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Editors

Towards an Innovative Web-based Lab Delivery System for a Management Information Systems Course

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Abstract

While online systems are an essential component of distance learning, they can also play a critical role in improving the delivery of activities in a traditional laboratory setting. The quality and effectiveness of online course delivery is often compared to equivalent face-to-face alternatives. In our approach, we have harnessed what we feel to be the best of both delivery methods. We have developed a web-based system with some novel characteristics for use in a face-to-face laboratory-based Management Information Systems course. To assess its impact, we surveyed 110 students where approximately half completed the lab using our web-based system while the other half completed a paper-based equivalent. The promising results have encouraged us to develop further experiments to measure student performance as well as the impact of video versus text in presenting activity instructions.

Keywords: web-based labs, management information systems, automated feedback, laboratory-based learning, blended learning

1. INTRODUCTION

Is the quality of delivering online course material equivalent to face-to-face alternatives? This is a persistent question in the field of instructional technology. Many studies show no differences between online and face-to-face course delivery. Disadvantages often cited for online delivery include lack of face-to-face interaction with instructors and social isolation (van Schaik, *et al*, 2003). Other studies have shown evidence of online delivery offering superior quality instruction when compared to face-to-face alternatives. Studies have demonstrated that online course delivery has been shown to keep students more engaged and even entertained, which often translates into a richer learning experience (Elsenhiemer, 2003).

The driving force behind many online delivery systems is shifting the control of learning from the teacher to the student (Junaidu, 2004). Online course delivery also provides opportunities for a more robust process of knowledge transfer, the process of synthesizing classroom theory into practical real life work

situations (Hansen, 2008). Practical application of topics taught is an overarching theme of our labs.

In our study, we propose a blended model of instructional delivery that maintains the focus on knowledge transfer and practical application for our students. We harness the benefits of online delivery systems, providing an entertaining and engaging environment that is conducive for knowledge transfer while also providing a social, face-to-face learning environment. We believe that this blended model combines the "best of both worlds," where students can work at their own pace, with automated, instant feedback and the opportunity to obtain guidance from an instructor.

Our goal is to improve students' learning experience by moving away from paper-based lab worksheets to a new web-based lab delivery system. Our previous system had detailed instructions but it was easy to inadvertently skip steps. Grading paper lab worksheets was very time consuming, and we suspect that sometimes students rush through the labs but were not learning key concepts. We seek to improve their lab experience by making the labs more interesting, reinforcing concepts as needed, while implementing a system for recording students' responses, reactions, and other feedback as a way to assess their progress. This allows us to focus on what skills or concepts the students need to learn, and improve our capacity for collaboratively developing and testing lab materials.

Our institution, course, and lab: We are a liberal arts college of approximately 3000 students with an AACSB accredited School of Business. Our Management Information Systems (MIS) course, a required core business course, is taught within the Computer Science department, which offers a BS in Computer Science and a minor in Information Systems. MIS is an introductory level course that requires students to have spreadsheet proficiency. The course consists of two hours of lecture and two hours of lab each week. Labs sections are restricted to a maximum of 16 seats where students typically work in pairs at a computer with dual monitors.

2. EVOLUTION OF OUR LABS

Before developing our web-based lab delivery system, we implemented a collaborative approach to scaling our MIS course to many sections (Breimer, *et al*, 2009). The material presented in labs is the driving force for integrating content and experience for the course. We created a shared repository of lab and lecture materials in Blackboard that fosters collaboration among faculty teaching the course. A faculty member can contribute new lab ideas and corrections using an editing review system, where at least two other faculty members must review the suggested changes and perform the lab in entirety to ensure continuity and cohesiveness.

Our labs have a "triad" structure that incorporates (i) theory from the textbook or lectures and (ii) practical case studies with (iii) information technology, such as Excel, Access, Geographic Information Systems, and Radio Frequency ID readers. Most labs have pre-lab reading assignments and an online quiz to introduce the lab. The in-lab experience is fast paced, where students are paired in teams to use technology and learn basic concepts to solve problems and to work through examples. Lastly, students individually complete a post-lab assignment to synthesize material and to reflect on the lessons learned in the lab.

