Student Perspectives on a New Online Biomass Production Module for Fundamentals of Biorenewable Resources and Technology[1]

Darren H. Jarboe[2], D. Raj Raman[3], Thomas J. Brumm[4] and Robert A. Martin[5]
Iowa State University
Ames, IA

Scott McLeod[6]
Prairie Lakes Area Education Agency
Pocahontas, IA

Abstract

In 2007, a Virtual Education Center for Biorenewable Resources was initiated that offered three online courses, one being Biorenewable Resources and Technology (BRT) 501 – Fundamentals of BRT. The objective was to assess student perceptions on two delivery methods, 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 non-farm students closer to the knowledge level of farm students 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 scholarship GPA minimums and employer interview requirements as well as higher GPA leading to better jobs with higher incomes may influence student interest in connectedness to the instructor.

Introduction

Online delivery continues to penetrate higher education, which is demonstrated by students taking at least one online course growing from 19.6% in 2006 to 32.0% in 2011 (Allen and Seaman, 2013). As online education has become a mainstream method of delivery, students expect a good experience, similar to or better than in the classroom. Technology has driven improvements in the online course experience, which is beneficial to students (Palmer et al., 2014). The use of technology has the potential to narrow the transactional distance (space and/or time) that Moore (1997) considered important in the teacher-learner relationship. Learner-instructor interactions were significant for higher perceived learning (Arbaugh and Benbunan-Fich, 2007; Marks et al., 2005). Lee and Rha (2009) found that student-student and student-instructor dialogue, verbally or electronically, led to significantly higher student achievement for critical thinking learning. Thus, increasing opportunities for student-instructor and student-student interactions with technology may improve student experience and increase retention in online courses.

Instructional technology also needs to be accessible and seen as improving the learning experience. Howland and Moore (2002) found that students lacking computer technical experience had difficulties in their online course while proficient students did not; therefore, students must be comfortable and proficient with technology for a good learning experience. Universities and colleges provide technical support for students to

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[2]Program Manager, Center for Crops Utilization Research and BioCentury Research Farm, 1041 Food Sciences Bldg., Ames, IA 50011; (515)294-2342; jarboe@iastate.edu. (Corresponding author)

[3]Professor and Associate Chair for Teaching, Department of Agricultural and Biosystems Engineering; 3356 Elings Hall, Ames, IA 50011; (515)294-0465; rajraman@iastate.edu.

[4]Associate Professor, Department of Agricultural and Biosystems Engineering; Professor-in-Charge, Engineering-LAS Online Learning; and Director of Assessment, College of Engineering; 4335 Elings Hall, Ames, IA 50011; (515)294-5145; tbrumm@iastate.edu.

[5]Professor, Department of Agricultural Education and Studies, 201 Curtiss Hall, Ames, IA 50011; (515)294-0896; drmartin@iastate.edu.

[6]Founding Director of the UCEA Center for the Advanced Study of Technology Leadership in Education (CASTLE); and Director of Innovation, Prairie Lakes Area Education Agency 8, 500 NE 6th St., Pocahontas, IA 50574; (707)722-7853; dr.scott.mcleod@gmail.com.

assist them with the use of online education technology, which has been found to be very important for student success in online courses (Herrington et al., 2006, Lee et al., 2011). Ross et al. (2003) found their students thought the addition of video was more effective than using only books (90%) and the video of relevant subject matter was entertaining and enjoyable to watch. Thus, technology has the potential to provide students with a high quality learning experience.

In 2007, a Virtual Education Center (VEC) for Biorenewable Resources was initiated (Raman et al., 2006). The Center offered three courses through online distance education, including Biorenewable Resources and Technology (BRT) 501 – Fundamentals of Biorenewable Resources and Technology. 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 preparation and conversion 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 video lectures with a tablet computer and pen to annotate, draw, and make calculations onscreen. The selection of a viable alternative technology for the online delivery method was necessary. Flash player was selected as the alternative delivery method due to its widespread availability on multiple computer operating systems (Millward Brown, 2009; Statowl.com, 2010).

This study sought to better understand the student learning experience in BRT 501. Students were surveyed about their experience in the 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 Figure 1), and (2) determine if alternative delivery method modifications to BRT 501 would improve the student learning experience.

Materials and Methods

This study was deemed exempt by the Iowa State University Institutional Review Board for Human Subjects (Iowa State University, 2010). The lead instructor made an announcement about the research project in the class period prior to the start of the biomass production module. 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. 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.

