Assessment of Wireless Webcam Technology for Construction Management Field Trips

Mark Shaurette, MSCE
Purdue University
West Lafayette, Indiana

Webcam technology offers a means for construction management students to interact with the actual conditions and context of the construction jobsite when field trips are not practical. When possible, field trips are arranged so students are able to observe the conditions and communications typical of jobsite activities. Unfortunately, field trips present numerous challenges. Even when they are available, the logistics of transportation and timing create problems. In addition, job sites may not be accessible to large numbers of students, or may present dangerous conditions for observation. As an alternative, it has been suggested that webcam technology could be utilized as a means to provide job site observation without many of the drawbacks experienced with field trips. The purpose of this study was to investigate available webcam technology to ascertain the most cost-effective and functional systems for the university setting; to implement the use of this technology in construction techniques and project management classes in the Department of Building Construction Management at Purdue University; and to survey students, professors, and field personnel who experience the job site to classroom webcam educational activities.

Keywords: Field Trip, Webcam, Undergraduate Education, Educational Technology

Introduction

A significant portion of the curriculum in construction management requires an understanding and appreciation for application of techniques in management and technology that are impacted by the conditions and context of the construction jobsite. In many cases these complex and interrelated applications can best be demonstrated during a field trip in an actual application (Rose, 2002). Field visits enable the educator to expand the students' view and help students avoid mere reflexive application of exercises provided in class. Field visits also expose students to a broader background and mix of common sense knowledge and situational factors that provide insight into the range of problem areas to be encountered on a construction project. The desire is for students to be able to function "in-the-world" rather than simply "in-the-model" or "in-a-theory" (Turk, 2001).

When possible, field trips are arranged for students to observe the conditions and communications typical of jobsite activities. Unfortunately, field trips present numerous challenges. For example, appropriate construction job activity may not be available at the right time and the right place every semester. Even when it is available, the logistics of transportation and timing create problems (Epstein, 2000). Finally, job sites may not be accessible to large numbers of students and may present counterproductive or even dangerous conditions for observation.

As an alternative, it has been suggested that webcam technology could be utilized as a means to provide job site observation without many of the drawbacks experienced with field trips. The addition of two-way communication in real-time would enhance the experience substantially. In the past, the advanced technologies required for interactive video came with the limitations of high cost, timing challenges, and a lack of clear sound or video. Current computer and Internet technology now provides a vehicle for an open two-way flow of video and sound that could be utilized for a more realistic field observation experience for students. By utilizing recent advancements in Internet video, field personnel would be able to present commentary and students could ask questions or participate in field meetings.

The fundamental problem of this study was to ascertain the viability of webcam technology as an alternative to job site field visits in construction management (CM) education. To accomplish this goal, it was necessary to investigate available webcam hardware and software to establish the most cost-effective and functional systems available for use in the university setting. Recent advances in Internet data transfer speed and data compression technology coupled with the reduction in the cost and size of computer hardware required for video capture and transmission provide the opportunity for Internet-based two-way audio and video job site communication with the classroom. To make use of these advances as a substitute for field visits, hardware and software that offer simplicity of use and affordability to the community of CM educators were identified. Issues and challenges of implementation and use were investigated. Finally, objective measurement of successful applications was examined in anticipation of future large-scale implementation of the practice.

Literature Review

A significant portion of the curriculum in CM requires an understanding of and appreciation for the application of changing technology as well as a real-world understanding of techniques in management and procedures that are impacted by the conditions and context of the construction job site. Field trips provide opportunities for students to obtain experience with new and emerging technologies outside the traditional lecture setting. Limitations clearly exist in the ability to incorporate all technological advances into the undergraduate curriculum. Nevertheless, exposing students to some of these technologies is advantageous, especially if they can be demonstrated during a field trip in an actual application (Rose, 2002). Field visits enable the educator to expand the students' views and assist students in avoiding the reflexive application of exercises assigned in class. Field visits expose students to a broader background and mix of common sense knowledge that provides insight into the range of problem areas to be encountered on a construction project.