The single printed lab handout: The original labs we developed consisted of a single lab handout, a Microsoft Word document. The lab handout included introductory text, activity instructions, and questions appropriately embedded within the instructions. Many of the questions would ask about the output of an activity to help verify that students were properly completing each task. These questions might ask about the result of a database query or a spreadsheet function. Some questions required students to either show the instructor the output of key tasks (task checks) or to print and attach the output (deliverables). Towards the end of the lab, a few questions were designed to assess student learning. For example, we might ask about the purpose of a query or function, or we might ask the student to explain how the activity they just completed demonstrated a concept from the readings.

40,000 pages per semester: Our printed lab handouts were lengthy documents ranging from 20-35 pages. We wanted the activity instructions to be easy to read, so we were generous with font size, line spacing and logical pagination. The length of the handouts became problematic. With approximately 200 students each semester, the course was taxing the print shop with over 4000 pages per week. In addition, the instructors found it to be mechanically burdensome to page-through a 30-

page handout to find the answers to 20 questions.

Electronic instructions: To solve printing and grading problems, we removed the answer areas from the lab instructions and instead directed students to write their answers on a printed worksheet. Rather than print the lab instructions, students download and view the instructions electronically. Our computer labs have dual-monitor desktops, which enabled students to view the lab instructions on one display while performing tasks on the other display. The worksheets, which are the only documents printed, typically range from 3-6 pages and include only the questions and space for answers. This approach significantly reduced the amount of paper we used and created a concise worksheet, which was easier to grade.

Too many sources: While separating the lab handout into two documents (online instructions and printed worksheet) solved printing and grading problems, it may have come at a cost for students. In lab, instructors noticed that students struggled to find their place in the lab instructions. The labs now required students to manage three different sources of information. Students had to read the instructions (one source) and then switch to using an application (second source) to help answer questions on a worksheet (third source). Rather than return to the instructions, some students would continue on the printed worksheet and try to answer the next question without realizing that the instructions were necessary to help answer the next question. In returning to read the instructions, students would often lose their place. In some cases, students would start the same task again, not realizing that they had already completed the task; or even skip steps and fail to realize it until they hit a serious roadblock.

One source - web-based labs: We have long realized that the solution to our problem is to have entirely web-based labs where students submit their answers electronically within the online instructions. This has a number of advantages. First, it allows us to avoid paper documents entirely. Second, it allows close-ended or multiple choice questions to be graded automatically, which gives us the option to give students immediate feedback. Third, open-ended questions can be more easily graded in a batch format where the instructor can view all student answers to a particular question rather than all the answers for a particular

student. Finally and perhaps most importantly, students do not have to switch from electronic instructions to paper worksheets, since questions will be embedded within the web-based instructions.

Solution is not obvious: We have considered using a number of different systems to support entirely web-based labs including the test management systems provided by Blackboard and Moodle (http://moodle.org). However, the systems that are readily available are missing key features and functionality that are important to our lab environment. Thus, we have been reluctant to invest the time to migrate our existing lab content into a system that may be inflexible, proprietary, or requires additional system administration. An ideal system would allow us to accomplish much of the migration process by simply saving our existing labs (Microsoft Word documents) into robustly formatted web pages (HTML documents) with the following features:

A. Question Embedding: A web-based lab system should allow questions to be embedded anywhere in a document. Many online testing systems are question-centered where only a single editable content area is provided for each question. Question-centered systems often prevent content from being placed both before and after each question on a single page. Our lab content includes formatted text, images, and will soon include embedded video/animation. A key requirement is the ability to place reinforcing content immediately before and after questions on a single web page.

B. Robust Pagination: A web-based system should allow a single page to contain two or more questions and allow two or more pages to be displayed in sequence without requiring a question on each page. Many question-centered systems present the entire test or assessment as a single web page or they require each question to be on a separate web page. These systems lack the flexibility to create documents with logical pagination. Unlike paper-based labs, which have fixed page size, web-based labs can have pages with variable page height, which enables documents to be broken into pages as needed by specific content requirements. Typically, systems that are question-based force the break at each question, which is very inflexible.

