

**AC 2010-1432: EVALUATION OF A WEB-BASED LEARNING TOOL FOR  
TEACHING GIS WITHIN THE CONTEXT OF TRANSPORTATION  
ENGINEERING**

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# **Evaluation of a Web-Based Learning Tool for Teaching GIS within the Context of Transportation Engineering**

## **Abstract**

An exploratory study was conducted to evaluate a web-based learning module for teaching Geographic Information Systems to civil engineering students within the context of a problem related to crash data analysis. This module is one part of a National Science Foundation Course, Curricula, and Laboratory Improvement Project in which GIS modules are being developed for several areas of civil engineering. The module was used as a laboratory assignment in a transportation engineering course. Two days later students completed both an objective multiple choice quiz over the material covered in the lab and a subjective questionnaire. Quantitative analysis was carried out on the quiz answers and the Likert scale portion of the questionnaire. A qualitative grounded-theory open-coding analysis was applied to the open-ended questionnaire items. This analysis provided more detail regarding the perceived usefulness of the module. Combined analysis revealed a link between students' perceived usefulness of the material and their motivation to learn. Analysis also supported the learning tool's effectiveness and justified its further implementation and investigation.

## **Introduction**

A Geographic Information System is a computer application that allows data to be interpreted and visualized in many ways.<sup>1</sup> This technology is being employed in the field of engineering to better view and understand data collected by surveyors and satellites. Other industries, government, and education are using and exploring the applications of GIS as well. With the growing need for engineers that are knowledgeable about and can effectively use this system, researchers at Missouri University of Science and Technology, supported by the National Science Foundation, have set out to explore creative and effective means of teaching this system to students. There are many segments of GIS, but for the purpose of this study we will be evaluating the transportation module created by Missouri S&T scientists and engineers to complement the Geographic Information System learning tool.

The transportation module itself is a web-based help system that contains categories to explain how to use many of the transportation-related capabilities of Geographic Information Systems. This module is to act as an aid to learning the application of GIS. The purpose of this study is to examine the value of this module, focusing on its effectiveness in aiding learning, ease of use, and real world applicability.

## **Use of Progressive Scaffolding in the Learning Module**

The transportation module uses a technique referred to as progressive scaffolding to help the user guide his/her way through GIS. The scaffolding starts as simple text with some graphics. However, if the user needs additional help, he/she can select to watch a video walk-through of an operation. These options allow individuals with different learning styles the ability to use the system effectively. Engineers are generally found to be visual learners;<sup>2</sup> therefore the incorporation of graphics with text should theoretically aid engineering students with their tasks. Videos are generally found especially helpful when a task is more complex.<sup>3</sup>

## Evaluation Methods

### Objectives

A small-sample usability study was conducted in a laboratory session of a civil engineering course at Missouri S&T to test the transportation module created for GIS. The goal was to observe student experiences and observations to analyze the strengths and weaknesses of the system. Researchers took note of questions asked by students and observed potential problems as they unfolded. Effectiveness of the system was assessed through the learning outcomes and perceived usefulness.

### Method

Students were given a lab assignment that required the application of material covered in lectures and the class textbook. This assignment used the GIS system as well as the transportation module. After a brief presentation about some functionality of GIS, students were instructed to work on the system and ask for help if they could not find the answers in the ‘Help’ menu. Two days after the lab, students were given both a technical questionnaire and a subjective questionnaire to complete. The fourteen-question (true/false and multiple-choice) technical questionnaire quizzed students on the material covered in the course textbook, course lecture and lab. They were scored and then analyzed using basic descriptive statistical measures (due to the small sample size). The subjective questionnaire had fifteen questions relating to usability, perceived worth, and experiences with the lab activities as compared to course lecture, and course textbook. Eleven questions used a nine-point Likert scale, one was yes/no, and three questions were open-ended. The Likert scale questions were analyzed using descriptive statistics while the open-ended questions were analyzed using the open-coding portion of Strauss and Corbin’s Grounded Theory Approach.<sup>4</sup>

### Results

#### *Quantitative*

For the technical questionnaire (gauging student learning) the average score was a 75% (or 10.5 out of 14) with the highest score being an 86% (12 out of 14) and the lowest score being a 57% (8 out of 14). The standard deviation was 10.8%.

The lab and lecture consistently outscored the class textbook in learning effectiveness, “real world” applicability, and motivation (see Figure 1). The lecture, however, outscored the lab in learning effectiveness and motivation. It is also important to note that only one-third of the participants had used GIS software previously.

Question	Course component		
	Lab	Lecture	Text
I learned a great deal from ...	6.333	6.833	5.167
The ... was applicable to “real world” engineering.	7.667	7.500	5.833
I have found the ... to be very motivational.	5.167	6.500	4.833

Figure 1. Item ratings (on a nine-point scale) for questionnaire items on lab, lecture, and text.

## *Qualitative*

Participants responses to the three open-ended questions were analyzed, coded, and categorized based on their answers. With regard to system effectiveness, responses overall supported the conclusions reached during analysis of the Likert scale questions, as most were largely positive.

