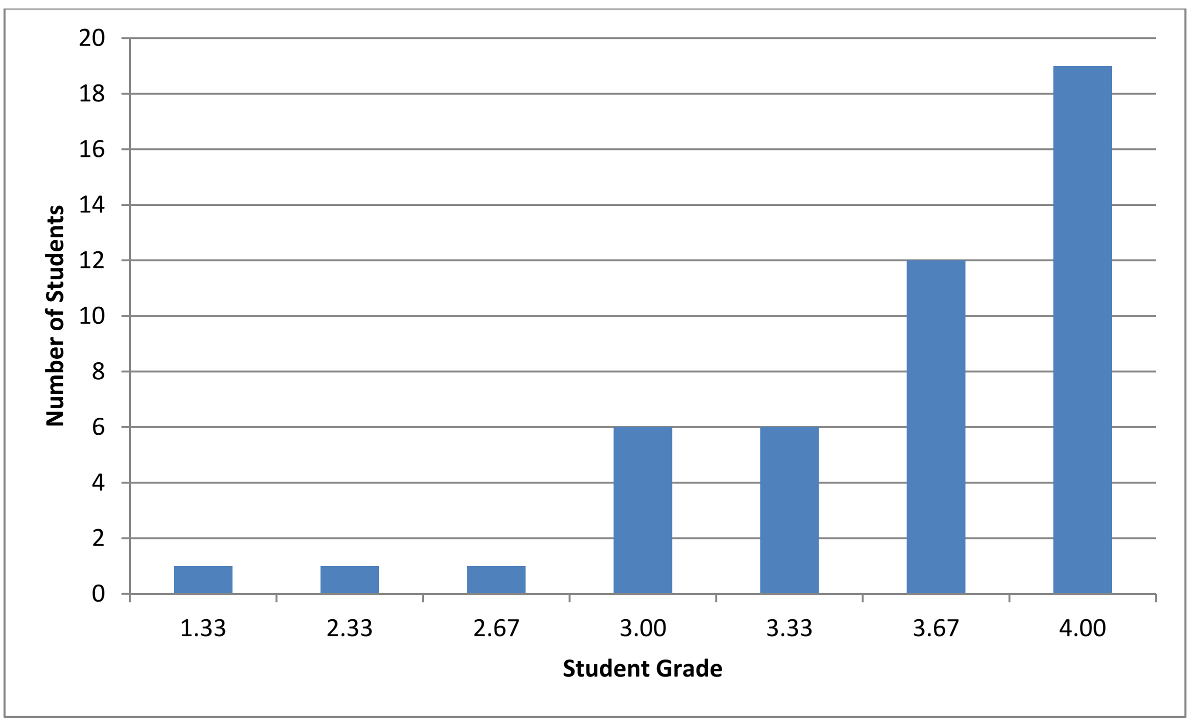

Figure 2.8. Frequency of course grades earned by Biorenewable Resources and Technology 501 students. The grades are on a four-point scale with A = 4, B = 3, C = 2, and D = 1. The 0.33 values are "+" the grade immediately below, while the 0.67 values are "–" the grade immediately above.

Pearson product moment correlation coefficients for the project variables are given in table 2.4. Midterm exam and final exam scores were positively correlated and both were positively correlated with course grade. Since the midterm and final exam made up 30% and 35% of the course grade, respectively, it was expected that student performance on the exams would relate strongly to course grade.

Students were allowed to take quizzes as many times as they desired. The highest score counted toward their grade. There was a significant positive correlation between the first attempt quiz scores for the biomass production and the remaining modules, showing consistency across quizzes for the course. The lack of significant correlation with the midterm exam score, final exam score, and course grade for first attempt quiz score total for biomass production was unexpected since the remaining modules first attempt quiz score total was positively correlated with them. The first attempt quiz score total for all BRT 501 modules was positively correlated with first attempt quiz score total for biomass production and the remaining modules as well as the midterm exam score, final exam score, and course grade. This was anticipated since Angus and Watson (2009) tested the connection between exposure to online quizzes and end-of-session examination performance and found a link between them. The highest quiz score total for the biomass module was positively correlated with the midterm and final exam scores. The highest score total for all BRT 501 module quizzes was positively correlated with the biomass module highest score quiz total and the remaining modules quiz total score for first attempt and highest attempt. This was expected since these are the two components that make up the highest score total for all modules.

Table 2.4. Pearson's product moment correlation coefficients for variables collected from the Biorenewable Resources and Technology 501 grade book. Correlation values in bold had p-values < 0.05.

Variable	1	2	3	4	5	6	7	8	9	10
1. Midterm Exam Score	1.00									
2. Final Exam Score	**0.76**	1.00								
3. Course Grade	**0.72**	**0.99**	1.00							
4. Biomass Module Quizzes - 1st Attempt Score Total	0.24	0.25	0.23	1.00						
5. Biomass Module Quizzes - Highest Score Total	**0.32**	0.25	0.24	0.17	1.00					
6. Remaining Modules Quizzes - 1st Attempt Score Total	**0.33**	**0.45**	**0.42**	**0.60**	0.13	1.00				
7. Remaining Modules Quizzes - Highest Score Total	0.05	0.16	0.16	-0.09	0.10	0.27	1.00			
8. All Modules Quizzes - 1st Attempt Score Total	**0.33**	**0.43**	**0.41**	**0.76**	0.15	**0.98**	0.20	1.00		
9. All Modules Quizzes - Highest Score Total	0.14	0.22	0.21	-0.04	**0.36**	**0.29**	**0.96**	0.22	1.00	
10. Biomass Module Final Exam Questions - All	**0.41**	**0.44**	**0.44**	0.10	-0.02	0.20	0.25	0.19	0.23	1.00

Biomass module final exam question score total was positively correlated with midterm exam score, final exam score, and course grade, but was not correlated with the biomass module first attempt or highest attempt quiz score total. Performance by students on the biomass module final exam questions indicated they fit well with the rest of the course material for the final exam.

A t-test of means was used to determine if sample means classified by delivery method, student major, and gender were significantly different from each other for the variables in table 2.1.

Delivery Method

Table 2.5 provides the mean, coefficient of variation, and the 95% confidence interval for the mean for both delivery methods for each variable. The differences in summary statistics for some variables were large between the two groups. The removal of an outlier in the video lecture group would have eliminated much of this difference and would not have had a meaningful impact on t-test significance. The decision was made to include the observation.

Table 2.5. Performance of students by delivery method on the midterm and final exams, and course grade.

Variable	Delivery Method	N	Mean	Coefficient of Variation (%)	95% Confidence Level Mean
Biomass modules	Video	23	392	14.7	368 – 418
quiz first attempt total	MDAP	23	398	15.3	372 – 424
Biomass modules	Video	23	503	5.0	492 – 514
quiz highest total	MDAP	23	509	1.0	506 – 511
Remaining modules	Video	23	1,526	12.1	1,446 – 1,606
quiz first attempt total	MDAP	23	1,521	13.6	1,432 – 1,611
Remaining modules	Video	23	1,830	4.7	1,793 – 1,868
quiz highest total	MDAP	23	1,855	0.8	1,848 – 1,861
All modules quiz first	Video	23	1,919	11.6	1,822 – 2,015
attempt total	MDAP	23	1,920	12.9	1,812 – 2,027
All modules quiz	Video	23	2,333	3.9	2,294 – 2,373
highest total	MDAP	23	2,363	0.7	2,356 – 2,370
Midterm exam score	Video	23	85.0	12.2	80.5 – 89.5
	MDAP	23	85.7	12.1	81.2 – 90.2
Final exam score	Video	23	91.1	6.5	88.5 – 93.7
	MDAP	23	90.2	11.0	85.9 – 94.4
Biomass final exam	Video	23	29.4	7.8	28.4 – 30.3
question score	MDAP	23	30.4	4.9	29.8 – 31.1
Course grade	Video	23	3.59	10.6	3.43 – 3.76
	MDAP	23	3.55	19.2	3.26 – 3.85

MDAP: Menu-driven autotutorial presentations delivered via Flash.

Table 2.6 shows the delivery method t-scores for the student variables first and highest score for quizzes, midterm and final exams, biomass module final exam questions, and course grade. Student performance was not significantly impacted by the module delivery method, except for the biomass final exam questions. Students in the MDAP group scored higher on the biomass final exam questions than students in the video lecture group, with a mean of 30.4 vs. 29.4 points, which was statistically significant (p=0.07). This was unexpected since the information presented was nearly identical and all students had access to both delivery formats after completion of the biomass production module and prior to the final exam. None of the other student variable t-scores showed a significant difference for delivery method. The reason for this may be that participants were graduate students or undergraduate upper classmen, who were high ability students. Offir, Lev, and Bezalel (2008) found that high ability students could overcome the learning environment and be successful.

Table 2.6. Delivery method t-test scores for the student variables. Variables in bold are statistically significant at $p < 0.1$.

Analysis Variable	t-score	p
Biomass production module quiz scores – first attempt total	-0.32	0.75
Biomass production module quiz scores – highest attempt total	-1.06	0.30
Remaining modules quiz scores – first attempt total	0.04	0.97
Remaining modules quiz scores – highest attempt total	-1.34	0.19
Score on all quizzes – first attempt total	0.05	0.96
Score on all quizzes – highest attempt total	-1.55	0.13
Student score on the midterm exam	-0.24	0.81
Student score on the final exam	0.38	0.70
Student score on the biomass module final exam questions	**-1.89**	**0.07**
Student course grade received	0.27	0.79

n = 46.

Student Major

Students were deemed to have an agricultural major if their current major was agricultural engineering, agronomy, horticulture, or pre-veterinary medicine (undergraduate). The mean, coefficient of variation, and 95% confidence interval for the mean based on student major for each variable are shown in table 2.7. Students with an agricultural major were outperformed by students with a non-agricultural major, most of whom were engineering students, on the midterm and final exams, and course grade. The t-test scores in table 2.8 show these differences were significant. The t-scores for student total scores on the biomass production module quizzes, remaining modules quizzes, all quizzes, and biomass production module final exam questions showed no significant difference.

Table 2.7. Performance of agricultural and non-agricultural students on the midterm and final exams, and course grade.

Variable	Student Major	N	Mean	Coefficient of Variation (%)	95% Confidence Level Mean
Biomass modules quiz first attempt total	Agricultural	19	384	14.8	353 – 415
	Non-agricultural	25	403	15.8	380 – 426
Biomass modules quiz highest total	Agricultural	19	503	5.5	489 – 516
	Non-agricultural	25	508	1.3	505 – 510
Remaining modules quiz first attempt total	Agricultural	19	1,510	12.6	1,418 – 1,602
	Non-agricultural	25	1,538	13.2	1,454 – 1,622
Remaining modules quiz highest total	Agricultural	19	1,844	2.1	1,826 – 1,863
	Non-agricultural	25	1,841	4.2	1,808 – 1,873
All modules quiz first attempt total	Agricultural	19	1,895	12.1	1,784 – 2,006
	Non-agricultural	25	1,941	12.6	1,840 – 2,042
All modules quiz highest total	Agricultural	19	2,347	2.0	2,324 – 2,370
	Non-agricultural	25	2,348	3.4	2,315 – 2,382
Midterm exam score	Agricultural	19	82.2	13.5	76.9 – 87.6
	Non-agricultural	25	87.7	10.8	83.8 – 91.7
Final exam score	Agricultural	19	89.3	8.4	85.7 – 92.9
	Non-agricultural	25	92.8	6.1	90.4 – 95.1
Biomass final exam question score	Agricultural	19	29.5	8.5	28.3 – 30.7
	Non-agricultural	25	30.2	5.3	29.6 – 30.9
Course grade	Agricultural	19	3.49	13.8	3.26 – 3.72
	Non-agricultural	25	3.72	10.2	3.56 – 3.88

Table 2.8. Student major (agricultural vs. non-agricultural) t-test scores for the student variables. Variables in bold are statistically significant at $p < 0.1$.

Analysis Variable	t-score	p
Biomass production module quiz scores – first attempt total	1.04	0.30
Biomass production module quiz scores – highest attempt total	0.79	0.44
Remaining modules quiz scores – first attempt total	0.66	0.52
Remaining modules quiz scores – highest attempt total	-0.21	0.84
Score on all quizzes – first attempt total	0.82	0.42
Score on all quizzes – highest attempt total	0.07	0.95
Student score on the midterm exam	**1.78**	**0.08**
Student score on the final exam	**1.73**	**0.09**
Student score on the biomass production module final exam questions	1.05	0.30
Student course grade received	**1.78**	**0.08**

n = 44 (19 agricultural majors and 25 non-agricultural majors, two students were undeclared and not included).

The differences in summary statistics for some variables were large between the two groups of majors. The removal of an outlier in the non-agricultural major group, a different student than for the delivery method analysis, would have eliminated much of this difference and would not have had a meaningful impact on t-test significance. The decision was made to include the observation.