C. Inline Feedback: After a question is answered, a system should allow feedback to be dynamically inserted near the question. Inline

feedback should become part of the lab content after the question is answered. Many systems display feedback in a dialog box, which disconnects the feedback from the flow of the lab. Worse yet, feedback is lost once the dialog box is closed. Students should be able to return to previous pages and see the embedded questions, their answers, and the positive or negative feedback.

D. Temporal Tracking: A system should record a time stamp when a student views a new page or answers a question. Question-centered systems often only track students' progress from question to question. However, each page of a lab can be designed to represent a discrete task or activity. By tracking the time stamp of page views instructors can better understand how long it takes to complete activities, and make adjustments as needed.

3. OUR WEB-BASED FRAMEWORK

To implement the four features described in the previous section we use a very straightforward approach with a single HTML document. A single document approach greatly facilitates lab authoring and migration from our existing sources. Our paper-based labs were authored in Microsoft Word, and we can easily convert our existing formatted content by saving our documents as web pages. While Microsoft Word does not create the most elegant web pages, the result is quite usable.

The single document approach has two key advantages. First, the entire lab is portable and can be opened in an HTML editor such as Adobe's Dreamweaver or KompoZer (an open-source project) enabling robust editing and searching of the entire lab activity. In question-centered systems where the content is divided across numerous independent content areas for each question, searching for content across the entire lab or editing across different sections can be tedious and problematic. Second, after the single document is downloaded by the web browser, students can answer questions and navigate to pages without pages needing to be reloaded. We use JavaScript and simple tags to render the single document into pages. Upon loading, the first page is displayed along with navigation buttons to move to the next and previous page as well as a list so users can jump to a specific page number. Since the entire document is already loaded, navigating through the pages occurs instantaneously without the need to download content again from the server.

Rather than create an entire web application from scratch, we use PHP and JavaScript to enhance a basic HTML document. To transform a web page into an interactive lab, you simply insert two PHP function calls inside the <head> of the document (see Figure 1). For those not familiar with PHP and other web scripting languages, a PHP-enabled web server will execute the code inside of the PHP delimiters (<? and ?>) and return the output (result) rather than the code itself.

```
<html>
<head>
<? include("functions.php");
   create_lab("Lab Name or ID"); ?>
</head>

<body>

<h1>Lab Title</h1>

<p>Lab content formatted with
HTML</p>

</body>
</html>
```

Figure 1: Including the necessary code

For the code in Figure 1, the *include* and *create_lab* functions inserts all the necessary JavaScript code in order to embed interactive questions, add page breaks and dynamically generate the page navigation.

The web page must be hosted on a web server that supports the PHP scripting language. While the web server should also support a database system such as MySQL, our system can be easily adapted to use flat files to store the data.

Question Embedding: To embed a question, we implemented a set of PHP functions that insert the appropriate HTML and JavaScript code. Figure 2 shows the function declaration for creating a multiple-choice question. The function allows an author to specify the text of the question followed by an ordered list of possible choices as well as a number indicating which item in the list is the correct answer. Optionally, the author can specify feedback text to display if the answer is correct or incorrect.

```
string multiple_choice(
  string question,
  array choices, int correct_choice
  [, string correct_feedback
  [, string incorrect_feedback]] );
```

**Figure 2: PHP function declaration for multiple-choice question**

```
<? multiple_choice(
"Which day has the most employees?",
array("Mon","Wed","Thurs","Sat"), 4,
"Correct, Saturday has the most",
"Incorrect, are you using the proper
table?" ); ?>
```

Figure 3: PHP function call for creating a multiple-choice question.

Figure 3 shows a sample function call to embed a typical multiple-choice answer with both positive and negative feedback. Authors familiar with HTML code need only learn the parameters of the PHP functions to add interactive questions to existing HTML documents. For simplicity, we only show multiple-choice questions in our first web-based lab, but we have implemented functions to support a number of different question formats.

When the web browser requests the document, the PHP functions automatically generate and label the questions with sequential numbers. Questions can be removed, added, and re-ordered without the author needing to re-number questions. Figure 4 shows a basic web page with an embedded multiple-choice question at the bottom.

