Differential Impacts of Online Delivery Methods on Student Learning: A Case Study in Biorenewables[1]

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Abstract

In 2007, a Virtual Education Center for Biorenewable Resources was initiated that offered three distance education courses, 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 auto-tutorial presentations (MDAP) delivered via Flash format), student major (agricultural and non-agricultural), and gender influence online student learning in BRT 501. 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. Gender differences seen on the biomass-module first-attempt total quiz score disappeared for the final total quiz score on that module.

Introduction

Technology has been a driver in the advancement of distance education throughout its history, from mail correspondence courses in the 1700s (Jeffries, 2010) to phonograph records in the early 1900s (University of Wisconsin Extension, 2005) and television which peaked in the 1970s (Jeffries, 2010) to the Internet used to deliver massive open online courses today (MOOC) (DeSantis, 2012). The number of students that take at least one higher education course online has grown from 9.6% of total enrollment in fall 2002 to 32% of total enrollment in fall 2011 (Allen and Seaman, 2013). Students desire more flexibility (Mills and Xu, 2005), particularly non-traditional students (Arbaugh and Duray, 2002) who are expected to make up most of the student population increase by 2020 (Hussar and Bailey, 2011). Online courses provide students with flexibility and better access to courses, which was positively associated with student learning and satisfaction (Arbaugh, 2005; O'Malley and McCraw, 1999). Early studies comparing student learning in face-to-face and online environments favored the latter, but many recent studies show no significant difference between them (Bourne et al., 2005; Chen and Jones, 2007; Hoadley, 2009; Terry et al., 2015).

New delivery technologies and online education pedagogical advancements have been instrumental in improving the quality of online instruction (Mirriahi and Alonzo, 2015). Internet technologies allow hybrid and online courses to offer easy access to a wide array of outside resources such as videos, articles, and links to other materials (Hoadley, 2009; Hanover, 2009).

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Terry et al. (2015) found this was a two-way street; students could record videos, presentations, and team activities and then upload them for the instructor and classmates. Online technologies enable asynchronous discussions and collaborations by graduate students, leading to improved learning and scholarship (Bowden, 2012). Mirriahi and Alonzo (2015) note that expansion of mobile technology use by students continues to create opportunities for additional distribution methods and course customization. This study compared two methods of content distribution.

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 and offered three online courses, including Biorenewable Resources and Technology (BRT) 501 – Fundamentals of Biorenewable Resources and Technology (Raman et al., 2006). BRT 501 was co-taught by faculty from all three institutions. The BRT 501 syllabus described the course as an introduction "to the science and engineering of converting biorenewable resources into bioenergy and biobased products" (Raman, 2010). Course topics covered the entire biorenewables system from biomass production through biomass conversion to products as well as economics. This study took place during 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.

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: (1) video lectures and (2) menu-driven auto-tutorial 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. 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. This study was deemed exempt by the Iowa State University Institutional Review Board for Human Subjects.

The standard for online delivery of BRT 501 content was an asynchronous 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 represented 73% of the world's Internet users. Other media plug-ins with significant market share were Oracle Java (77%), Apple Quicktime Player (61%), and Adobe Shockwave Player (52%). Statowl.com (2010) showed the Adobe Flash plugin on 97% of computers, followed by Oracle Java (79%), Microsoft Windows Media Player (67%), and Apple Quicktime Player (60%). 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.

Participants

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).

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. Ten students were female and 36 were male.

Bohn and Wolfe (1992) found that using ranking was better for non-parametric methods of data analysis than simple random sampling. Thus, 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 randomly assigning students to groups (Horn, 2012). Adjustments to the groupings were made to balance for gender. A Wilcoxon rank-sum test was conducted on midterm 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 and the video voiceover followed the text written for the 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 accessible to students in both groups.

BRT 501, the Course

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, and hay and forages
- Production of woody biomass: coppices and trees
- Transgenic plants

The lectures for each biomass crop included crop history; plant and seed nomenclature; classification; crop composition; biomass production operations; land quality and value; crop rotation; calculating costs of production; and 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. The course was not closed captioned, but if a student with a disability had requested this type of accommodation the university would have provided it.

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; therefore, 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 noted.