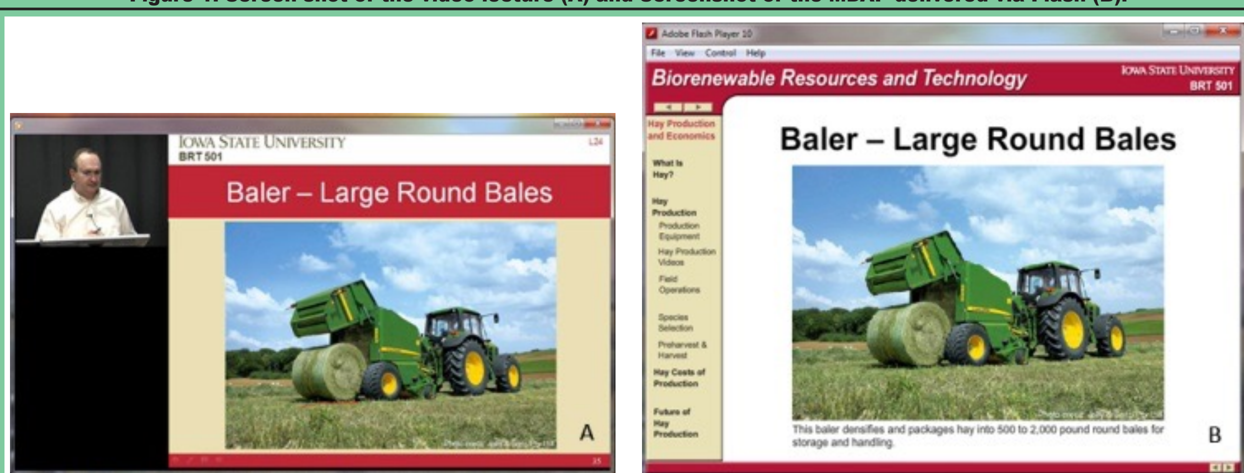
Participants

The Iowa State BRT 501 course had 51 students enrolled for spring semester 2010, 44 on-campus and seven at a distance. Four students, three on-campus and one at a distance, 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 to date (i.e., upon homework, quiz, and exam scores). Students were subsequently split into two groups based on a serpentine selection through their rankings. Specifically, Group 1 students ranked 1, 4, 5, 8… and Group 2 students ranked 2, 3, 6, 7… 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 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 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,

Figure 1. Screen shot of the video lecture (A) and Screenshot of the MDAP delivered via Flash (B).



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 midterm exams for the two groups were compared using a t-test and there was no significant difference (p < 0.81).

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. 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.

Data Collection and Analysis

The survey instrument had 37 questions to gather information on demographics, online course and computer experience, module content and delivery, self-reported student learning, communication, and production agriculture experience. The survey variables for the study were: (a) module – best and worst, (b) biomass production knowledge before module, (c) biomass production knowledge after module, (d) biomass production video usefulness, (e) classmate interaction, (f) online and classroom module comparison, (g) quiz comparison for different modules, (h) computer proficiency impact on learning, (i) current major, (j) degree pursued, (k) employment status, (l) farm background and participation, (m) gender, (n) instructor visible on screen, (o) instructor availability, (p) internet proficiency, (q) non-traditional student, (r) educational experience overall, (s) quizzes reflected material, (t) self-assessed learning, (u) software proficiency: design, (v) software proficiency: internet, (w) software proficiency: productivity, (x) student able to learn independently, (y) study time, and (z) online class enrollment 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 following scale for interpretation of the Pearson's product moment correlation coefficient values: very low (r = 0.00–0.19), low (r = 0.20–0.39), modest (r = 0.40–0.69), high (r = 0.70–0.89), and very high (r = 0.90–1.00). This scale was used to evaluate the significant correlations identified.

The categories used for t-test analysis of the survey data were: (a) delivery method: video or MDAP, (b) computer software proficiency, (c) student: domestic or international, (d) instructor visible onscreen was important or not, (e) student: at distance or on-campus, (f) peer to peer interaction, (g) online course taken previously or not, (h) online class enrollment in the future or not, (i) student had farm background or not, and (j) classroom or online course better for learning.

Results and Discussion

Twenty of the 46 students enrolled in BRT 501 completed the 37-question survey. 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 were male; 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; 30% were international students. Nearly all participants were graduate students, 15 M.S. and four Ph.D. (one student did not respond) with 75% engineering and 25% other science majors such as agronomy or horticulture. Tables 1 and 2 show the student demographics broken out by delivery method.

Delivery Methods

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 (Arbaugh and Benbunan-Fich, 2007; Bernard et al., 2004). One currency for students is money; another is their course grade, which students expect to translate into money in the future (Siebert et al., 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 et al., 1989; Preston et al., 1990). Students read market signals such as scholarships that require a minimum GPA (Iowa

Table 1. 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 2. 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[a]	Employed Full-time[b]	Taken Online Course Previously[c]	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

[a]Non-traditional students were students greater than 30 years old.

[b]All students employed were employed full-time and were only part-time students. The rest were full-time students.

[c]All the part-time students who were employed full-time had taken an online course previously.

MDAP: Menu-driven autotutorial presentations delivered via Flash.

State University, 2012; University of Illinois, 2012) or employers setting GPA standards that must be met to be considered for a job interview (Gaul, personal communication). 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.

Students liked the convenience and accessibility offered by an online course, with one student stating it was their only option to pursue a M.S. engineering degree. This agrees with the findings of Arbaugh (2005) and Harlen and Doubler (2004).