Inline Feedback: When a question is answered, the JavaScript code disables the submit button and optionally displays the feedback in a dynamic area next to the question. Different types of questions can be implemented to allow for multiple responses and multiple levels of feedback. The key feature is that the feedback is displayed inline with the question. The jQuery library (McCormick & De Volder, 2004) is used to animate the feedback display. In our implementation, the feedback text fades-in as the submit button disables (see Figure 5).
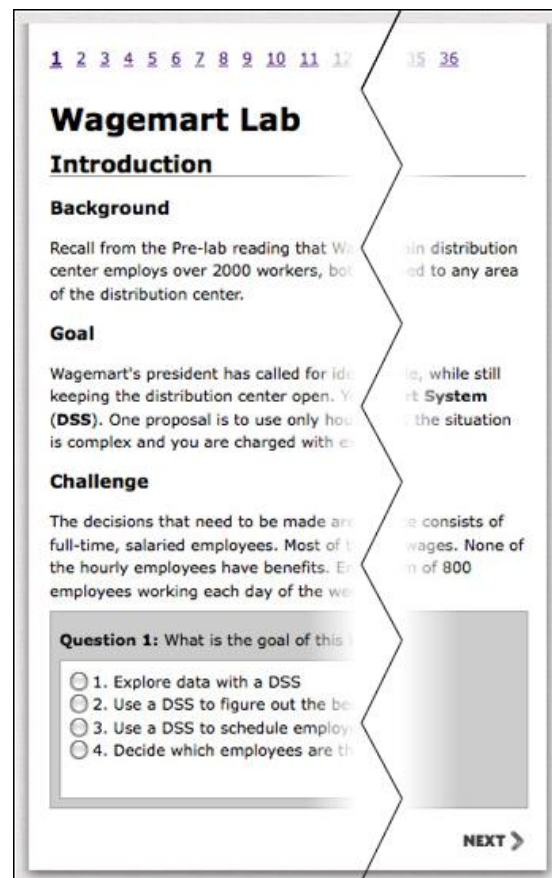
Figure 4: Example page with embedded multiple-choice question
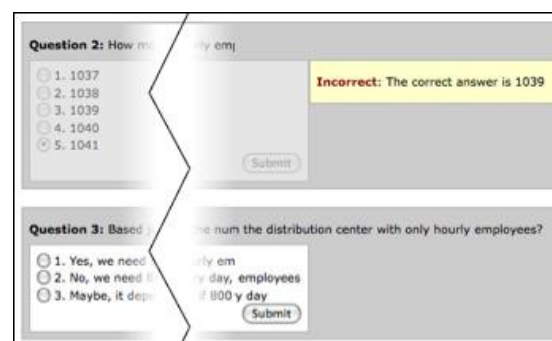
Figure 5: Answered question with inline feedback and un-answered question.

Page Navigation: In standard HTML, the *body* tag indicates the start and end of the displayed page. However, a single HTML document can be broken into logical divisions where Cascading Style Sheets (CSS) and Document Object Model (DOM) scripting can be used to display each

division as a page. Figure 6 shows our approach to breaking a single document into multiple pages.

```
<body>

<? startNavigation(); ?>

<h3>First Page</h3>
<p>HTML formatted content</p>

<? pageBreak(); ?>

<h3>Another Page</h3>
<p>More content</p>

<? pageBreak(); ?>

<h3>Last Page</h3>
<p>More content</p>

<? endNavigation(); ?>

</body>
```

Figure 6: Breaking a single document into multiple pages

The *startNavigation*, *endNavigation*, and *pageBreak* functions insert appropriate HTML tags that encapsulate each logical page into structural divisions that can be controlled by the inserted JavaScript functions in the *head* of the document.

We use JavaScript to count the number of pages/divisions and then dynamically generate navigation that allows the user to move from page to page. Figure 4 shows the page number navigation at the top and the "Next" button located at the bottom of the page.

In our particular implementation, we arrange each page horizontally but hide all the pages except the one being currently viewed. The navigation triggers JavaScript functions that slide the pages left and right appropriately. The left and right sliding is designed to give the user a visual cue that they have moved to a new page. Moving right will bring users to the next page, while moving left will bring them to the previous page. Because the pages have variable height, the user must often scroll up or down to view the content of a particular page. Thus, we did not want to use sliding up or down as a metaphor for moving to a new page as it can be easily confused with typical page scrolling.