Gender

The mean, coefficient of variation, and 95% confidence interval for the mean based on grouping students by gender for each variable are shown in table 2.9. Table 2.10 shows that female students scored significantly lower on biomass module first attempt quiz score total. There was one student's score that was an outlier on the biomass quiz first attempt, which contributed to the significant difference among gender due to the small sample size. This difference disappeared for the highest quiz score attempt total, which showed no significant difference between scores achieved by female and male students. Other than this outlier of poor performance by one female student on the first attempt, the remaining gender performance agreed with Marks, Sibley, and Arbaugh (2005), who found that gender was not related to learning performance. They stated that “demographic and personal variables may no longer provide meaningful distinctions of students and their performance.” None of the remaining variables showed a significant difference due to gender.

The differences in summary statistics for some variables were large between the genders. The removal of an outlier in the male student group, a different student than for the delivery method or student major analyses, would have eliminated much of this difference and would not have had a meaningful impact on t-test significance. The decision was made to include the observation.

Table 2.9. Performance of students by gender on the midterm and final exams, and course grade.

Variable	Gender	N	Mean	Coefficient of Variation (%)	95% Confidence Level Mean
Biomass modules quiz first attempt total	Female	10	365	16.5	322 – 408
	Male	36	403	13.9	385 – 423
Biomass modules quiz highest total	Female	10	507	1.3	502 – 512
	Male	36	505	4.0	498 – 512
Remaining modules quiz first attempt total	Female	10	1,521	11.5	1,397 – 1,646
	Male	36	1,524	13.2	1,456 – 1,592
Remaining modules quiz highest total	Female	10	1,850	1.6	1,828 – 1,872
	Male	36	1,840	3.7	1,817 – 1,864
All modules quiz first attempt total	Female	10	1,886	10.9	1,739 – 2,034
	Male	36	1,928	12.6	1,846 – 2,010
All modules quiz highest total	Female	10	2,357	1.5	2,332 – 2,382
	Male	36	2,346	3.1	2,321 – 2,370
Midterm exam score	Female	10	86.5	12.1	79.3 – 93.8
	Male	36	85.0	11.9	81.5 – 88.5
Final exam score	Female	10	92.8	5.1	89.4 – 96.2
	Male	36	90.0	9.7	87.1 – 93.0
Biomass final exam question score	Female	10	30.2	6.0	28.9 – 31.5
	Male	36	29.8	7.0	29.1 – 30.5
Course grade	Female	10	3.70	8.9	3.46 – 3.94
	Male	36	3.54	16.7	3.34 – 3.74

Table 2.10. Student gender t-test scores for the student variables. Variables in bold are statistically significant at $p < 0.1$.

Analysis Variable	t-score	p
Biomass production module quiz scores – first attempt total	**1.90**	**0.06**
Biomass production module quiz scores – highest attempt total	-0.41	0.69
Remaining modules quiz scores – first attempt total	-0.25	0.80
Remaining modules quiz scores – highest attempt total	-0.66	0.52
Score on all quizzes – first attempt total	0.31	0.76
Score on all quizzes – highest attempt total	-0.70	0.49
Student score on the midterm exam	0.41	0.68
Student score on the final exam	-0.97	0.34
Student score on the biomass production module final exam questions	-0.54	0.59
Student course grade received	-0.84	0.41

n = 46 (10 female and 36 male students).

Conclusion

This study compared student performance in BRT 501 for two online course delivery methods (video lecture and MDAP), student major (agricultural and non-agricultural), and gender. The study found that student performance was not significantly impacted by the module delivery method, except for the biomass final exam questions. Students in the MDAP group scored higher on the biomass final exam than students in the video lecture group, with a mean of 30.4 vs. 29.4 points out of 31 possible points, respectively. Students scored very well on the final exam biomass production questions. For the video lecture students, 12 of 23 had perfect scores with lowest score 22.4 of 31 possible points. Twenty of the 23 MDAP students had a perfect score with the lowest score 26 of 31 possible points. Only three questions had more than one student out of 46 answer incorrectly: annual capital charge for a loan (4 students), alfalfa production fertilizer inputs (4 students), and soybean canopy closure (3 students). These were split between the two delivery methods except the alfalfa question, for which all three students were in the video lecture group and picked the same incorrect answer. These students may have confused phosphorus and potassium or the elemental symbols (P and K, respectfully) when learning the material.

Students with agricultural majors were outperformed by students with non-agricultural majors, most of whom were engineering students, on the midterm and final exams, and course grade. This was most likely because the course had a fairly high emphasis on math skills, typically a strength of engineering students.

Female students scored significantly lower for biomass module first attempt quiz score total in this study. One student's score was an outlier on the biomass module first attempt quiz score total. The effect of this outlier was more prominent due to the small sample size. This difference disappeared for the highest quiz score attempt, which showed no significant difference between scores achieved by female and male students.

There are limitations that impact the usefulness of the study results. This sample was one class at a single institution, which may limit generalizability of the results. The sample size of 46 may be too small to show statistically significant differences for some variables that would be significant with a larger sample. Students saw the instructor in the video lecture and not in the MDAP, which may have impacted results. Day, Foley, and Catrambone (2006) found significant differences in student learning when video presentations were used and the only difference was if the instructor's image was visible to students or not. They speculated that nonverbal information was being passed to students via the instructor's image. The Day et al. (2006) study found a significantly higher level of student learning through video, audio, and PowerPoint slide delivery as compared audio and PowerPoint slide delivery for an online training course offered to Georgia Institute of Technology students. Arbaugh and Benbunan-Fich (2007) concluded the online presence of the instructor was crucial to insure the success of online environments. Marks et al. (2005) found that instructor-student interaction is twice as important as student-student interaction. This same effect may have affected student learning performance in this study, favoring the video presentation.

In the future, a study of BRT students at all three VEC institutions (Iowa State University, University of Idaho, and University of Kentucky) that explores performance across modules and institutions may be useful. The VEC institutions are in a unique position to explore the value of the institutional linkages already in place and develop linkages with new institutions, measuring the impact cooperative delivery of programming has on student learning and educational cost management. The identification and development of models that relate how to effectively develop successful joint educational efforts could help higher education better serve students.

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CHAPTER 3. STUDENT PERSPECTIVES ON A NEW BIOMASS PRODUCTION MODULE FOR FUNDAMENTALS OF BIORENEWABLE RESOURCES

A paper to be submitted to Distance Education

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Abstract

In 2007, a Virtual Education Center for Biorenewable Resources was initiated (Raman, Brown, Brumm, Anex, Euken, Nokes, Crofcheck, Van Gerpen, and He, 2006). The Center offered three courses through online distance education, one being Biorenewable Resources and Technology (BRT) 501 – Fundamentals of Biorenewable Resources and Technology. The primary objective of the study was to assess student perceptions of two delivery methods (video lecture and menu-driven autotutorial presentations, MDAP, delivered via Flash), course assessments, module material, and student learning. Twenty students completed the survey of qualitative aspects of student experiences in BRT 501. The biomass production module brought students without a farm background closer to the knowledge level of students with a farm background as demonstrated by students' self-assessed knowledge and their BRT 501 assessment scores. Students desired a stronger connection with the course instructor and peers, whether electronically or in-person. This may reflect a relationship between student-instructor connectedness and grade point average (GPA). Market signals to students in the form of GPA minimums for scholarships (Scholarships, 2012; College-wide Scholarships, 2012) and employer interview requirements (Gaul, 2012) as well as higher GPA leading to better jobs with higher incomes (James, Alsalam, Conaty, and To, 1989; Preston, Broder, and Almero, 1990) may influence student

interest in connectedness to the instructor. The learning style scores for our study participants were similar to those found by van Zwanenberg et al. (2000) and Zywno (2003), except the active-reflective dimension. Our students were neutral whereas students in the other studies were mildly active.

Introduction

Background

In 2007, a Virtual Education Center (VEC) for Biorenewable Resources was initiated (Raman, Brown, Brumm, Anex, Euken, Nokes, Crofcheck, Van Gerpen, and He, 2006). The Center offered three courses through online distance education, including Biorenewable Resources and Technology (BRT) 501 – Fundamentals of Biorenewable Resources and Technology, the subject of this study. The BRT 501 syllabus (Raman, 2010) described the course as an introduction “to the science and engineering of converting biorenewable resources into bioenergy and biobased products.” Topics included the entire biorenewables value chain, from biomass production and harvest to biomass processing to techno-economics and environmental concerns. The VEC was interested in learning if other methods would be suitable for online delivery of BRT courses.

The standard for BRT 501 content delivery was via video lecture with a tablet computer and pen to annotate, draw, and make calculations onscreen. For the study, selection of a viable alternative technology for the online delivery method was necessary. Surveys by Millward Brown (2009) and Statowl.com (2010) estimated the Flash plug-in was on over 97% of computers in significant markets, nearly 20% more than other plug-ins such as Oracle Java and Apple Quicktime Player. Flash was selected as the delivery technology for the alternative delivery method due to its widespread availability on multiple computer operating systems.

For this study, a survey was given to students to learn about their experience in the BRT 501 course offered spring semester 2010 at Iowa State University. The objectives of the study were to: 1) identify student characteristics or demographics that impact BRT 501 student learning for both the standard video lecture and menu-driven autotutorial presentations (MDAP) delivered via Flash delivery methods (see appendix A for examples), and 2) determine if alternative delivery method modifications for BRT 501 would improve the student learning experience.

Materials and Methods

Dr. D. Raj Raman, then Associate Professor, Department of Agricultural and Biosystems Engineering and Associate Director of Educational Programs, Bioeconomy Institute, was the primary lecturer for BRT 501 and Katrina Christiansen, then Graduate Research Assistant, Department of Agricultural and Biosystems Engineering, served as the graduate teaching assistant. Darren Jarboe, then Program Manager for the Center for Crops Utilization Research and Ph.D. candidate in Industrial and Agricultural Technology, served as a special lecturer for the biomass production module, the section of the course during which data for this study were collected. Jarboe and Raman developed the content for the biomass production module. The BRT 501 biomass production module content was delivered to students through WebCT using video lecture or MDAP. Raman and Christiansen wrote all exam and quiz questions, including for the biomass production module. Jarboe reviewed the biomass production module exam and quiz questions.

The Institutional Review Board for Human Subjects (IRB) (Investigator's Guide, 2010) at the Iowa State Office for Responsible Research required submission of the study plan for review and approval prior to its start due to the involvement of live humans as subjects. The IRB determined the project was exempt from the requirements of federal human subject regulations. All three Iowa State BRT 501 instructors successfully completed the Protecting Human Research Participants training offered by the National Institutes of Health Office of Extramural Research as required by the IRB. Students were made aware of the potential risks and benefits of participating in the study through a consent letter distributed via WebCT that had to be viewed before students could access the survey. Raman made an announcement about the research project in the class period prior to the start of the biomass production module. Students had the option to opt out of the survey. The survey results were embargoed by Iowa State Engineering Distance Education and released after spring semester grades had posted.

Participants

The Iowa State BRT 501 course had 51 students enrolled for spring semester 2010, 44 on-campus and seven online. Four students, three on-campus and one online, dropped the course prior to the biomass production module. One on-campus student chose not to take the biomass production module quizzes and was excluded. Students were enrolled as graduate students (42) and upper-level undergraduate students (4) from various majors, most of which were technical in nature (e.g., engineering, agronomy).

After the course midterm exam, students were ranked based on academic performance in the first half of the class and then students were split into two groups based on their ranking. Group 1 students ranked 1, 4, 5, 8… and Group 2 students ranked 2, 3, 6, 7… formed the groupings. Adjustments to the groupings were made to balance for gender. Group 1 received the biomass production module through standard course video lectures and Group 2 received MDAP. The video lecture content was delivered as a sequence of slides with voiceover and the MDAP content was delivered as slides through a menu driven Flash presentation with text. The written material was identical, but spoken words on the video may have provided additional content. Appendix A shows screenshots from the hay and forages unit of the video lecture and MDAP. PDFs of the slides for each lecture were available to all students. Furthermore, the slides included links to outside resources such as videos and animations, which were thus accessible to students in both groups.

The 10 female students were split evenly in the two groups, which required some shuffling of students. A Wilcoxon rank-sum test was conducted on midterm exam scores to determine if the students in the video lecture and MDAP groups had similar performance on assessment scores up to and including the midterm exam (Horn, 2012). The results indicated no significant difference, $z = 0.00$, $p < 1.00$. The mean ranks in the video lecture and MDAP groups were each 23.5. Also, the two group's midterm exams were compared using a t-test and there was no significant difference ($p < 0.81$).

Twenty of the 46 students enrolled in BRT 501 completed a 37 question survey. The response rate was lower than expected due to a technical problem with the interaction between SurveyGizmo (www.surveygizmo.com) and WebCT. WebCT indicated that all students were able to access the consent form which led to the survey. The time stamps for consent form access indicated that only students who accessed the survey during a limited window were able to successfully submit data. Of the 20 students completing the survey, eight received biomass production module information through video lectures and 12 through

MDAP. Two students were female and 18 male. Of the 20 students, only one was a non-traditional student, defined as 30 or more years old. Three students were enrolled in school part-time while employed full-time and 17 were full-time students. International students made up 30% of the participants. Nearly all participants were graduate students, 15 M.S. and four Ph.D. Current student majors were 75% engineering and 25% other science majors such as agronomy or horticulture. Four students were online and 10 had taken an online course previously. Five students grew up on a farm.