Students appear to have a preference for inclusion of field trips in the construction management plan of study. Anecdotal evidence supports the notions that field trips are more interesting to students than class lectures and labs, that they help students to visualize entire projects, that they help students understand what construction managers do and how they learn, and that field visits provide long-lasting memories (Bartlett, 2002; Kuennen & Pocock, 2003; Chanson, 2001). The visual nature of job site visits has also been noted as a reason for including them in construction education (Turk, 2001). Field visits relate well to a predominant visual learning style identified as a preference of both students and instructors at the Michigan State University's Construction Management Program (Abdelhamid, 2003). This visual connection tends to be more interesting to students than lecture or discussion (Kuennen & Pocock, 2003).

Since construction is more than bricks and mortar, the construction process requires communication between the contractor, design professionals, and subcontractors (Diekmann, Songer, & Han, 2000). When possible, field trips are arranged so students are able to observe the conditions and communications typical to job site activities. These communications are seldom isolated to a single time and place. For a useful sampling of the range of communication required for the implementation of a construction project, numerous interactions must be sampled. A single field trip is very limited since it represents a single set of interactions at one instant in time (Rose, 2002).

Unfortunately, field trips present numerous additional challenges. Appropriate construction job activity is not available at the right time and the right place every semester. Even when they are available, the logistics of transportation and timing create problems (Epstein, 2000). Finally, job sites may not be accessible to large numbers of students, or they may present dangerous conditions for observation. These obstacles of time, cost, transportation, and liability prompt instructors to seek similar but less instructive examples in the completed and soon to be constructed or renovated built environment that is suitably close to the classroom (Kuennen & Pocock, 2003).

Methodology

The problem of this study was to ascertain the viability of webcam technology as an alternative to job site field visits in construction management education. To accomplish this goal, this study sought to answer four research questions:

1. Which webcam technologies and configurations would provide cost-effective implementation of real-time jobsite communication experiences to the classroom?
2. Which curricular planning and implementation issues must be considered when utilizing webcam technology to supplant job site field trips in Building Construction Management courses?
3. What are the perceptions of students, professors, and field personnel who use the webcam field contact technology toward its use in providing job site observation and interaction?
4. What recommendations would be appropriate for future implementations and research relating to the use of webcam technology for real-time field visits?

To answer the first research question, four faculty members in the Purdue University Department of Building Construction Management served as an expert panel to define the required level as well as the desired but not required level of function and features needed for successful implementation of webcam field interactions in CM courses. This input included objectives, considerations for the cost and functionality of the webcam equipment, techniques for utilizing the technology, and strategies for coordinating webcam interaction with classroom activities. The function and feature specifications developed by the faculty panel along with the quality issues cited in the literature were combined in a spreadsheet of weighted decision making criteria for selecting the equipment to be used. The size of the spreadsheet prevented inclusion of the full matrix. Some detail concerning the decision criteria are provided in the results section of the paper.

Technology alone will not provide the concrete experience of a field visit. Even if well planned, implementation of webcam technology requires appropriate administration. Research question number two sought to provide evidence of the technical support, field activity, and classroom administration required to successfully implement webcam field visits. Classroom administration and equipment use protocol development to complete the response to research question two required extensive equipment pilot testing as well as input from the faculty in each classroom in which the webcam technology was implemented, from the technology consultants used, from the construction field staff involved in field visits, and from the researcher.

Full realization of the opportunities of webcam field interaction, as with case studies, guest speakers, and field trips, requires the coordination of presentations with classroom topics (Rose, 2002). By coordinating appropriately, it becomes possible to provide instruction with active student participation as preferred by construction management students in a recent survey of learning styles (Abdelhamid, 2003). Contemporary research in distance education also provides a body of evidence that demonstrates the importance of interaction and provides guidance in instructional design that promotes interaction (Fulford & Zhang, 1993). The related educational tool of videoconferencing has been used and studied in many settings, providing multiple sources of instructional design guidelines and strategies (Atkinson, 1999; Hearnshaw, 2000; MacKinnon, 1994). These pedagogical theories and experiences were combined with faculty input to produce a specific lesson planning guide for webcam mediated construction field visits as partial response to research question two. The prompts and questions used in the lesson plan guide are listed in Appendix A.