Temporal Tracking & Submission: The JavaScript code uses the AJAX web development framework (Garrett, 2005) to asynchronously transmit the user's response to any server where the student responses can be recorded in a database or log file. Each response includes the question number, the local time stamp, whether or not the submitted answer was correct, and the user's name or ID. The time stamp is generated using the JavaScript *Date* and *getTime* functionality. Since question submission does not require a synchronous server response, the time stamp reflects the instantaneous local time without any delay from network lag or server load. Our system also has the ability to transmit a time stamp each time a user clicks a navigation link. The page number and the time stamp can be used to better understand how long it takes to complete the activity described on each page. Thus, the pagination can be adjusted to reflect discrete tasks or activities that the instructor would like timed.

Our PHP submission script can be configured to work with an independent login or authentication system. The submission script will only store the user's response if the user's browser transmits a cookie- or URL-stored session ID that matches the server-side session ID established by the login or authentication script. While we've implemented our own email-verified registration and login system, a number of existing frameworks can be used to implement authentication. If an instructor does not wish to record student responses, the lab can act as a stand-alone interactive activity with dynamic feedback that does not record student IDs or responses.

4. PROTOTYPE TEST AND STUDENT IMPRESSION SURVEY

Overview: To test our system, we converted one of our existing labs into the web-based format by saving the Word Document as a web page and inserting all the appropriate tags to embed 40 questions. This particular lab requires students to create and execute a series of Microsoft Access queries that act as a simple decision support system (DSS) to help a fictional company cut labor costs. The lab is designed to help develop student database skills such as creating select, action and summary queries, as well as joining tables and creating calculated fields. The lab covers the concepts of decision structure, scenario and data modeling, and decision optimization.

We administered the paper-based lab in four sections (52 students) and the web-based lab in four different sections (58 students). Immediately after the lab session, we surveyed all 110 students in the 8 lab sections to assess their impression of the lab they just completed.

Five different instructors taught the eight lab sections. Three instructors each taught two labs and these instructors administered the web-based lab to one of their sections and the paper-based lab to their other section. Two instructors each teach one lab and one of these instructors administered the web-based lab while the other administered the paper-based lab.

Q1.	How long did it take you to do this In Lab work? Rate 1 (very short) to 10 (very long)
Q2.	How difficult did you find the work for this Lab? Rate 1 (very easy) to 10 (very hard)
Q3.	How would you rate the level of feedback you received in lab? Rate 1 (no value) to 10 (great value)
Q4.	How easy was it to keep your place and follow Lab procedures using this lab format? Rate 1 (very easy) to 10 (very hard)
Q5.	How much did this Lab help you understand what is being studied in this course? Rate 1 (very little) to 10 (very much)
Q6.	How did the lab format affect how easy it was to keep your place and follow the lab procedures? Rate 1 (very easy) to 10 (very hard)
Q7.	How much did you enjoy the activities in this Lab? Rate 1 (very little) to 10 (very much)

Table 1: Survey Questions

The Results: Table 1 shows the exact wording of each question. Table 2 shows the mean and standard deviation for students who completed the paper-based lab and web-based lab. Table 3 shows the probability of the null hypothesis of no difference between the groups for the t-test (T) and the Mann-Whitney test (U). Although

many researchers use the t-test for Likert scale data if the sample sizes are large enough (over 30 or so), the Mann-Whitney statistic is designed for ordinal (ranked) data to compare unpaired groups (Motulsky, 1995). Statistically significant differences between the two datasets correspond to T and U values below 0.05.

The data indicates a very slight but insignificant favoring of the web-based lab with respect to both perceived length of the lab (Q1) and the value of the feedback (Q3). There was no meaningful difference in perceived difficulty (Q2). Interestingly, students did not think that the web-based lab made it easier to keep their place and follow the lab procedures (Q4). However, the difference in question 4 was not significant and a similarly worded question (Q6) showed the opposite where the web-based lab was easier to follow.

Question 5 was indicated as being significant by t-test but not by the Mann-Whitney test, indicating mild favoring of the web-based lab for helping students understand the course material, but this concept should be investigated further. Question 7 definitely indicates a statistically significant difference favoring the assertion that students found the web-based lab to be more enjoyable than the paper-based lab (Q7).