<u>BRT501, the Course</u>

New online BRT 501 course video lectures and MDAP covering seven class periods were developed for the biomass production module. The content covered was:

- Production of herbaceous biomass
  - Corn
  - Soybean
  - Hay and forages
- Production of woody biomass
  - Coppices
  - Trees
- Transgenic plants

The following information was included in the lectures for each biomass crop:

- Crop history
- Plant and seed nomenclature
- Classification
- Crop composition
- Biomass production operations
- Land quality and value
- Crop rotation
- Calculating costs of production
- Challenges, advantages, and outlook

The biomass production content was delivered to students through WebCT starting in the ninth week of the semester and ending in the eleventh week. The presentations used slides with text, images, example problems, and Internet videos. The videos demonstrated biomass production machinery and production practices. Ross, Siepen, and O'Connor (2003) found that video was useful as part of a learning package, but not stand-alone. Their students thought the addition of video was more effective than using only books (90%). The students in the Ross et al. (2003) study also thought video of relevant subject matter was entertaining and enjoyable to watch. Information on production costs for corn, soybean, and hay and forages production was from *Estimated Costs of Crop Production in Iowa – 2010* (Duffy, 2009). Information on production costs for short rotation woody crops (SRWC) came from *Assessing the Economic Feasibility of Short-Rotation Woody Crops in Florida* (Langholtz, Carter, and Rockwood, 2007).

WebCT had a feature that allowed content delivery to specific groups, which was used to provide the video lectures to Group 1 and the MDAP to Group 2. After the biomass production presentations were completed and all quiz attempts made, the content from both delivery platforms was available to all students. The quizzes and final exam were scored and graded within each delivery method and then normalized across the entire class. The ranking system used to sort students into two groups was checked to insure good randomization because assessments in the first half of the course were on engineering principles and chemistry, not biomass production or economics.

Data Collection and Analysis

The survey instrument (see appendix B) had 37 questions to gather information on demographics, online course and computer experience, learning styles, module content and delivery, self-reported student learning, communication, and production agriculture experience. The survey variables for the study are shown in table 3.1. Students also took the Index of Learning Styles (ILS) survey on Dr. Richard Felder’s web site at North Carolina State University (Felder, 2012). Students reported their learning style scores for this study.

Table 3.1. The survey variables for the study.

Best/worst module	Internet proficiency
Biomass production knowledge before module	Learning Style: active vs reflective
Biomass production knowledge after module	Learning style: sensing vs intuitive
Biomass production video usefulness	Learning style: sequential vs global
Classmate interaction	Learning style: visual vs verbal
Compare online and classroom modules	Non-traditional student
Compare quizzes from different modules	Overall educational experience
Computer proficiency impact on learning	Quiz reflect material
Current major	Self-assessed learning
Degree pursued	Software proficiency: design
Employment status	Software proficiency: internet
Farm background and participation	Software proficiency: productivity
Gender	Student able to learn independently
Importance of instructor visible	Study time
Instructor availability	Take online class in the future

Bryman and Cramer (2008) was referenced for the statistical plan and analysis. SAS Enterprise Guide (Slaughter and Delwiche, 2010) was used for computation and analysis of summary statistics, correlations, and t-tests. Cohen and Holliday (1982, p. 93) suggested the scale in table 3.2 for interpretation of the Pearson’s product moment correlation coefficient values. This scale was used for evaluation of the significant correlations identified.

Table 3.2. Cohen and Holliday (1982, p. 93) scale for evaluation of Pearson's product moment correlation coefficients.

r	Meaning
0.00 to 0.19	Very low correlation
0.20 to 0.39	Low correlation
0.40 to 0.69	Modest correlation
0.70 to 0.89	High correlation
0.90 to 1.00	Very high correlation

The categories used for the t-test analysis of the survey data were as follow:

- Delivery method: video or MDAP
- Domestic or international student
- Off-campus or on-campus student
- Taken online course previously or not
- Student had farm background or not
- Computer software proficiency
- Instructor visible was important or not
- Peer to peer interaction
- Take an online class in the future or not
- Learned more in classroom or online course

Results and Discussion

Tables 3.3 and 3.4 show the student demographics broken out by delivery method. Students in the MDAP group were twice as likely to have taken an online course previously. Only female students from the MDAP group participated in the survey, which was a much smaller percentage than in the full class (10% and 22%, respectively). All the survey participants were graduate students.

Table 3.3. Demographic information for Biorenewable Resources and Technology 501 students in each delivery method group.

Delivery Method	Agricultural Major	Engineering Major	Graduate Student	On-campus	Male Students
Video Lecture (n=23)	11	12	19	21	18
MDAP (n=23)	8	9	21	19	18

MDAP: Menu-driven autotutorial presentations delivered via Flash.

Table 3.4. Demographic information for Biorenewable Resources and Technology 501 students participating in the survey.

Delivery Method	Agricultural Major	Engineering Major	Graduate Student	On-campus	Domestic Student	Male Students	Non-traditional Student[1]	Employed Full-time[2]	Taken Online Course Previously[3]	Farm Background
Video Lecture (n=8)	2	5	8	6	6	8	0	2	3	2
MDAP (n=12)	8	9	12	10	8	10	1	1	7	3

[1]Non-traditional students were students greater than 30 years old.
[2]All students employed were employed full-time and were only part-time students. The rest were full-time students.
[3]All the part-time students who were employed full-time had taken an online course previously.
MDAP: Menu-driven autotutorial presentations delivered via Flash.

Table 3.5 shows the summary statistics for the biomass production module student survey variables. The results and analyses are broken into three groups: course components, computer proficiency, and student learning.

Table 3.5. Summary statistics for the student survey on the biomass production module.

Variable	N	Mean	Standard Deviation	Range Min.	Range Max.
Biomass production knowledge before biomass module	20	2.70	1.22	1	5
Biomass production knowledge after biomass module	20	3.60	0.75	2	5
Biomass production video usefulness	20	2.65	0.93	1	4
Farm participation level	5	4.20	1.30	2	5
Quiz difficulty comparison	20	3.00	0.73	1	4
Biomass quizzes reflected the material	20	3.60	0.75	2	5
Instructor availability	14	3.29	0.61	3	5
Internet proficiency	20	4.50	0.69	3	5
Productivity software proficiency	20	3.65	0.81	2	5
Design software proficiency	20	3.70	0.80	2	5
Learning styles: active vs. reflective	20	5.30	2.66	1	10
Learning styles: sensing vs. intuitive	20	7.00	2.47	3	11
Learning styles: visual vs. verbal	20	8.35	2.50	2	11
Learning styles: sequential vs. global	20	6.10	2.45	1	10
Self-reported study time	20	2.10	0.91	1	5
Self-assessed learning	20	2.95	0.83	1	4
Students ability to learn independently	20	3.65	0.81	2	5
Compare online and classroom experience	17	2.88	0.70	2	4
Overall educational experience for biomass module	20	3.35	0.81	2	5

Course Components

The biomass production videos used to supplement the video lectures and MDAP were considered slightly useful to useful. Students who thought the videos were useful made comments such as “I learned a lot about the different equipment that is used/and how it is used” and “I enjoyed the videos by the ISU Ag Farm on how to convert your planter to no-till.” Mills and Xu (2005-2006) found that students liked the movie clips offered in their course.

Of the 20 students completing the survey, five indicated they had a farm background and a high level of participation in work on the farm. These students were familiar with agricultural production as indicated by statements such as “knew most of material covered” and “I'm from a farm so most of these videos I have seen an example of this before.” One student stated, “While seeing the production videos was interesting, there wasn't much discussion of the process in the video or [F]lash modules to describe what was actually going on” indicating the videos might serve as more than examples, such as drivers of class or chat room discussion. Student comments were similar for both delivery methods.

Students were asked what helped them learn most and detracted from learning in the biomass production module. Students indicated pictures, diagrams, and videos were used to effectively illustrate concepts. One student stated, “[The] corn module was really good, organized and it also was complete.” Some students liked seeing different types of biomass production and learning about the costs of production. On the other hand, one student thought the videos were “repetitive and distracted from the aspects of biomass production that are most important to their [respective] roles as a bioenergy feedstock.”

One of the learning detractors was prior knowledge of biomass production, which was 25% of survey respondents. An example was “based upon what I know from my farm background the basics covered in this was [sic] not very interesting to me and so I tried to skip to other topics in the presentation that look[ed] more interesting.” A couple of students noted their difficulty in knowing the “take aways” for the biomass production module segments.

The instructor intentionally did not deviate from the slides to insure the information received by all students was similar regardless of delivery platform. Students did not like this as was apparent from a student comment in the group receiving the video that stated “the reading straight from the slides and not adding any insight into anything didn't hold my attention.”

To improve learning in the biomass production module, students suggested field visits, real life examples, and the addition of a segment on precision agriculture. Students in the MDAP group thought the addition of an instructor for guidance and explanation would improve learning. This is similar to the students surveyed by Mills and Xu (2005), who recommended a technology orientation on the first day of class for their statistics course.

Self-reported study time averaged 1-2 h/wk with a range from <1 h/wk to 6+ h/wk. This was less than the 5.5 h/wk reported by Harlen and Doubler (2004) for students in the initial module of an online master’s degree course for elementary and middle school science teachers. It was also less than the 2-3 h/h of class expected by Marks, Sibley, and Arbaugh (2005).

Students thought the biomass production module quizzes were about the same difficulty as the other BRT 501 module quizzes. This was likely due to the continuity provided by Christiansen writing the quiz questions for all modules, including the biomass production module. They also felt the quizzes reflected the biomass module material presented at the acceptable to good level.

Biomass production knowledge was estimated by students to be low to average before completing the biomass production module and average to high after completing the module. Students considered their learning from the biomass production module similar to other BRT 501 modules. They also thought the overall educational experience was average to good.

Students selected the corn and biotechnology units as the best in the biomass production module (see table 3.6). Overarching themes across units were students enjoyed learning about a crop familiar to them and the potential for the crop to impact their research project. Individual units had various reasons for student interest. The history of corn, familiarity with the crop, and the many uses for corn were some of the reasons students selected corn as the best unit. One student stated, “corn has several uses so learning about this crop is important.” Students also found the unit interesting as demonstrated by the student comment, “Because there was quite a bit I did not know about corn and found it very interesting.” One student observation about the corn unit stated, “I worked with corn stover, and the information about corn production gave me an idea about corn stover collecting too.”

Table 3.6. Student selections of the best and worst units in the biomass production module.

Unit	Best	Worst
Corn	7	4
Soybean	1	3
Short Rotation Woody Crops	4	3
Hay and Forages	1	3
Biotechnology	6	4
Total	19	17

Students liked learning about short rotation woody crops and biotechnology, topics unfamiliar to them. One student noted “it was something that I am not familiar with/seen before.” Another student thought the biotechnology segment “had the most in common with the aspects of bioenergy that I am interested in.”

Table 3.6 shows the unit students considered worst was spread evenly among all five units. The most common comment from students was a lack of interest in the unit. An example for the hay and forages unit was “not really interesting, maybe because of the crop itself which seems a lot simpler in comparison with the others.” Some of the information was considered repetitive since some of the production practices are similar for crops as are calculations for the costs of production. Criticism of the corn unit ran the gamut from “it is almost like common knowledge in Iowa” to “lecture should have been broken up and each part extended for those of us who are not too familiar with farming techniques.” The biotechnology unit also had wide-ranging responses from “I am interested more in the raising of the crops then [sic] the science behind the crops” to “only few [sic] information, too brief for this complex field.”

Some students in the MDAP group considered that the lack of an instructor reduced learning. One student stated, “No interaction/additional information provided by live instructor” was a detractor. Students in Reisetter and Boris’s (2004, p. 284) study suggested “the teacher was a most important factor in the course.” Offir, Lev, and Bezalel (2008) noted that most students wanted an instructor in the class for guidance and facilitation. Studies have shown the importance of student-instructor contact to student achievement in online and classroom courses (Arbaugh and Benbunan-Fich 2007; Bernard, Abrami, Lou, Borokhovski, Wade, Wozney, Wallet, Fiset, and Huang, 2004). Similarly, Mills and Xu (2005-2006) observed that some students disliked the lack of connectivity during the online portion of a hybrid course.

Computer Proficiency

Student computer proficiency is an important aspect of students’ ability to successfully learning online. BRT 501 required students to use WebCT to access lectures and class materials, productivity software for assignment development and submission, and internet to access videos, animations, and support materials. Most participants were graduate students from engineering or other technical backgrounds that require computer proficiency. Students assessed their computer proficiency for internet use, productivity software, and design software as good to very good. The university's technology support system may foster a sense of computer proficiency by students. Herrington, Reeves, and Oliver (2006) found technology support was very important to student success in online courses. The range of responses was wide, indicating some students did not consider themselves proficient, which could challenge them in an online course. Howland and Moore (2002) found that students lacking technical experience had difficulties in their online course while proficient students did not.

Student Learning

BRT 501 quizzes were given very frequently throughout the semester, which Angus and Watson (2009) and Smith (2007) found improved student performance on the final exam. Therefore, consistency between the biomass module quizzes and the rest of the course was important. Students considered the biomass module quizzes about the same difficulty as quizzes for other BRT 501 modules. As stated previously, this was likely due to Christiansen drafting the quiz questions for all the modules. Most students felt the questions on the quizzes reflected the module material at an acceptable to good level.