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 et al., 2003; Smith, 2007). Raman and Christiansen developed the quizzes for all BRT 501 modules. 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 as many times as desired 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 including 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; University of California at Los Angeles, 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.

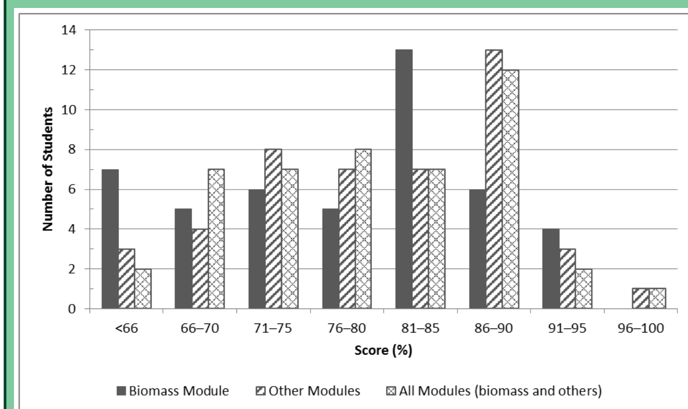
Summary statistics (sample mean, coefficient of variation, median, and range) were computed for the following variables: (a) first-attempt total quiz score on the biomass module, (b) final total quiz score on the biomass module, (c) first-attempt total quiz score on remaining modules, (d) final total quiz score on remaining modules, (e) first-attempt total quiz score on all modules (biomass and others), (f) final attempt total quiz score on all modules (biomass and others), (g) midterm exam score, (h) final exam score, (i) course grade, and (j) final exam score on biomass production module questions. 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 1. Summary statistics for BRT 501 student scores (in points unless noted).

Student Variables	Mean	Mean (%)	Coefficient of Variation (%)	Median	Range		Total Possible
					Minimum	Maximum	
Biomass-module quiz scores							
First-attempt total	395	77.5	14.9	409	230	480	510
Final 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
Final 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
Final 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

Figure 1. Distribution of student total scores for first quiz attempt on the biomass module, remaining modules, and on all modules.



Results and Discussion

Overall Student Performance

Data were broken into ten student variables that <were calculated for all students taking BRT 501 (items a–j as described above). These variables enabled comparisons among teaching modules, delivery technologies, student major, and gender.

Summary statistics calculated for each student variable are summarized in table 1. Figure 1 shows the distribution of student scores for the first-attempt total quiz score on the biomass module. All but one student scored 96% or more for the final total quiz score on the biomass module. Figure 1 also shows the distribution of student scores for the first-attempt total quiz score on remaining modules. For the final total quiz score on remaining modules, 43 of 46 students scored over 96%, two additional students scored over 91%, and one student scored under 80%.

The first-attempt total quiz score on the biomass module was slightly lower than for the remaining course modules (77.5% vs. 80.3%). This trend was reversed for the final quiz score mean, which was slightly 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 led to the relatively lower first-attempt scores. It also indicates that students were motivated to do the work necessary to increase their score and improve their course grade.

Figure 1 shows the distribution of student scores for the first-attempt total quiz score on all modules (biomass and others). Only four students scored less than 96% for the final attempt total quiz score on all modules (biomass and others), three scoring 91% or more and the remaining student scoring over 80%. The median scores for the final total quiz score for the biomass and remaining modules show a majority of students had extremely high scores, 99.2% and 98.0%, respectively.

The midterm exam was taken in week 8, prior to the biomass production module, and the final exam was taken in week 16. Figure 2 shows the midterm and final exam score distributions for students, respectively. 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.

Figure 2. Distribution of student midterm and final exam scores.