	Paper-Based Mean (STD) n = 52	Web-Based Mean (STD) n = 58
Q1.	7.92 (1.92)	7.31 (1.85)
Q2.	7.40 (1.90)	7.10 (1.86)
Q3.	6.69 (2.37)	7.35 (2.10)
Q4.	5.90 (2.61)	6.45 (2.45)
Q5.	5.65 (2.69)	6.62 (2.14)
Q6.	6.08 (2.27)	5.81 (2.35)
Q7.	4.56 (2.63)	5.72 (2.44)

Table 2: Means and standard deviations

	T	U
Q1.	0.091	0.069
Q2.	0.400	0.386
Q3.	0.130	0.157
Q4.	0.260	0.239
Q5.	0.039	0.070
Q6.	0.550	0.678
Q7.	0.018	0.022

Table 3: Statistical differences

Analysis: The paper-based lab format provided no built-in feedback at all, so it is surprising that there is no significant difference in students' perception of the value of the feedback (Q3). However, the paper-based format may in fact encourage students to check with the instructor for clarification and assurances. Students who completed the paper-based lab may have considered their interaction with the instructor when evaluating the level of feedback. Also, students who completed the web-based lab may have interacted less with the instructor than they normally do and this lack of instructor feedback could impact the perceived quality of the overall feedback received.

Prior to the experiment, students had already experienced six paper-based labs and had become quite accustomed to the format. Students who experienced the web-based lab for the first time may have lost their place because of the abrupt change in lab format, not necessarily because the web-based format was more disorienting. In the future, we are going to consider conducting similar experiments earlier in the semester before students become accustomed to the paper-based lab format.

The increased enjoyment (Q7) that students experienced with the web-based lab was statistically significant with a $P=0.018$ and $U=0.022$. Based on in-lab observations, the anticipation of immediate feedback certainly had a positive impact on students. Students received immediate assurances about whether the task they completed was correct or incorrect. In the paper-based lab, students experienced great frustration in discovering a task error after moving forward with dependent tasks. This often occurred because the instructor was not readily available to provide clarification or feedback to all students. The automated feedback provided by the web-based lab allowed students to more quickly correct errors before moving forward with incorrect results and data. Thus, students seemed to make fewer mistakes and perhaps perceived that they were learning more (Q5). While students may not have explicitly valued the feedback, it may ultimately contribute to a more successful and more enjoyable lab experience.

5. CONCLUSION & FUTURE WORK

Our preliminary experiment showed that students had a more favorable impression of the web-based delivery compared to the paper-based delivery. Interestingly, we saw contradictory results when two similar questions about keeping place and following the instructions were asked. We had hoped that by eliminating the paper-based worksheet we could create a lab process that was easier for students to follow. While student impressions did not improve in this area, the web-based lab received more positive impressions in two critical areas, enjoyment and, to some extent, understanding of material. We believe that providing automated feedback is the critical advantage of the web-based system.

In a face-to-face environment it is unrealistic to assume the instructor can provide feedback to many students in the same timely manner as an automated system. While some students may still prefer asking the instructor for clarification or assurance, the web-based system provides great advantages in a face-to-face environment. The system helps free the instructor to spend even more time with students who prefer face-to-face interaction while those who are satisfied with automated interaction can move through the lab without having to wait for feedback. Aside from some anxieties about switching to a new system, the instructors found the web-based labs to also be more enjoyable and successful.

Finally, we found it rewarding to implement our own system using standard JavaScript and basic PHP code insertion techniques. The most time consuming aspect of creating interactive labs is creating the content or migrating the content into inflexible online testing systems. In our approach we did not have to convert our content into the format of question-centered testing and content management systems. Instead, we could literally save our existing Word document as a web page and simply insert page breaks and question generating functions.