Bernard et al. (2004) found that lack of connection to the instructor and fellow students impacted online student retention. Students in our study considered it important as well. About two-thirds of students commented on instructor availability, even though they gave a neutral mean score. Only one student indicated an attempt to contact the instructor and the instructor was reached successfully. Bernard et al. (2004) also found interaction with instructor and peers was important to academic achievement.

Students are willing to take free online courses as demonstrated by the over 3,000 lessons available and 130 million lessons delivered by Khan Academy (Khan Academy, 2012). This model uses expert lecturers to provide the video content. Lessons are broken into short segments “from 3 to 15 minutes long” (Lynley, 2011, p. 1). The lessons generally do not show the instructor’s face or offer a visual connection to the instructor.

Yale University offers open access to undergraduate courses on a variety of subjects. The site offers audio or video of the classroom lecture, which can be downloaded, as well as other course materials (e.g., reading list, problem sets, searchable transcripts) (About, Open Yale Courses, 2012a). The courses are not for credit nor are they applicable toward a degree or certificate (Courses, Open Yale Courses, 2012b).

Neither Khan Academy nor Yale University provides a two-way connection with the instructor or peers, which students in this study thought important. A recurring theme of student comments throughout the survey was the desire to have time with the instructor and classmates, to have a connection with them. The majority of students thought it was important for the instructor to be visible or present, regardless of the delivery method. One student stated, “[instructor interaction] makes it more real, [a] more personal experience.” Other students mentioned nonverbal communication and cues as important to understanding what concepts are most important and creating a feeling of connectedness. Statements such as “the instructor is able to communicate both verbally and non-verbally” and “hearing and seeing someone helps me learn and makes me feel more connected to the material” emphasize this. An immediate communication channel allows the “professor [to] provide context,” “give examples,” and “asking real time questions…to get the instructor on certain points,” and enables students to “ask questions and for explanations.”

Students self-select to use the Khan Academy and Yale University materials, which may best suit a particular group of students. Neither Khan Academy nor Yale University supports students beyond providing the lectures and materials, nor do they indicate how many students access and complete an entire series or course (Khan Academy, 2012; Courses, Open Yale Courses 2012b). Khan Academy does have staff to support the use of their videos by schools (Khan Academy, 2012).

A recent online course offering a glimpse into usage and completion rates is the *Introduction to Artificial Intelligence* course offered in fall 2011 by Dr. Sebastian Thrun, Stanford University and Dr. Peter Norvig, Google, using YouTube (Thrun and Norvig, 2012). The course was an extension of their classroom course, with the online course being free. Thrun and Norvig did offer support mechanisms to students such as an online community and video office hours. The course attracted 160,000 students with over 23,000 students completing the course requirements, a 14% retention rate (DeSantis, 2012).

There are two reasons we believe students in the study desired connectedness with the instructor and peers. One reason is students pay for a service and expect a high level of performance for their tuition dollars. Another possibility is students may believe connectedness with the instructor will help them achieve a better course grade. One currency for students is money, another is their course grade, which students expect to translate into money in the future (Siebert, Davis, Litzenberg, and Broder, 2002). Siebert et al. (2002) found that one key student objective is a high grade point average (GPA). This is rightly so since GPA has been found to be associated with greater income after graduation (James, Alsalam, Conaty, and To, 1989; Preston, Broder, and Almero, 1990). Students read market signals such as scholarships that require a minimum GPA (Scholarships, 2012; College-wide Scholarships, 2012) or employers setting GPA hurdles students must meet to be considered for a job interview (Gaul, 2012). Student comments about the importance of better connectedness with the instructor may be related to their expectations that connectedness translates into better understanding of homework assignments, projects, and exams, leading to better grades, and eventually large economic benefit.

Overall, students thought synchronous instruction provided better learning than asynchronous instruction. Arbaugh and Benbunan-Fich (2007) found learner-instructor interactions were significant for higher perceived learning. Bernard et al. (2004) stated that poor student-instructor communication factored into high distance education dropout rates, with higher dropout rates for asynchronous than synchronous courses. Communication with instructors benefits both asynchronous and synchronous online students (Bernard et al., 2004). The visual interface, including accessibility, interactivity, and attractiveness, is important (Jung, 2001). Marks et al. found that student-instructor interaction was twice as important as student-student interaction. Lee and Rha (2009) found that student-student and student-instructor dialogue were important, verbally or electronically. This led to significantly higher student achievement for critical thinking learning and overall record. This seems to support Moore's theory of transactional distance which states that "distance education is not simply a geographic separation of learners and teachers, but, more importantly, is a pedagogical concept. It is a concept describing the universe of teacher-learner relationships that exist when learners and instructors are separated by space and/or by time" (Moore, 1997, p.22).

Students liked the convenience and accessibility offered by an online course. This agrees with the findings of Arbaugh (2005) and Harlan and Doubler (2004). One student stated, "It is nice to do them [lessons] when you are available." Another student said it was their "only option right now for pursuing [a] MS engineering degree."

A secondary goal of this work was to provide students with an understanding of their learning style, particularly since many of the students will have teaching roles in the future as graduate teaching assistants, professors, or managers. We believe that understanding their own learning styles and knowing that there are differences between individuals would increase their likelihood of success. Initially, the Myers-Briggs Type Indicator (MBTI) and DiSC Profile were considered as the devices to provide this exposure. The fees required to deploy these methods were deemed too expensive, which led to consideration and selection of the ILS developed by Felder and Soloman (2011a). The ILS attempts to identifies students preferences to take in and process information and deployment of the test requires no user fee (Felder, 2012).

Students were asked to take the ILS survey developed by Felder and Soloman (2011a) that is available free on Felder's web site (www.engr.ncsu.edu/learningstyles/ilsweb.html). The instrument has been tested and had consistency reliability and construct validity (Litzinger, Lee, Wise, and Felder, 2007; Zywno, 2003). Van Zwanenberg, Wilkinson, and Anderson (2000) had mixed results for internal consistency reliability of the global-sequential dimension. Students took the ILS survey and recorded their learning style scores for each of the four ILS dimensions and entered these values in the survey for this study. Twenty students took the ILS survey and completed the four learning style dimension questions. The learning style descriptions below for the four dimensions are directly from Felder and Soloman (2011b).

Active-Reflective: Active learners tend to retain and understand information best by doing something active with it--discussing or applying it or explaining it to others. Reflective learners prefer to think about it quietly first.

Sensing-Intuitive: Sensing learners tend to like learning facts, intuitive learners often prefer discovering possibilities and relationships.

Visual-Verbal: Visual learners remember best what they see--pictures, diagrams, flow charts, time lines, films, and demonstrations. Verbal learners get more out of words--written and spoken explanations. Everyone learns more when information is presented both visually and verbally.

Sequential-Global: Sequential learners tend to gain understanding in linear steps, with each step following logically from the previous one. Global learners tend to learn in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it."

The scale for these dimensions ranged from 11 to -11. Felder and Spurlin (2005) suggested converting the original scale to a range of 0 to 11 for statistical analysis, which has been done here (see table 3.7).

Table 3.7. Preferences legend for converted Index of Learning Styles scores (Felder and Spurlin, 2005).

Score	Active-Reflective	Sensing-Intuitive	Visual-Verbal	Sequential-Global
0-1	Reflective-High	Intuitive-High	Verbal-High	Global-High
2-3	Reflective-Moderate	Intuitive-Moderate	Verbal-Moderate	Global-Moderate
4-5	Reflective-Low	Intuitive-Low	Verbal-Low	Global-Low
6-7	Active-Low	Sensing-Low	Visual-Low	Sequential-Low
8-9	Active-Moderate	Sensing-Moderate	Visual-Moderate	Sequential-Moderate
10-11	Active-High	Sensing-High	Visual-High	Sequential-High

Past engineering instruction has favored certain groups of students over other groups (Cagiltay, 2008; Felder and Silverman, 1988). Felder and Silverman (1988) advocated that students learn in different ways and designing courses, particularly engineering courses, to cater to the two extremes of each learning style dimension would benefit students. Otherwise, a student with learning styles that closely match the instructors teaching style has a systemic advantage over another student who does not (Felder and Silverman, 1988). In other words, multiple channels need to be used to teach rather than individualized instruction as proposed by Evans and Sadler-Smith (2006) and Rayner (2007). Felder and Silverman (1988) did not intend for every activity to meet the needs of every learning style, but that the favored learning style dimensions for activities should vary over the semester.

Both the video lecture and MDAP offer an opportunity to access sources beyond the instructor (this is true for classroom lectures as well), which create the opportunity to supplement the instructor teaching styles with materials and activities favoring student learning styles opposite of the instructor (Felder and Silverman, 1988). An instructor could provide materials and activities meeting the needs of each learning style dimension extreme for all materials and activities, if instructor time commitment is not a constraint.

One concern with learning style surveys is that many were developed for industry and not the educational system (Coffield, Moseley, Hall, and Ecclestone, 2004a). Also, instrument developers have a financial conflict of interest since they own the instrument application and distribution system (Coffield, Moseley, Hall, and Ecclestone, 2004b). The ILS was used for this study because it was developed for education rather than industry (Battalio, 2009), particularly for engineering education (Felder and Spurlin, 2005) and it was free for research use. Although there is a danger of students being labeled or labeling themselves (Coffield et al., 2004b), learning styles testing can serve as one part of formative student assessment, helping instructors better work with students (Rayner, 2007). Learning styles are relatively stable over time (Felder and Spurlin, 2005; Salter, Evans, and Forney, 2006). Learning style information allows learners to adapt to the teaching methods used in their classes (Evans and Sadler-Smith, 2006), which may lead to improved academic performance (Cagiltay, 2008).

The statistics for all four ILS dimensions are summarized in table 3.5. Figure 3.1 shows the distribution of student scores for the active-reflective dimension, which appears normally distributed. Students were split evenly between active and reflective, with the average and median straddling the reflective-low and active-low categories.

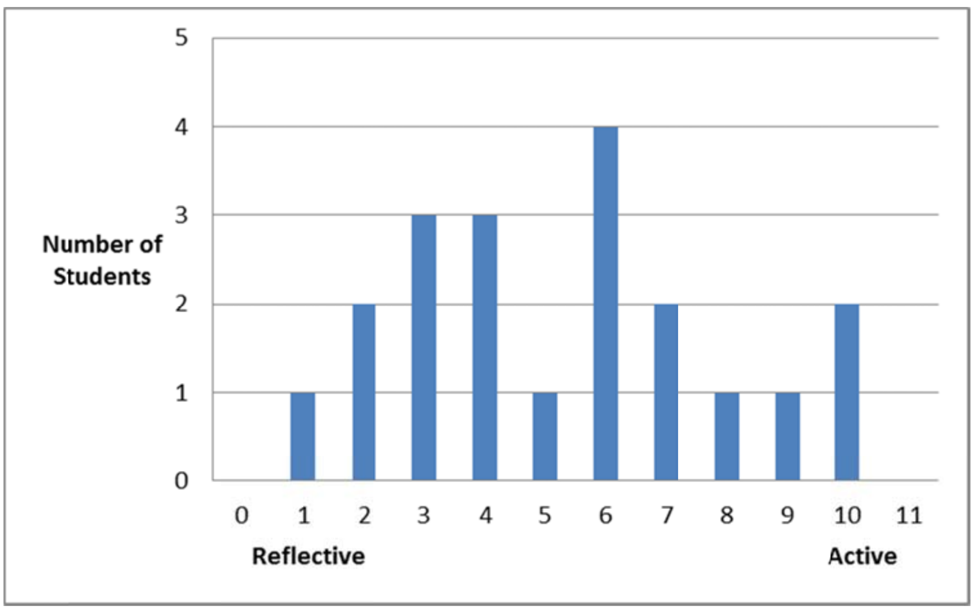

Figure 3.1. Distribution of student scores for the Index of Learning Styles active-reflective dimension.

The sensing-intuitive dimension mean falls in the sensing-low category. Figure 3.2 shows that two-thirds of student scores were in sensing and none were in the extreme portion of the intuitive category of the dimension.

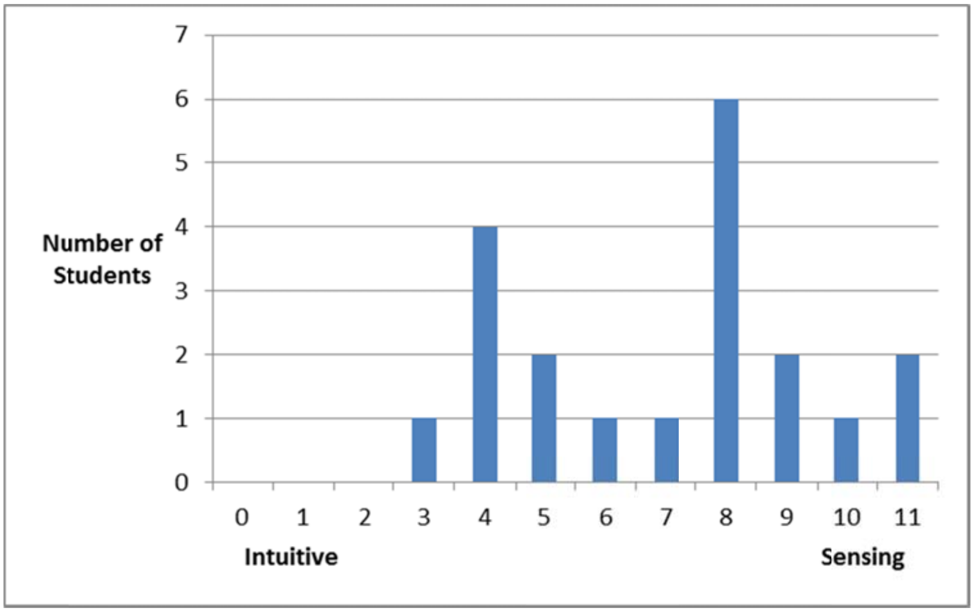

Figure 3.2. Distribution of student scores for the Index of Learning Styles sensing-intuitive dimension.