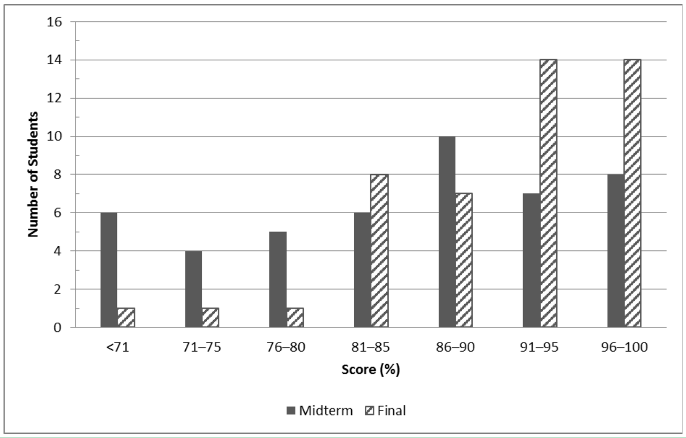
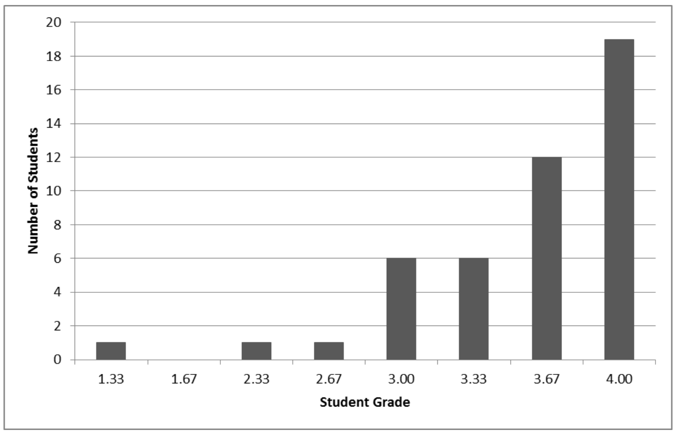


Figure 3. Frequency of course grades earned by BRT 501 students.



The course grade students received was derived from weighted assessment scores on quizzes (15%), project (20%), midterm exam (30%), and final exam (35%) (Raman, 2010). Figure 3 shows the distribution of student grades. The grades were 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. 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.

Pearson product moment correlation coefficients for the project variables are given in table 2. 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. The lack of significant correlation between the first-attempt total quiz score on the biomass module and the midterm exam score, final exam score, and course grade was unexpected since the first-attempt total quiz score on remaining modules was positively correlated with them. This may be because the course focused on science, engineering, and economics up through the midterm exam and the biomass production module covered farming practices.

The first-attempt total quiz score on all modules (biomass and others) was positively correlated with first-attempt total quiz score on the biomass module and 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 them linked.

The final total quiz score on the biomass module was positively correlated with the midterm and final exam scores. The final attempt total quiz score on all modules (biomass and others) was positively correlated with the final total quiz score on the biomass module and the first-attempt and final total quiz score on remaining modules. This was expected since these are the two components that make up the final attempt total quiz score on all modules (biomass and others).

The biomass-module final exam question score total was positively correlated with midterm exam score, final exam score, and course grade, but not with first-attempt or final total quiz score on the biomass module. Student performance on the biomass-module final exam questions indicated they fit well with the rest of material on 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 studied.

Delivery Method

Table 3 provides the mean, coefficient of variation, and the 95% confidence interval for the mean for both delivery methods for each variable. The differences in

Table 2. Correlation coefficients for BRT 501 grade book variables.

Variable	1	2	3	4	5	6	7	8	9	10
Midterm exam score	1.00									
Final exam score	0.76*	1.00								
Course grade	0.72*	0.99*	1.00							
First-attempt total quiz score on the biomass module	0.24	0.25	0.23	1.00						
Final total quiz score on the biomass module	0.32*	0.25	0.24	0.17	1.00					
First-attempt total quiz score on remaining modules	0.33*	0.45*	0.42*	0.60*	0.13	1.00				
Final total quiz score on remaining modules	0.05	0.16	0.16	-0.09	0.10	0.27	1.00			
First-attempt total quiz score on all modules (biomass and others)	0.33*	0.43*	0.41*	0.76*	0.15	0.98*	0.20	1.00		
Final attempt total quiz score on all modules (biomass and others)	0.14	0.22	0.21	-0.04	0.36*	0.29*	0.96*	0.22	1.00	
Biomass-module final exam questions	0.41*	0.44*	0.44*	0.10	-0.02	0.20	0.25	0.19	0.23	1.00

Statistically significant at $p < 0.05$.

summary statistics for some variables were large between the two groups. The removal of a low-scoring 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.

Delivery method t-scores indicate student performance was not significantly impacted by the module delivery method. The reason for this may be that participants were graduate students or undergraduate upper classmen who were high ability students. Similarly, Offir et al. (2008) found that high ability students could overcome the learning environment and be successful.