The Next Step: Our system is still very experimental and our results are preliminary. The next step is to assess the impact of the web-based system on student performance, i.e., how accurately do students answer questions and how quickly do they complete tasks. In our preliminary experiment, we were unable to compare student performance because of variation in the question format between the paper-based and web-based questions. To avoid technical problems and for simplicity of grading, our proto-type system used only multiple-choice questions. However, we did not have time to convert all the questions of the paper-based lab to multiple-choice. Given the difference in question format, we could not fairly compare

student grades (paper-based vs. web-based). We plan to re-run the experiment with identical questions for the two lab formats.

Also, we were unable to precisely compare completion times of web-based vs. paper-based because of the obvious task tracking limitations of the paper-based format. However, our web-based system provides the perfect environment for comparing possible differences in performance and completion time given different kinds of web-based content, namely text-based instructions vs. video-based instructions.

The next step will include the integration of video instruction into the online system. Our hypothesis is that the video delivery will provide a richer, more meaningful method when compared to just text and images. Building on research demonstrating the positive benefits of using video, we plan to test if video-based instruction provides greater acquired practical skills and superior application or craftsmanship of skills taught in our labs (Donkor, 2010).

For our future research, we will again divide our students into two groups - four sections will receive the online video-based lab and four sections will receive the online text-based lab. All sections will use the same online delivery system with identical questions. The only difference will be the presentation of the content (i.e. video instructions vs. text instructions).

After the viability of including video with the on-line instructions has been demonstrated, we plan to develop a collaborative model where a team of instructors can contribute to the system content and video delivery. We strongly believe that a content delivery system should facilitate collaboration among instructors to achieve a synergistic effect. Instructors should be able to add and modify content without a restrictive approval system. We plan to develop an authoring environment so that expertise in PHP is not required for course development.

Labs should be dynamic, so that additional help or questions can be provided based on previous responses. The flow of content should be easily mapped using the authoring environment. We also envision providing functionality for students to report problems and rate content as they perform the lab - was this section clear? Did you learn from this module? Did you like the way concepts were presented? This gives course developers immediate feedback on potential problems and opportunities for improvement.

Our continued challenge is that we as teachers need to formalize the concepts and to develop good tools to assess whether or not students truly learn these concepts. To this end, careful attention to lab design will be incorporated to ensure that the core concepts are presented in measurable ways that improve students' retention of these concepts.

6. REFERENCES

Breimer, E., J. Cotler, R. Yoder (2009). 'Co-"Lab"oration: A New Paradigm for Building a Management Information Systems Course' *ISEDJ* volume 8 (2).

Donkor, Francis (2010). The Comparative Instructional Effectiveness of Print-Based and Video-Based Instructional Materials for Teaching Practical Skills at a Distance. *International Review of Research in Open and Distance Learning* Volume 11, Number 1.

Elsenhiemer, J. (2003). Terms of Engagement: Keeping Learners Online. *Learning Circuits*.

Garrett, J. J. (2005) Ajax: A New Approach to Web Applications http://adaptivepath.com/ideas/essays/ archives/000385.php

Hansen, D. (2008). Knowledge Transfer in Online Learning Environments. *Journal of Marketing Education* , 93 - 105.

Junaidu, S. (Volume: 5, Number: 4, October 2004). Use of Internet for Online Course delivery: A Case Study. *Turkish Online Journal of Distance Education*, 1 - 11.

McCormick, E. & De Volder, K. (2004) JQuery: finding your way through tangled code. In Companion To the 19th Annual ACM SIGPLAN Conference on Object-Oriented Programming Systems, Languages, and Applications (Vancouver, BC, CANADA, October 24 - 28, 2004). OOPSLA '04. ACM, New York, NY, 9 - 10.

Motulsky, H. (1995). Intuitive Biostatistics, Oxford University Press, USA.

Samarawickrema, G. A. (Vol. 28, No. 3, Nov 2007). Adopting Web-Based Learning and Teaching: A case study in higher education. *Distance Education*, 313 - 333.

Stacey, E., & Wiesenberg, F. (Vol. 22, No. 1). A Study of Face-to-Face and Online Teaching Philosophies in Canada and Australia.

Journal of Distance Education, Pages 19 - 40.

van Schaik, P., Barker, P., & Beckstrand, S. (Feb 2003; 40, 1). A Comparison of On-Campus and Online Course Delivery Methods in Southern Nevada. *Innovations in Education and Teaching International*, 5 - 15.