For the visual-verbal dimension, figure 3.3 shows student scores skewed toward the visual end of the chart. The student score mean for this dimension was moderate-visual. This was expected since the literature has examples of student mean scores being in the visual category (Felder and Brent, 2005; Neuhauser, 2002; Zywno, 2003).

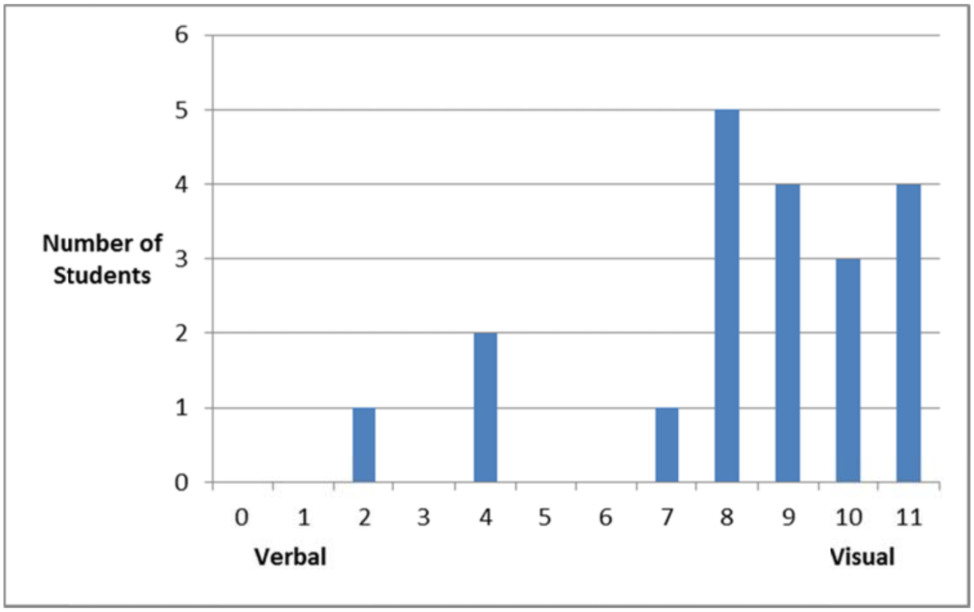

Figure 3.3. Distribution of student scores for the Index of Learning Styles visual-verbal dimension.

The sequential-global dimension had a mean that was sequential-low and the distribution appears normal (see figure 3.4).

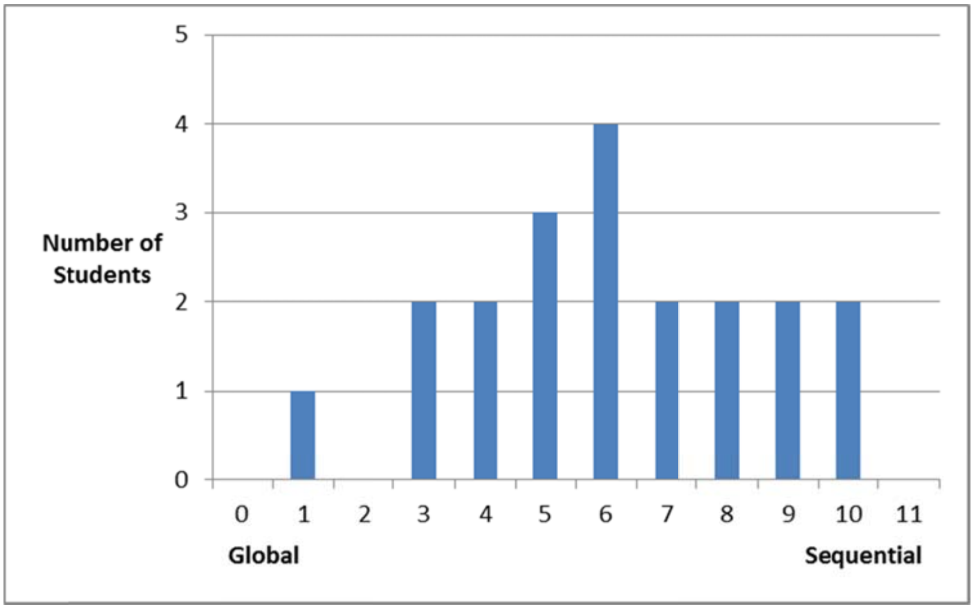

Figure 3.4. Distribution of student scores for the Index of Learning Styles sequential-global dimension.

The average student in our study straddled the active reflective dimension, and had low sensing and sequential styles, and moderately visual style. Table 3.8 shows a comparison of the means and standard deviations for studies by van Zwanenberg et al. (2000) and Zywno (2003) as well as our results. Our results are very similar to those of van Zwanenberg et al. (2000) and Zywno (2003) with one exception. The mean for all students in the van Zwanenberg (2000) study and a subset of engineers from that study in the active-reflective category were the only means that differed from our results by more than 1.00. This may be due to most of our students being graduate students, a selection process that might lean toward reflective. The standard deviations for our study are likely larger due to the smaller sample size.

Table 3.8. A comparison of learning style mean scores and standard deviations across dimensions.

	Jarboe (this dissertation)		Van Zwanenberg (all)		Van Zwanenberg (engineers only)		Zywno	
Learning Style Dimension	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Active-Reflective	5.30	2.66	6.35	2.10	6.60	2.25	5.79	2.37
Sensing-Intuitive	7.00	2.47	6.85	2.45	6.70	2.45	6.24	2.65
Visual-Verbal	8.35	2.50	7.75	2.05	8.35	1.85	8.18	2.11
Sequential-Global	6.10	2.45	5.90	2.00	6.20	2.10	5.77	2.19

The student learning style scores emphasize the importance of teaching BRT 501 such that students in both categories of the four dimensions are reached. A key concern of Coffield et al. (2004b) was the categorization of students. The most beneficial aspect of student learning scores is awareness, both student self-awareness and instructor awareness of student differences (Evans and Sadler-Smith, 2006; Felder and Spurlin, 2005).

Pearson's product moment correlation coefficients were calculated for the survey variables listed above (see table 3.1). Table 3.9 summarizes the relationships among the survey variables with those significant at the $p < 0.05$ level shown in bold. Cohen and Holliday (1982, p. 93) suggested the scale in table 3.2 for interpretation of the Pearson's product moment correlation coefficient values. This scale was used to evaluate the significant correlations identified.

Table 3.9. Correlations for the survey variables. The r values in bold were statistically significant at $p < 0.05$.

Item	1	2	3	4	5	6	7	8	9	10	11
1. Biomass Production Knowledge Before Module	1.00										
2. Biomass Production Knowledge After Module	**0.72**	1.00									
3. Biomass Production Video Usefulness	-0.10	0.31	1.00								
4. Farm Participation	0.00	0.34	0.34	1.00							
5. Compare Quizzes from Different Modules	0.00	0.29	0.31	0.05	1.00						
6. Biomass Quizzes Reflect Material	0.32	**0.54**	**0.46**	-0.21	0.38	1.00					
7. Instructor Availability	-0.34	-0.11	0.37	0.50	-0.19	-0.03	1.00				
8. Internet Proficiency	0.38	0.20	0.12	-0.56	-0.21	0.20	0.00	1.00			
9. Productivity Software Proficiency	**0.58**	**0.45**	0.32	0.54	-0.09	0.27	-0.27	0.42	1.00		
10. Design Software Proficiency	**0.50**	0.31	0.27	**0.94**	0.00	0.31	-0.34	0.38	**0.88**	1.00	
11. Learning Style: Active vs Reflective	0.27	0.17	-0.19	0.63	-0.25	-0.04	0.35	-0.17	0.29	0.12	1.00
12. Learning Style: Sensing vs Intuitive	0.38	0.28	0.07	-0.73	0.06	0.20	0.08	**0.53**	0.24	0.27	-0.06
13. Learning Style: Visual vs Verbal	**0.47**	0.16	-0.10	-0.37	0.03	0.30	-0.01	0.35	0.06	0.16	-0.03
14. Learning Style: Sequential vs Global	0.01	-0.21	-0.01	-0.83	-0.09	-0.23	-0.14	0.25	-0.06	-0.01	-0.15
15. Study Time	-0.11	-0.02	0.35	0.21	-0.16	0.21	0.49	0.00	0.12	0.19	0.25
16. Self-assessed Learning	0.40	**0.64**	**0.45**	**-0.94**	**0.53**	**0.64**	0.07	0.14	0.05	-0.02	-0.11
17. Student Able to Learn Independently	0.15	0.19	0.39	**-0.99**	-0.09	0.36	-0.08	0.42	0.12	0.07	-0.41
18. Overall Educational Experience	0.05	-0.10	0.04	0.47	-0.45	-0.31	0.47	0.15	0.24	0.15	0.16

Very low correlation: 0.00 – 0.19, low correlation: 0.20 – 0.39, modest correlation: 0.40 – 0.69, high correlation: 0.70 – 0.89, and very high correlation: 0.90 – 1.00 (Cohen and Holliday, 1982, p.93).

Table 3.9. (continued)

Item	12	13	14	15	16	17	18
1. Biomass Production Knowledge Before Module							
2. Biomass Production Knowledge After Module							
3. Biomass Production Video Usefulness							
4. Farm Participation							
5. Compare Quizzes from Different Modules							
6. Biomass Quizzes Reflect Material							
7. Instructor Availability							
8. Internet Proficiency							
9. Productivity Software Proficiency							
10. Design Software Proficiency							
11. Learning Style: Active vs Reflective							
12. Learning Style: Sensing vs Intuitive	1.00						
13. Learning Style: Visual vs Verbal	**0.51**	1.00					
14. Learning Style: Sequential vs Global	0.34	0.31	1.00				
15. Study Time	-0.12	0.05	0.07	1.00			
16. Self-assessed Learning	0.23	0.44	0.08	0.01	1.00		
17. Student Able to Learn Independently	0.26	0.14	0.20	-0.02	0.36	1.00	
18. Overall Educational Experience	-0.20	-0.25	-0.07	0.34	-0.42	-0.06	1.00

Very low correlation: 0.00 – 0.19, low correlation: 0.20 – 0.39, modest correlation: 0.40 – 0.69, high correlation: 0.70 – 0.89, and very high correlation: 0.90 – 1.00 (Cohen and Holliday, 1982, p.93).

Biomass production knowledge before the biomass production module was highly positively correlated with biomass production knowledge after the module. The farm student mean for biomass production knowledge before and after the module was good (4.0/5.0 and 4.2/5.0, respectively), whereas the non-farm student mean for biomass production knowledge before the module was poor to acceptable (2.3/5.0) and acceptable to good after the module (3.4/5.0).

Biomass production knowledge after the module was modestly positively correlated with biomass quizzes reflect material. This may suggest that how well students scored on the quizzes indicated an increase in biomass production knowledge.

Participation in the farming operation by students with a farm background was very highly negatively correlated to self-assessed learning and students' self-assessed ability to learn independently. The latter was surprising since farmers are generally considered self-starters and independent. The mean for self-assessed learning for farm students and non-farm students was average (3.2/5.0 and 2.9/5.0, respectively, not significant at $p < 0.05$). The scores for ability to learn independently were nearly identical at the acceptable to good level.

Moderate correlation between the sensing-intuitive dimension and the sequential-global dimension was expected (Felder and Spurlin, 2005), but was not seen in this study. The sensing-intuitive and visual-verbal learning style dimensions were moderately positively correlated, which was unexpected.

Students were grouped using these characteristics and t-scores were calculated:

- Delivery Method
- Domestic or International Student
- Graduate or Undergraduate Degree Pursued
- On-campus or Online
- Had Taken an Online Course Before
- Farm Background or Not
- Instructor Visible
- Learned More in Classroom Modules
- Interacted with Classmates
- Willing to Take a Future Online Course

The t-scores significant at the $p < 0.05$ level are highlighted in table 3.10. Domestic and international students differed significantly on the sensing-intuitive learning style dimension and internet proficiency. International students were neutral, while domestic students were moderately sensing.

All students considered themselves proficient with use of the internet. Domestic students considered themselves very good using the internet while international students considered themselves good. It may be that more domestic students have internet access at home (Song, 2005), better access at home (cable/DSL vs. dial-up) (Song, 2005), or grew up using it frequently.