The correlations for the survey variables significant at $p < 0.05$ are discussed below and were evaluated using Cohen and Holliday's (1982) scale described above in Data Collection and Analysis. Biomass production knowledge before accessing the biomass production module was highly positively correlated with biomass production knowledge after the module ($r = 0.72$). 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 nonfarm 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).

Participation in the farming operation by students with a farm background was very highly negatively correlated to self-assessed learning ($r = -0.94$) and students' self-assessed ability to learn independently ($r = -0.99$). The latter was surprising because farmers are generally considered self-starters and independent. Since these students knew much of the material presented, they may have felt learning did not take place and thus, they did not explore their ability to learn independently. The mean for self-assessed learning for farm students and nonfarm 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.

Comparisons between Groups

Students were grouped using these characteristics and t-scores were calculated for categories shown in *Data Collection and Analysis* above. The results of the calculations are presented in table 3.

Domestic and international students differed significantly on internet proficiency. All students considered themselves proficient with use of the internet ($p = 0.03$). Domestic students considered themselves very good (4.7/5.0) using the internet while international students considered themselves good (4.0/5.0). Song (2005) suggested this may reflect that more domestic students have internet access at home or that their access is higher speed.

Student responses about knowledge before and after the biomass production module were collected. Students who grew up on a farm reported their self-assessed biomass production knowledge before ($p = 0.01$) and after ($p = 0.04$) completing the biomass production module as significantly higher than students who did not grow up on a farm. Students without a farm background showed a significant increase in self-assessed biomass production knowledge ($p = 0.01$), whereas students with a farm background did not ($p = 0.37$). There was a significant increase in self-assessed biomass production knowledge for all BRT 501 students ($p = 0.01$) since 75% of the class did not have 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. The self-assessment finding is supported by student scores on the biomass production quizzes (mean = 99%) and final exam questions (mean = 96%) for the BRT 501 course (Jarboe et al., 2012).

Splitting students into those who thought they would have learned more in a traditional classroom setting (classroom group) and those who did not (no preference group), there were significant differences in the perceived ability of students to learn independently ($p = 0.01$), the biomass quizzes represented the lecture/presentation material ($p = 0.02$), and self-assessed learning ($p = 0.05$). The classroom group also considered their ability to learn independently as acceptable to good (3.4/5.0), whereas the no preference group thought their ability to learn independently was good to very good (4.3/5.0). Both groups thought the biomass quizzes reflected the lecture/presentation material at least reasonably well (classroom = 3.4/5.0 and no preference = 4.2/5.0), although the no preference group more so. For self-assessed learning, the classroom group considered their learning to be low to average (2.7/5.0), while the no preference group felt their learning was average to good (3.5/5.0).

Institutions of higher learning are expanding distance and online education offerings (Allen and Seaman, 2013) and video lectures are a viable teaching method

Table 3. Summary statistics for Biorenewable Resources and Technology 501 students participating in the 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
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
Would have learned more in classroom or online	17	2.88	0.70	2	4
Overall educational experience for biomass module	20	3.35	0.81	2	5

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 a bond with students are a viable option (Offir et al., 2008; Mills and Xu, 2005; Reisetter and Boris, 2004). 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 enhancing student learning through group work, hands-on laboratories, class discussions, student presentations, and other methods, time in which students could create their own learning under facilitation of the instructor. Flash delivery technology may have a role in the development of animations, examples, and other visual tools. This type of instruction also has the potential to strengthen the network students gain by being on campus and creates an opportunity for universities to remain relevant.

The *Introduction to Artificial Intelligence* online course offered in fall 2011 by Dr. Sebastian Thrun, Stanford University and Dr. Peter Norvig, Google, used YouTube for distribution (Thrun and Norvig, 2012a) and was an extension of their classroom course. The online course attracted 160,000 students with over 23,000 students completing the course requirements, a 14% retention rate (DeSantis, 2012). Thrun and Norvig did offer support mechanisms to students such as an online community and video office hours, which are potential methods that could create connectedness in BRT 501, particularly for 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 (Lee and Rha, 2009; Thrun and Norvig, 2012b). It could also provide the instructor with material to discuss during a weekly video. These additions to BRT 501 would likely enhance student learning.

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 the prospect that students could graduate in three years, especially through coordination and cooperation with high schools using advanced placement classes and other methods of credit acquisition. 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. As noted earlier, online education was the only option for one of our students to pursue a M.S. degree in engineering. Online education can help students gain the competencies employers desire and offer people 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 et al., 2011). Developing nations also have limited broadband infrastructure except in major metropolitan areas (Al-Ghazawy, 2009; Kim et al., 2010). Courses using either video lecture or MDAP could be loaded onto DVDs 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.

Summary

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). The MDAP used for this study was less personal due to the lack of an 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.

The study could have been improved by securing additional participants from other VEC graduate level courses. 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 students, and between disciplines, making the results applicable to a more general population.

Recommendations for Future Research

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 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 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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