Table 3. Student performance by delivery method.

Variable	Delivery Method	N	Mean	Coefficient of Variation (%)	95% Confidence Level Mean
First-attempt total quiz score on the biomass module	Video	23	392	14.7	368–418
	MDAP	23	398	15.3	372–424
Final total quiz score on the biomass module	Video	23	503	5.0	492–514
	MDAP	23	509	1.0	506–511
First-attempt total quiz score on remaining modules	Video	23	1,526	12.1	1,446–1,606
	MDAP	23	1,521	13.6	1,432–1,611
Final total quiz score on remaining modules	Video	23	1,830	4.7	1,793–1,868
	MDAP	23	1,855	0.8	1,848–1,861
First-attempt total quiz score on all modules (biomass and others)	Video	23	1,919	11.6	1,822–2,015
	MDAP	23	1,920	12.9	1,812–2,027
Final attempt total quiz score on all modules (biomass and others)	Video	23	2,333	3.9	2,294–2,373
	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 question score	Video	23	29.4	7.8	28.4–30.3
	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 auto-tutorial presentations delivered via Flash.

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 4. The t-scores for performance on assessments and course grade showed no significant difference between students with an agricultural major and students with a non-agricultural major, most of who were engineering students.

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.

Table 4. Performance of agricultural and non-agricultural students.

Variable	Student Major	N	Mean	Coefficient of Variation (%)	95% Confidence Level Mean
First-attempt total quiz score on the biomass module	Agricultural	19	384	14.8	353–415
	Non-agricultural	25	403	15.8	380–426
Final total quiz score on the biomass module	Agricultural	19	503	5.5	489–516
	Non-agricultural	25	508	1.3	505–510
First-attempt total quiz score on remaining modules	Agricultural	19	1,510	12.6	1,418–1,602
	Non-agricultural	25	1,538	13.2	1,454–1,622
Final total quiz score on remaining modules	Agricultural	19	1,844	2.1	1,826–1,863
	Non-agricultural	25	1,841	4.2	1,808–1,873
First-attempt total quiz score on all modules (biomass and others)	Agricultural	19	1,895	12.1	1,784–2,006
	Non-agricultural	25	1,941	12.6	1,840–2,042
Final attempt total quiz score on all modules (biomass and others)	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

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 5. Female students scored comparably to male students, which agrees with Marks et al. (2005), who found that gender was not related to learning performance.

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 5. Student performance by gender.

Variable	Gender	N	Mean	Coefficient of Variation (%)	95% Confidence Level Mean
First-attempt total quiz score on the biomass module	Female	10	365	16.5	322–408
	Male	36	403	13.9	385–423
Final total quiz score on the biomass module	Female	10	507	1.3	502–512
	Male	36	505	4.0	498–512
First-attempt total quiz score on remaining modules	Female	10	1,521	11.5	1,397–1,646
	Male	36	1,524	13.2	1,456–1,592
Final total quiz score on remaining modules	Female	10	1,850	1.6	1,828–1,872
	Male	36	1,840	3.7	1,817–1,864
First-attempt total quiz score on all modules (biomass and others)	Female	10	1,886	10.9	1,739–2,034
	Male	36	1,928	12.6	1,846–2,010
Final attempt total quiz score on all modules (biomass and others)	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

Summary

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. Student performance was not significantly impacted by module delivery method. Students with agricultural majors performed similar to students with non-agricultural majors, most of whom were engineering students. Female and male student scores showed no significant difference in assessment scores or course grade.

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.

Recommendations for Future Research

The VEC institutions are in a unique position to explore the value of institutional linkages already in place and develop linkages with new institutions, measuring the impact of cooperative programming delivery on student learning and educational cost management. The identification and creation of models that relate how to effectively develop successful joint educational efforts could help higher education better serve students.

Undergraduate students and students from multiple disciplines and institutions could also be studied. The inclusion of these additional categories of data could reveal the effects of different institutions, graduate and undergraduate, and between disciplines, making the results applicable to a more general population.

An experiment that offers BRT 501 online, similar to the Introduction to Artificial Intelligence MOOC at Stanford University (DeSantis, 2012), could explain 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 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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