Online students were four of the 20 respondents. They differed significantly from on-campus students on the sequential-global learning style dimension. Online students were moderately global and on-campus students were mildly sequential.

Students who grew up on a farm reported their self-assessed biomass production knowledge before and after completing the biomass production module as significantly higher than students who did not grow up on a farm. They also reported their self-assessed biomass production knowledge as high before and after completing the biomass production module. Students who did not grow up on a farm considered their biomass production knowledge low prior to completing the biomass production module and average to high after completing the module.

Table 3.10. Results for t-tests conducted for the survey that were statistically significant at $p < 0.05$.

Item	t-score	*p* value	N	Mean	Min.	Max.	95% Confidence Level	
Domestic or International Student								
Learning Styles: Sensing (+) vs. Intuitive (-)	-2.44	0.03						
Domestic Student			14	7.79	4	11	6.52	9.05
International Student			6	5.17	3	8	2.83	7.51
Internet Proficiency	-2.37	0.03						
International Student			6	4.00	3	5	3.34	4.66
Domestic Student			14	4.71	3	5	4.36	5.07
Off-campus or On-campus Student								
Learning Styles: Sequential (+) vs. Global (-)	-2.76	0.01						
Off-campus Student			4	3.50	1	6	0.19	6.81
On-campus Student			16	6.75	3	10	5.62	7.88
Student Did Not Grow Up on Farm or Grew Up on Farm								
Biomass Production Knowledge Before Biomass Module	-3.46	0.01						
Student Did Not Grow Up on a Farm			15	2.27	1	4	1.69	2.84
Student Grew up on a Farm			5	4.00	3	5	3.12	4.88
Biomass Production Knowledge After Biomass Module	-2.27	0.04						
Student Did Not Grow Up on a Farm			15	3.40	2	5	2.99	3.81
Student Grew up on a Farm			5	4.20	4	5	3.64	4.76

All entries had a degrees of freedom value of 18.

Table 3.10. (continued)

Item	t-score	p value	N	Mean	Min.	Max.	95% Confidence Level	
Would Have Learned More in Traditional Class than Online								
Learning Styles: Sensing (+) vs. Intuitive (-)	3.09	0.01						
Would Not Have Learned More in Classroom Setting			6	9.17	7	11	7.36	10.97
Would Have Learned More in Classroom Setting			14	6.07	3	9	4.82	7.32
Biomass Quizzes Reflected the Material	2.48	0.02						
Would Not Have Learned More in Classroom Setting			6	4.17	3	5	3.38	4.96
Would Have Learned More in Classroom Setting			14	3.36	2	4	2.99	3.72
Self-assessed Learning for biomass production module	2.12	0.05						
Would Not Have Learned More in Classroom Setting			6	3.50	3	4	2.93	4.07
Would Have Learned More in Classroom Setting			14	2.71	1	4	2.24	3.19
Students Ability to Learn Independently	2.90	0.01						
Would Not Have Learned More in Classroom Setting			6	4.33	3	5	3.48	5.19
Would Have Learned More in Classroom Setting			14	3.36	2	4	2.99	3.72
Did Not Interact or Did Interact with Classmates								
Productivity Software Proficiency	2.70	0.01						
Did Not Interact with Classmates			14	3.93	3	5	3.57	4.28
Interacted with Classmates			6	3.00	2	4	2.06	3.94
Student Willing or Not to Enroll in a Future Online Class								
Biomass Quizzes Reflected the Material	-2.27	0.04						
Willing to Enroll in a Future Online Course			15	3.80	3	5	3.43	4.17
Not Willing to Enroll in a Future Online Course			5	3.00	2	4	2.12	3.88

All entries had a degrees of freedom value of 18.

Table 3.11 compares student responses about knowledge before and after the biomass production module. Students without a farm background showed a significant increase in self-assessed biomass production knowledge, whereas students with a farm background did not. There was a significant increase in self-assessed biomass production knowledge for all BRT 501 students since 75% of the class was students without a farm background. This indicates the module was useful in bringing the self-assessed biomass production knowledge of three-quarters of the participating students closer to that of students who grew up on a farm. This self-assessment is supported by student scores on the biomass production quizzes and final exam questions for the BRT 501 course.

Table 3.11. Comparison of student biomass production knowledge before and after the biomass production module.

Students	N	t-value	p-value
Without farm background	15	-5.26	0.01
With farm background	5	-1.00	0.37
All BRT 501	20	-4.72	0.01

Splitting students into those who thought they would have learned more in a traditional classroom setting (classroom group) and those who did not (online group), there were significant differences in the sensing-intuitive learning style dimension, student's perceived ability to learn independently, the biomass quizzes represented the lecture/presentation material, and self-assessed learning. The classroom group leaned more strongly toward sensing as compared to the online group. They also considered their ability to learn independently as acceptable to good whereas the online group thought their ability to learn independently was good to very good. Both groups thought the biomass quizzes reflected the lecture/presentation material at least acceptably well, although the online group more so. For self-assessed learning, the classroom group considered their learning to be low to average, while the online group felt their learning was average to good. “Intuitive learners [online group] often prefer discovering possibilities and relationships” (Felder and Soloman, 2011b), which would make them more likely to find independent, online learning acceptable, and possibly preferred.

Comparisons and inferences that were expected between the grade book data and student survey data did not materialize due to information technology challenges. The linkage between WebCT and SurveyGizmo broke down such that student survey data could not be linked directly to student performance on quizzes and exams. The Iowa State IRB required that student participants first read a survey consent form before accessing the survey to insure students had a brief description of the project and understood their participation in the study was voluntary. A WebCT quiz with the survey consent form was developed that had a link to the survey located at SurveyGizmo. The link between the student identification and student survey results was lost. This greatly limited the conclusions that could be made.

The women survey participant rate (2/20) was about half that of the class (10 of 46). The limited female student response constrained the survey as a tool to identify student differences based on gender. The female survey participants did offer important qualitative observations that were useful.

Conclusion

The biomass production module brought students without a farm background closer to the knowledge level of students with a farm background as demonstrated by students’ self-assessed knowledge and their BRT 501 assessment scores.

Students desired a stronger connection with the course instructor and peers, whether electronically or in-person. This may reflect a relationship between student-instructor connectedness and grade point average (GPA). Market signals to students in the form of GPA minimums for scholarships (Scholarships, 2012; College-wide Scholarships, 2012) and employer interview requirements (Gaul, 2012) as well as higher GPA leading to better jobs with higher incomes (James et al., 1989; Preston et al., 1990) may influence student interest in connectedness to the instructor. The MDAP used for this study was less personal due to the lack of the instructor's image, particularly compared to the video lecture where emphasis on specific portions of the materials, non-verbal cues, and connection with the lecturer could be seen. The inclusion of material that might accomplish this could be done in a MDAP, but would be time consuming and more costly. Because of the stronger instructor-student connection that is facilitated by video lecture, and because this connection has value to students, this study suggests that video lectures are preferable to the MDAP for online content delivery.

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CHAPTER 4. A COMPARISON OF INSTRUCTOR TIME COMMITMENT FOR THREE COURSE DELIVERY METHODS

A paper to be submitted to the Journal of Engineering Education

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Abstract

In 2007, a Virtual Education Center (VEC) for Biorenewable Resources was initiated (Raman et al., 2006). The VEC offered three courses through distance education, including Biorenewable Resources and Technology (BRT) 501 – Fundamentals of Biorenewable Resources and Technology. The primary objective of the study was to compare instructor time commitment for three delivery methods: classroom lecture, video lecture, and menu-driven autotutorial presentations (MDAP) delivered via Flash. The instructor time commitment data for module development and delivery were gathered for classroom lecture, video lecture, and MDAP formats. These values were compared with the student learning information to determine the instructor time commitment of the three methods. Our results indicate that a classroom lecture takes less instructor time commitment than a video lecture or a MDAP delivered online for the initial course offering. For subsequent course offerings, both the video lecture and MDAP delivered online have the potential to take similar or less instructor time commitment than a classroom lecture. In a related study, we found that the instructor needs to be visible on screen part of the time to fulfill student desires for a connection to the instructor and an opportunity for them to gather nonverbal cues. For BRT 501, it appears the best choice for content delivery is the use of online video lectures. A hybrid course using video lectures and a limited number of classroom meetings (two to four

per semester) may offer an alternative that addresses the instructor connection issue (Mills and Xu, 2005-2006). Both formats would minimize instructor time commitment and offer a good learning environment for students. The MDAP required substantially higher instructor time commitment, some of which could be shifted to support staff. This shift would require considerable support staff time to develop high quality presentations and lead to a significant cost increase.

Introduction

In an effort to better serve students and stakeholders, institutions of higher learning have expanded offerings beyond the classroom using online technologies for over two decades (Harasim, 2000; History of the OU, 2012). Students taking at least one online course increased from 1.6 million in 2002 to 6.1 million in 2010 in the United States, a compound annual growth rate of 18.3% (Allen and Seaman, 2011). This represents over 31% of all students enrolled in postsecondary degree-granting institutions (Allen and Seaman, 2011).

Students are attracted to online courses due to student online learning success and satisfaction, greater flexibility and convenience (Arbaugh, 2005; Arbaugh and Duray, 2007), learner-centered approaches have been proven effective, costs are comparable to classroom delivery, and courses are scalable (Bourne, Harris, and Mayadas, 2005). Also, studies have found no significant difference in student learning between face-to-face and online education environments (Arbaugh and Benbunan-Fich, 2007; Bourne et al., 2005; Chen and Jones, 2007; Neuhauser, 2002; Tucker, 2001).

One disadvantage of online courses has been greater instructor time commitment (Bender, Wood, and Vredevoogd, 2004; Dumont, 1996). This study explored the time commitment of instructors.

Goals

1. Compare instructor time commitment differentials for delivery of one 50-minute class for three delivery methods: classroom lecture, video lecture via the internet, and menu-driven autotutorial presentations (MDAP) delivered via Flash via the internet.
2. Compare instructor time commitment by delivery method for four sections (soybean, hay and forages, short rotation woody crops, and biotechnology) of the biomass module.
3. Identify the most efficient delivery method for BRT 501 based on instructor time commitment.

Materials and Methods

Three content delivery methods were explored: classroom lecture, video lecture, and MDAP (see appendix A for video lecture and MDAP examples). The traditional classroom lecture served as the baseline for this study. The video lectures used a tablet computer and pen to annotate, draw, and make calculations for content delivery and served as the standard online delivery method. The third delivery method used was online MDAP. Flash was selected as the technology for MDAP delivery because surveys by Millward Brown (2009) and Statowl.com (2010) estimated the Flash plug-in was on over 97% of computers in significant markets, nearly 20% more than other plug-ins such as Oracle Java and Apple

Quicktime Player. Fang (2009) found that 99% of Rutgers University Law Library visitors had the Flash plugin.

Dr. D. Raj Raman, then Associate Professor, Department of Agricultural and Biosystems Engineering and Associate Director of Educational Programs, Bioeconomy Institute, was the primary lecturer for BRT 501 and Katrina Christiansen, then Graduate Research Assistant, Department of Agricultural and Biosystems Engineering, served as the graduate teaching assistant. Darren Jarboe, then Program Manager for the Center for Crops Utilization Research and Ph.D. candidate in Industrial and Agricultural Technology, served as a special lecturer for the biomass production module, the section of the course during which the data for this study were collected.

In spring 2010, seven 50-minute biomass production classes were developed for a graduate course in the fundamentals of biorenewable resources and technology. The syllabus described the course as an introduction “to the science and engineering of converting biorenewable resources into bioenergy and biobased products” (Raman 2010). The class material developed and delivered covered production and economics for corn, soybean, hay and forages, and short rotation woody crops (trees and shrubs) as well as a brief introduction to biotechnology. The following information was included in the lectures for each biomass crop:

- Crop history
- Plant and seed nomenclature
- Classification
- Crop composition
- Biomass production operations
- Land quality and value
- Crop rotation
- Calculating costs of production
- Challenges, advantages, and outlook

The biomass production content was delivered to students through WebCT starting in the ninth week of the semester and ending in the eleventh week. Both modes contained nearly identical information presented as text, tables, and images. The video lecture content was delivered as a sequence of slides with voiceover and the MDAP content was delivered as slides through a menu driven Flash presentation with text. The written material was identical, but spoken words on the video may have provided additional content. PDFs of the slides for each lecture were available to all students. Furthermore, the slides included links to outside resources such as videos and animations, which were thus accessible to students in both groups.

Course assessments were WebCT-based quizzes that reinforced student understanding of the course material and prepared students for the midterm and final exams. The biomass production module quizzes were given after the midterm exam so only the final exam contained biomass production questions. All course assessments were WebCT-based, timed, open-book, unproctored, and on the honor system. Questions were in the form of true-false, multiple choice, matching, fill-in-the-blank, and calculation problems. In virtually all cases, the multiple choice and matching problems had randomized orders of responses and the calculated problems had WebCT-generated parameter values so each student had a different set of numbers with which to work.