The first open-ended question asked respondents to, “Please list the strengths of this week’s lab activity affecting crash frequency, in terms of its effect on learning and motivation, and its applicability to ‘real world’ learning.” During coding, two categories were identified, Perceived Usefulness and Engagement.

Perceived Usefulness contained statements identified to pertain to “*real world*” applicability and the *importance of the material*. “Very applicable to my job,” noted one participant. Others praised the utilization of software used by industry and the software’s applicability to engineering problems. Another wrote that the program would be “very helpful in future problems.” Five out of six participants mentioned that this lab would be consistent with “real world” tasks and/or future jobs.

Engagement contained statements identified to pertain to *ease of use*, *aid to learning*, *heightened interest*, and *system confusion*. *Heightened interest* was especially important, as it pertained to motivation to learn the system. Two students made statements regarding their interest. “It was interesting... It motivated me to want to learn more about GIS,” said one student. *Ease of use* and *aid to learning* went hand-in-hand in most responses. Students positively noted the tutorial videos, lab tasks/design, and in-lab assistance. One student noted that the module was “easy to follow” and the videos were “easy to understand.” *System confusion* was mentioned by one participant, “I did not really understand [some tasks]... I was just following the tutorial...”

The second open-ended question (question fourteen) asked respondents to, “Please list ways in which the lab activity could be improved.” One respondent declined to answer. The remaining five responses were coded and categorized into two areas: Design and Context.

Design contained statements identified to pertain to *visual aids* and *pace*. One suggested that tool icons be posted to better identify buttons and icons that needed to be selected. Others were annoyed by the pace of the lab. “Make it shorter or accelerate the pace,” said one. Another suggested having a “shorter completion time.”

Context was mainly about better or more detailed explanations. “[Spend] more time explaining,” suggested one respondent. Another wanted “a little better explanation” of difficult areas. Overall, suggestions were short and few.

The last open-ended question (question fifteen) asked respondents to, “Please list the strengths and weaknesses of the web-based learning system you used for this lab activity.” After coding and categorization, one main category was identified: Scaffolding. This pertained largely to *progressive scaffolding*, in particular the video tutorials. Nearly every participant praised the use of progressive scaffolding. The response of one student summed it up, “I loved the format. You could read [it and if] it made sense [you could] do it, but if you were unclear you could watch the video. Very nice!” However, one student mentioned that some sections needed expansion in the help guide, “I got stuck,” he wrote. Perhaps the most praise of the scaffolding

system focused on the video tutorials—justifying its coding. All mentions of the video tutorials were very positive. Finally, although most participants found the system relatively easy to use and consistent to their learning styles, one mentioned that “it’s a great program, but the program didn’t work for me.” Unfortunately, he neglected to elaborate his response.

### **Unique Contributions**

This module is one part of comprehensive curriculum development in Civil Engineering at Missouri S&T. Instead of developing a separate course on Geographic Information Systems, GIS modules were developed especially to integrate into existing courses. Such an approach has broad implications for a model in which new technological approaches can be seamlessly integrated into existing courses. Second, this research demonstrates how a systematic qualitative approach with a small sample can provide meaningful and useful insights into the learning process, and serve as the foundation for future research.<sup>5</sup> Third, this represents one of the few studies aimed at examining the learning of GIS within a Civil Engineering context; despite the fact that GIS applications are in wide spread use by practicing Civil Engineers.

### **Discussion**

The qualitative and quantitative responses were compared to identify contradictions, agreement, and relationships of responses. This revealed a link between perceived usefulness of the material and motivation to learn. This is demonstrated in the subjective questionnaire in the Likert scale questions (as seen below) as well as in the open-ended analysis. As mentioned previously, five out of the six respondents commented on the real-world applicability of the application. Further, interest in the material was often mentioned in the context of real-world applicability. “It was interesting... helped see what factors affected crash frequency the most. It had an application in the real world because it can be used to identify possible dangerous spots on roads. It motivated me to want to learn more about GIS.” It was interesting to note that one student that tied for the highest score on the technical questionnaire and had high marks on his reviews of the lab in the subjective questionnaire, had some of the least positive open-ended responses. He wrote that he had confusion with parts of the system (inputting layers) and that he “just follow[ed] the tutorial.” Further, he wanted more detailed explanations. However, when asked evaluated the learning system itself he had “no complaints.”

### **Conclusion**

The quantitative ratings indicated that the lab scored well in all three areas of interest: learning effectiveness, “real world” application, and motivation. Favorable qualitative analysis suggested that the transportation module was considered to be helpful and well formatted, with video components receiving special mention. Improvement was suggested in the expansion of some subject areas as well as more visual cues in the text guide. The response to the laboratory exercise supported the conclusions reached in quantitative analysis.

This module appears to be accomplishing its goal of aiding learning while being easy to use and “real world” applicable. Additional analysis is necessary to replicate and extend these findings. In particular, a larger sample size would allow for inferential statistical analysis and expanded qualitative analysis. However, qualitative analysis performed did provide interesting insights and justify continued research.

## **Bibliography**

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