Data were collected during the development and delivery of the biomass module classes and analyzed. The data gathered were hours to develop and practice the presentation, lecture or presentation delivery, coordination with the online delivery staff, and assessment activities. Data were collected for seven 50-minute lectures. The development and delivery of two lectures on corn production were used to test the lecture development and delivery process to be used for the remaining five 50-minute lectures. The soybean and biotechnology units were each delivered during one 50-minute lecture period. The hay and forages and short rotation woody crops units were each delivered during one and a half 50-minute lecture periods.

Student interactions normally consume a significant amount of instructor time. For BRT 501, the graduate teaching assistant was the student interface for the biomass production module, the same as for the rest of the course. We did not collect these data, but we would expect them to be similar for the video lecture and MDAP.

Results and Discussion

Preparation and delivery data were collected for the three delivery methods. Table 4.1 breaks out the information by step for each method, unit, and provides total and average hours. The results show the classroom and video lectures were very similar in the amount of instructor time for lecture preparation and delivery, which took 10% more time for the video lectures (see grey boxes in table 4.1). Table 4.1 shows the total time for different units was similar across the delivery method for the classroom and video lectures, ranging from 6.5 to 7.5 h/lecture and 7.0 to 8.0 h/lecture, respectively. This is about the same amount of time Dumont (1996) suggested for online versus classroom courses. Bender et al. (2004) and Lazarus (2003) found online course instruction took 3.8 h/wk (excluding teaching assistant time) and 3.4 to 6.9 h/wk, respectively. Harlen and Doubler (2004) found online facilitators spent 16% more time per week than classroom facilitators (9.0 h/wk vs. 8.0 h/wk). Tomei (2006) found that online teaching took at least 14% more time than classroom instruction (9.1 h/wk vs. 10.4 h/wk, respectively) and was stable over the 15-week semester.

Table 4.1. Hours needed for three lecture preparation and delivery methods of four units on biomass production.

Delivery Method	Soybean	Hay & Forage	SRWC	Biotechnology	Total	Average
Classroom Module						
Develop presentation	4.0	3.0	3.0	3.0	13.0	3.3
Practice presentation	2.0	2.0	2.0	2.0	8.0	2.0
Classroom Presentation Delivery	1.0	1.5	1.5	1.0	5.0	1.3
Assessment Activities	0.5	0.5	0.5	0.5	2.0	0.5
Classroom Module Development Total	*7.5*	*7.0*	*7.0*	*6.5*	*28.0*	*7.0*
Video Module						
Develop Presentation	4.0	3.0	3.0	3.0	13.0	3.3
Practice Presentation	2.0	2.0	2.0	2.0	8.0	2.0
Video Room Presentation Delivery	1.0	1.5	1.5	1.0	5.0	1.3
Coordination with Online Delivery Staff	0.5	0.8	0.8	0.5	2.6	0.7
Assessment Activities	0.5	0.5	0.5	0.5	2.0	0.5
Video Module Development Total	*8.0*	*7.8*	*7.8*	*7.0*	*30.6*	*7.8*
MDAP Module						
Develop Presentation & Delivery	7.0	13.5	17.5	5.0	43.0	10.8
Coordination with Online Delivery Staff	0.5	0.5	0.5	0.5	2.0	0.5
Assessment Activities	0.5	0.5	0.5	0.5	2.0	0.5
MDAP Module Development Total	*8.0*	*14.5*	*18.5*	*6.0*	*47.0*	*11.8*

MDAP: Menu-driven autotutorial presentations delivered via Flash.
Total for average hours may not equal the total hours due to rounding.
Student interactions were handled by the graduate research assistant and not included in the study.
The graduate research assistant and professor developed assessments. Time is for question review by module instructor.

As shown in Table 4.1 (grey boxes), the MDAP took much more time than the classroom or video lectures, about 69% and 53%, respectively. The variability between MDAP was much higher, ranging from 6.0 h to 18.5 h/unit. Technical difficulties were experienced when developing the hay and forage and short rotation wood crops MDAP. This dramatically increased the development time due to the programming skill level of the instructor and a reluctance to overuse the Flash consultant due to cost. Using the consultant more would have reduced instructor commitment and programming time. However, it appears that MDAP could be competitive regarding instructor time commitment as demonstrated by the soybean and biotechnology lectures. The biotechnology lecture actually took less time to prepare in MDAP than the other two delivery methods because the template from the soybean presentation developed previously was used.

The total time to prepare and develop a lecture for all three delivery methods was impacted by the instructor's lack of teaching experience and development of new lectures rather than updating existing lectures. Wankat and Oreovicz (2000) suggest two hours of preparation for a new lecture on a known subject and 30 minutes for lectures presented previously. The University of Manchester uses 10 hours of preparation time per new lecture as a rule of thumb for new faculty members (Tomkinson, 2006). The lecture preparation and delivery time for the biomass module fell in this range, except for two of the MDAP discussed above. We believe the overall times per module reported in Table 4.1 to be significantly longer than might be possible for a more experienced instructor. However, the relationship between the time requirements for each method is expected to hold.

Each lecture delivery method has advantages and disadvantages for the instructor and these have evolved over time. Early in online education, classroom instruction had significant advantages over online instruction. In 1972, Moore put forth a theory that would come to be called the theory of transactional distance, which sought to describe the relationship between student and instructor (Moore, 1997). Moore (1997) suggested it may be closer and/or easier to establish relationships in the classroom than in distance education formats. Dumont (1996) suggested face-to-face instructor-student and student-student interactions were an advantage of classroom instruction. By 1997, Moore noted technology evolution could empower students in a self-directed learning environment and offer more peer interaction.

Others found disadvantages as well. Bender et al. (2004) found their distance education course required extra set up time to instruct students in use of the delivery technology and technology troubleshooting. Dumont (1996) experienced significantly greater time commitment to teach his online course. Bonk and Cummings (1998) warned of the difficulty of balancing the assignment of interesting projects to students and overloading them. They also suggested the instructor not inject themselves into student discussions too early, but let them “wrestle with the problem.”

Bernard, Abrami, Lou, Borokhovski, Wade, Wozney, Wallet, Fiset, and Huang (2004) stated that “attention to quality course design should take precedence over attention to the characteristics of the media.” Sitzmann, Kraiger, Stewart, and Wisher’s (2006) meta-analysis found that instructional methodology is more important than delivery medium. Bartley and Golek (2004) stated the main issue with online instruction is pedagogy, not technology. Sun, Tsai, Finger, Chen, and Yeh (2008) found technology was not a student satisfaction factor unless it was poor, improper, or lacking. Arbaugh (2005) found that neither the medium nor the course software positively impacted student learning. They also noted that neither increasing class size nor the medium impacted student learning. These studies demonstrate the need to focus on teaching strategies that enhance student learning, not the delivery medium or technology.

Lazarus (2003) found that a classroom course committed the instructor three days a week whereas an online course committed the instructor every day. Dumont (1996) thought the window for providing feedback to online students was much smaller than for classroom students and commenting on writing assignments was difficult. Online learners expect responses to inquiries 24/7 (Tomei, 2006) and online student email traffic was twice that of classroom students (Bender et al., 2004).

Marks, Sibley, and Arbaugh (2005) suggested that factors such as these create greater potential to overload instructors. Alavi, Yoo, and Vogel (1997) noted a large initial cognitive load on instructors using a new medium, but the load decreased rapidly as the instructors became familiar with the system. The potential for technology failure in an online course increases instructor time commitment (Bender et al., 2004).

The benefits of teaching an online course have also been documented. Alavi et al. (1997) found improved access to guest speakers for classes due to the smaller time commitment for participation. A similar strategy is to have instructors from other universities provide part of the online course content. Alavi et al. (1997) conducted a course split between two faculty members on different university campuses, allowing each faculty member to lecture in their area of expertise. The BRT 501 course, the subject of this study, was available on three university campuses with a faculty member from each campus teaching roughly one-third of the course. The instructors had different specializations and they prepared the lectures in their areas of expertise.

An advantage of video lectures and MDAP is the option to reuse the lecture/presentation, which eliminates much of the instructor time. The BRT 501 biomass production video lectures were used for the fall 2010 online class. Coordination with the online delivery staff and the assessment activities remain necessary, but are only about 15% and 10% of the original time needed to develop and deliver the video lecture or MDAP, respectively (see table 4.1).

Since online students are located too far away from campus or need a flexible schedule not amenable to classroom attendance, Arbaugh and Duray (2002) suggested that a premium might be charged to cover the additional costs for delivery of online courses. In 2012, Iowa State University charged students a delivery fee (premium) for online courses, including the online section of BRT 501 (Schedule of Classes, 2012).

Bonk and Cummings (1998) suggested hybrid courses could be an option that allows an instructor to use the positive aspects of classroom lectures and online instruction. Mills and Xu (2005-06) used a hybrid system for their statistics course, although they did not see improved student performance as compared to previous semesters.

Conclusion

The study results indicate that a classroom lecture takes less instructor time commitment than a video lecture or a MDAP delivered online for the initial course offering. For subsequent course offerings, both the video lecture and MDAP delivered online have the potential to take similar or less instructor time commitment than a classroom lecture.

For BRT 501 going forward, the best choice for online content delivery appears to be the use of video lectures. The instructor needs to be visible on screen part of the time to fulfill student desires for a connection to the instructor and an opportunity for them to gather nonverbal cues. A hybrid course using video lectures and a limited number of classroom meetings (two to four per semester) also has the potential to address this issue (Mills and Xu, 2005-2006). Both formats would minimize instructor time commitment and offer a good learning environment for students. The MDAP took substantially more instructor time compared to the other delivery methods, some of which could be shifted to support staff. This shift would require considerable support staff time to develop high quality presentations and lead to increased cost.

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CHAPTER 5. GENERAL CONCLUSIONS

General Discussion

The BRT 501 course project pulled together information from the WebCT grade book, a student survey, instructor time log, and internet sources to develop three main projects. The objectives of the projects were:

1. Determine if student learning in BRT 501 was influenced by course delivery method. Two methods were used – video lecture and menu-driven autotutorial presentations (MDAP) delivered via Flash. The influence of student major and gender on learning were also studied.
2. Assess student perceptions of the two delivery methods.
3. Compare instructor time commitment for classroom lecture, video lecture, and MDAP delivery methods.

Chapter 2 compared student performance in BRT 501 for the two online course delivery methods (video lecture and MDAP), student major (agricultural and non-agricultural), and gender. The study found that student performance was not significantly impacted by the module delivery method.

Structuring course content for blended learning offers the opportunity to transform higher education (Garrison and Kanuka, 2004; Osguthorpe and Graham, 2003). One model is students view lectures from a master content provider before attending class. Class time would be used for learning activities to apply the lecture content, activities that enable students to make meaning of the lecture material and learning through student-to-student interaction. These sessions would be facilitated by faculty or graduate teaching assistants, depending on student learning needs. These could be labs that conduct experiments, case studies, problem sets, and/or discussions that use the concepts from the lecture. Synchronous or asynchronous online discussions or communities could also be part of the local program.

A recent online course that gives a glimpse into the future of online course delivery is the *Introduction to Artificial Intelligence* course offered in fall 2011 by Dr. Sebastian Thrun, Stanford University and Dr. Peter Norvig, Google, using YouTube (Thrun and Norvig, 2012a). The course was an extension of their classroom course, with the online course being free. The course attracted 160,000 students with over 23,000 students completing the course requirements (DeSantis, 2012). The Stanford classroom section began with "about 200 traditional students…enrolled" (DeSantis, 2012). Students attending lectures "…eventually dwindled to 30 students," with the remainder having transitioned to watching lectures online (DeSantis, 2012). Thrun and Norvig expanded their offering beyond the online lecture to connect with students through an online community and weekly video office hours in which they answered student questions that were selected by the students in the online community (Thrun and Norvig, 2012b).

Chapter 3 identified opportunities to improve the learning experience of BRT 501 students. Twenty students completed a survey of the qualitative aspects of student experiences in BRT 501. The biomass production module brought students without a farm background closer to the knowledge level of students with a farm background as demonstrated by students' self-assessed knowledge and their BRT 501 assessment scores. Students desired a stronger connection with the course instructor and peers, whether electronically or in-person.

The majority of BRT 501 students thought it was important for the instructor to be visible or present, regardless of the delivery method. This appears to contrast with efforts at Khan Academy and Yale University. Students are willing to take free online courses as demonstrated by the over 3,000 lessons available and 130 million lessons delivered by Khan Academy (Khan Academy, 2012). This model uses expert lecturers to provide the video content. Lessons are broken into short segments "from 3 to 15 minutes long" (Lynley, 2011). The lessons generally do not show the instructor's face or offer a visual connection to the instructor.

Yale University offers open access to undergraduate courses on a variety of subjects. The site offers audio or video of the classroom lecture, which can be downloaded, as well as other course materials (e.g., reading list, problem sets, searchable transcripts) (About, Open Yale Courses, 2012a). The courses are not for credit nor are they applicable toward a degree or certificate (Courses, Open Yale Courses, 2012b).

Neither Khan Academy nor Yale University provides a two-way connection with the instructor or peers, which students in this study thought important. Students self-select to use the Khan Academy and Yale University materials, which may best suit a particular group of students. Neither Khan Academy nor Yale University supports students beyond providing the lectures and materials, nor do they indicate how many students access and complete an entire series or course (Khan Academy, 2012; Courses, Open Yale Courses 2012b). Khan Academy (2012) does have staff to support the use of their videos by schools.

Bernard, Abrami, Lou, Borokhovski, Wade, Wozney, Wallet, Fiset, and Huang (2004) also found interaction with instructor and peers was important to academic achievement. The *Introduction to Artificial Intelligence* course offers potential methods that could create connectedness in BRT 501, particularly the online version of the course. More extensive use of an online community to identify questions and exchange information would enable students to create connectedness. It could also provide the instructor with material to discuss during a weekly video. These additions to BRT 501 would likely enhance student learning.

Overall, multiple studies have shown that students believe synchronous instruction provides better learning than asynchronous instruction. Arbaugh and Benbunan-Fich (2007) found learner-instructor interactions were significant for higher perceived learning. Bernard et al. (2004) observed that poor student-instructor communication factored into high distance education dropout rates, with higher dropout rates for asynchronous than synchronous courses. Communication with instructors benefits both asynchronous and synchronous online students (Bernard et al., 2004). The visual interface, including accessibility, interactivity, and attractiveness, is important (Jung, 2001). Marks, Sibley, and Arbaugh (2005) found that student-instructor interaction was twice as important as student-student interaction. Lee and Rha (2009) found that student-student and student-instructor dialogue were important, verbally or electronically. This led to significantly higher student achievement for critical thinking learning and overall record. Moore (1997) stated “distance education is not simply a geographic separation of learners and teachers, but, more importantly, is a pedagogical concept. It is a concept describing the universe of teacher-learner relationships that exist when learners and instructors are separated by space and/or by time.”

There are two reasons we believe students in the study desired connectedness with the instructor and peers. One is students pay for a service and expect a high level of performance for their tuition dollars. Another possibility is students may believe connectedness with the instructor will help them achieve a better course grade. Siebert, Davis, Litzenberg, and Broder (2002) found that one key student objective is a high grade point average (GPA), which students expect to translate into money in the future. GPA has been associated with greater income after graduation (James, Alsalam, Conaty, and To, 1989; Preston, Broder, and Almero, 1990). Students read market signals such as scholarships that require a minimum GPA (Scholarships, 2012; College-wide Scholarships, 2012) or employers setting GPA hurdles for job interviews (Gaul, 2012). Student comments about the importance of better connectedness with the instructor may be related to their expectations that connectedness translates into better understanding of homework assignments, projects, and exams, leading to better grades, and eventually large economic benefit.

Chapter 4 highlighted that a classroom lecture takes less instructor time commitment than a video lecture or a MDAP delivered online for the initial course offering. For subsequent course offerings, both video lecture and MDAP delivered online have the potential to take similar or less instructor time commitment than a classroom lecture. For BRT 501 going forward, the best choice for online content delivery appears to be the use of video lectures. The instructor needs to be visible on screen for student-instructor connectedness and the opportunity for students to collect nonverbal cues. A hybrid course using video lecture and a limited number of classroom meetings (two to four per semester) offers an option to fulfill student desire for a connection with the instructor (Mills and Xu, 2005-2006). Both formats would minimize instructor time commitment and offer a good learning environment for students. As instructional technology becomes easier to use and more powerful, the focus of online education will continue its shift from delivery methods to successful student learning strategies.

For distance and online education, video lectures are a viable teaching method that serves the needs of students. There are indications that video lectures supplemented by supporting materials, online community, and instructor videos to answer questions and form the bond with students are a viable option. The student desire for connection to the instructor, electronically or in-person, creates an opportunity for universities to remain relevant. If there is a shift to the use of master content providers (i.e., one person provides lecture for many educational institutions), then there is an opportunity to provide group learning, student research and presentations on the topic, and hands-on laboratories. Flash delivery technology may have a role in the development of animations, examples, and other visual tools.

Brick and mortar colleges and universities may be able take advantage of this by offering students increased value. Expansion of online content use in higher education, particularly lectures by recognized content experts, would allow student-instructor and student-student contact time to focus on applying the information learned online. The campus instructor could focus on enhancing student learning through group work, experiential opportunities, class discussions and other methods, time in which students could create their own learning under facilitation of the instructor. This type of instruction also has the potential to strengthen the network students gain by being on campus.

Use of asynchronous online systems that enable students to complete degree and certificate programs more quickly have the potential to improve four-year graduation rates and create the chance students could graduate in three years, especially through coordination and cooperation with high schools (not only in Iowa) using advanced placement classes and other methods. This could be a great recruiting tool for colleges and universities and offer an opportunity to reduce student debt loads.

One reason students attend college is to improve their employment options. Online education can help students gain the competencies employers' desire and offer solutions as they progress in their career. Lifelong learning can be offered that enables students to advance in their career or change careers. Online distance education programs can serve this role, especially those that meet employee and employer needs. This will have the side benefit of creating a closer connection with employers that may become research and outreach program clients.

One of the limitations of video lectures is the bandwidth necessary for delivery. Many rural communities in the United States do not have broadband internet, which limits access (Katz, 2011). Developing nations also have limited broadband infrastructure except in major metropolitan areas (Al-Ghazawy, 2009; Kim, Kelly, and Raja, 2010). Courses using either video lecture or MDAP could be loaded onto a DVD and shipped to areas without broadband access.

In the developing world, the advancement of technology can leapfrog the educational distribution methods of developed countries. This can lower system development costs and open educational opportunities that would not be available otherwise. Online education offers access to world class educators for higher education and can reach into the K-12 system. This is an opportunity for colleges and universities to expand their reach and continue growing their student populations (Katsomitros, 2011) even as the student population in their traditional service area stagnates or declines.

Recommendations for Future Research

The study could be improved in a number of ways. Additional participants could have been recruited from other VEC graduate level course. Undergraduate students and students from multiple disciplines and institutions could be studied. The inclusion of these additional categories of data would reveal the effects of different institutions, graduate and undergraduate, and between disciplines, making the results applicable to a more general population.

As in any research that engages statistical methods, a larger sample size would have allowed a higher level of confidence for interpretation and better understanding of the outcomes. This would also be true had the observations and assessment methods used to measure student learning been broadened beyond exams and quizzes.

Better testing of the data collecting system to insure it worked properly would improve results. Also, checking data collection for problems while keeping the data embargo intact would insure the entirety of the data set. Deeper probing through focus group or individual interviews with students might give a different or deeper perspective to the qualitative findings.

Improvement unleashing the power of the Flash delivery technology might enhance student learning. It could provide demonstrations, animations, and simulations to help students better understand concepts being taught. The use of a Flash consultant to program the modules and/or support materials would have improved the offering; however there is an associated cost.

A study of BRT students at all three Virtual Education Center (VEC) institutions (Iowa State University, University of Idaho, and University of Kentucky) that explores performance across modules and institutions may be useful. The VEC institutions are in a unique position to take advantage of linkages already in place among the institutions and add linkages to new institutions so the impact of cooperative program delivery on student learning and educational cost management could be measured. An experiment that offers BRT 501 online, similar to the *Introduction to Artificial Intelligence* course at Stanford, could offer the opportunity to understand the reasons for student participation in the course, why students completed all aspects of the course while others did not (student retention), and identify support structures that enhance the likelihood that students complete the course. Developing viable online distance education programs based on sound research findings has become and will continue to play a key role for higher education to serve students effectively and competitively.

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APPENDIX A: VIDEO LECTURE AND MDAP SCREENSHOTS

Screen shot of the video lecture.

Screenshot of the menu-driven autotutorial presentations (MDAP) delivered via Flash.

APPENDIX B: BIOMASS MODULE STUDENT SURVEY

BRT 501 Crop Module Student Learning Survey

1. Did you receive video modules or Flash modules?

- Video
- Flash

2. According to the Felder-Soloman Index of Learning Styles, what is your learning style?

Active vs. Reflective

Active 11	Active 9	Active 7	Active 5	Active 3	Active 1
Reflective 1	Reflective 3	Reflective 5	Reflective 7	Reflective 9	Reflective 11

Sensing vs. Intuitive

Sensing 11	Sensing 9	Sensing 7	Sensing 5	Sensing 3	Sensing 1
Intuitive 1	Intuitive 3	Intuitive 5	Intuitive 7	Intuitive 9	Intuitive 11

Visual vs. Verbal

Visual 11	Visual 9	Visual 7	Visual 5	Visual 3	Visual 1
Verbal 1	Verbal 3	Verbal 5	Verbal 7	Verbal 9	Verbal 11

Sequential vs. Global

Sequential 11	Sequential 9	Sequential 7	Sequential 5	Sequential 3	Sequential 1
Global 1	Global 3	Global 5	Global 7	Global 9	Global 11

3. What is your gender?

- Female
- Male

4. Are you a traditional (<30 years old) or non-traditional student (30 or more years old)?

- Traditional
- Non-Traditional

5. Are you a domestic or international student?

- Domestic student
- International student

6. Are you a full-time student?

- Yes
- No

- Yes
- No

- Full-time
- Part-time

7. What degree are you pursuing?

- Bachelor’s Degree
- Master’s Degree
- Ph.D.
- Other

8. What is your current major?

- Agricultural and Biosystems Engineering
- Agronomy
- Animal Science
- Chemical and Biological Engineering
- Chemistry
- Civil, Construction, and Environmental Engineering
- Economics
- Food Science and Human Nutrition
- Materials Science Engineering
- Mechanical Engineering
- Natural Resource and Ecology Management
- Other

9. If you are a graduate student, what was your undergraduate major?

- Agricultural and Biosystems Engineering
- Agronomy
- Animal Science
- Chemical and Biological Engineering
- Chemistry
- Civil, Construction, and Environmental Engineering
- Economics
- Food Science and Human Nutrition
- Materials Science Engineering
- Mechanical Engineering
- Natural Resource and Ecology Management
- Other

10. Did you register to take BRT 501 on-campus or online?

- On-campus
- Online

11. Have you taken an online course previously?

- Yes
- No

12. Did you grow up on a farm?

- Yes
- No

Never	Rarely	Occasionally	Frequently	Very Frequently

13. How useful were the crop production videos about field equipment operations?

Usefulness:

Not Useful	Slightly Useful	Useful	Very Useful	Extremely Useful

Comments:

14. What about the crop production module most helped you learn?

15. What about the crop production module detracted from your learning?

16. What additional crop production materials would have helped you learn more in the crop production module?

17. Which crop production segment did you like most? Why?
Response:

- Corn
- Soybean
- Hay/Forage
- Short Rotation Woody Crops
- Biotechnology

Why?

18. Which crop production segment did you like least? Why?
Response:

- Corn
- Soybean
- Hay/Forage
- Short Rotation Woody Crops
- Biotechnology

Why?

19. How much time did you spend each week studying the crop production materials?
Number of hours:

<1 Hour	1-2 Hours	3-4 Hours	5-6 Hours	>6 Hours
○	○	○	○	○

Comments:

20. How difficult were the crop production quizzes compared to other BRT 501 quizzes?
Difficulty:

Much More Difficult	More Difficult	About the Same	Easier	Much Easier
○	○	○	○	○

Comments:

21. How well did the crop production quizzes reflect the material presented.
Response:

Very Poor	Poor	Acceptable	Good	Very Good
○	○	○	○	○

Comments:

22. What level was your crop production knowledge:
Before completing the crop production module?

Very Low	Low	Average	High	Very High
○	○	○	○	○

After completing the crop production module?

Very Poor	Poor	Acceptable	Good	Very Good
○	○	○	○	○

23. How would you assess your learning from the crop production module?

Response:

Very Low   Low   Average   High   Very High

Comments:

24. How was the overall education experience for the crop production module?

Response:

Very Poor   Poor   Average   Good   Very Good

Comments:

25. How proficient are you with use of the computer for:

	Very Poor	Poor	Average	Good	Very Good
Internet Use					
Productivity Software					
Design Software					

26. Did this impact your learning for the module? How?

Yes or No:

Yes

No

How?

27. Is it important for the instructor to be visible during the presentation? Why or Why Not?

Yes or No:

- Yes
- No

Why or Why Not?

28. Do you think you would have learned more in a traditional classroom setting? Why or Why Not?

Yes or No:

- Yes
- No

Why or Why Not?

29. What modifications would you recommended for the crop production module to improve the student learning experience?

30. Did you contact the instructor?

- Yes
- No

- Email
- Telephone
- In-Person
- Discussion Board
- Other

Yes or No:

- Yes
- No

Comments:

31. Rate instructor availability for the crop production module.

Unavailable ○ ○ ○ ○ ○ Available

32. Did you interact with classmates about the crop production module?

○ Yes

○ No

☐ Email

☐ Telephone

☐ In-Person

☐ Discussion Board

☐ Other

33. For in-class (section A) students: Did learning the content through online module take more, less, or the same amount of time as classroom module?

Response:

Much Less	Less	About the Same	More	Much More
○	○	○	○	○

Comments:

34. What delivery method modifications would you recommended for the crop production module to improve the student learning experience?

35. How well do you learn in an independent setting (outside the classroom)?

Response:

Very Poor	Poor	Acceptable	Good	Very Good
○	○	○	○	○

Comments:

36. Will you consider enrolling in an online course in the future? Why or why not?

Yes or No:

○ Yes

○ No

Why or Why Not?

37. Do you have other comments regarding the crop production module?