In both human resource training and distance education it has been advocated that measurement of reactions and feelings should precede measurement of learning (Biner, 1993 and Kirkpatrick, 1987). As called for in research question three, a survey instrument was used to ascertain the perceptions of the students and faculty who were involved with the webcam field visits regarding their opinion of the success of webcam field trips. The primary perception to be ascertained was student satisfaction utilizing a previously validated instrument called the Telecourse Evaluation Questionnaire (TEQ) as a template (Biner, 1993). The instrument modifications consisted of rewording all items to accurately reflect the context in which the webcam technology was used, elimination of questions that were not applicable to the instructional environment in which the equipment was used, and the addition of an item to measure students' self-report of learning that resulted from the webcam field visits. The modified instrument was checked for construct validity through review of each item modification by the CM faculty involved in creating the objectives for use of the webcam equipment for field visits. Additional validation was sought through review by a staff member of the Purdue University Psychometric Investigation Laboratory.

Information from a concluding focus group was of value in ascertaining what recommendations would be appropriate for future implementation and research as called for in research question five. In addition, the use of the researcher's detailed logs from the webcam field equipment pilot tests and implementations allowed the researcher to compile a group of “best practices” for the use of webcam technology.

The primary population for this study is the undergraduate student body in the Department of Building Construction Management at Purdue University. The sample for the study was the student enrollment in classes that utilized webcam technology. This convenience sample was a nonprobability design since the gathering of data was from the population conveniently available to the researcher (Sekaran, 2003). The student sample was 60 students or about 12% of the population. Student demographic data consisting of age, gender, years in college, grade point average, construction field experience, and number of construction field trips attended by the student in the past were collected with respect to the students sampled. The convenience sample yielded a rather homogeneous group of male students in their senior year of study who were almost entirely in the 20-23 age group. Two secondary populations were also be sampled. These samples included faculty members from the Purdue Department of Building Construction Management and construction field personnel.

Descriptive statistics were generated and a table of values for all questionnaire item responses was prepared enumerating mean response values, the most frequent response value, and standard deviation for each question. Mean response values were chosen as the measurement for the center of the response distribution due to the limited range of responses available in the five point measurement scale of the questionnaire. To account for the fact that the mean response is not a resistant measure, the potential influence of outliers or a skewed response was scrutinized through the use of the most frequent response value.

Results

The project began with a series of meetings of faculty interested in the use of wireless webcam equipment for field trips. From these meetings a list of essential, desirable but secondary, and low priority requirements for the equipment were established. The requirements were converted to equipment specifications in categories of ease of use, technical criteria, audio criteria, video criteria, flexibility and expansion capability, mobility, shipping considerations, recording capability, cost, and additional criteria. Each requirement was weighted according to its priority (low=1, desirable=2, required=3) in an equipment choice matrix where six types of wired and wireless audio and video signal transmission configurations were scored. The highest score (scores ranged from 276 to 329) was for a system combining microwave wireless audio and video with videoconferencing equipment. Other equipment configurations considered included variations of cellular mobile, free space optics, wired networks, and wireless networks.

Specific microwave and videoconference equipment choices were investigated through consultation with video broadcast services, digital media, and information technology personnel at Purdue as well as videoconferencing and TV broadcast industry equipment sales personnel. Subsequent demonstration of short range microwave audio and video equipment on the Purdue campus finalized the microwave equipment choice. The videoconferencing equipment was chosen to provide the greatest compatibility with equipment already available on the Purdue campus.

Two types of lightweight camera lens combinations were chosen for ease of mounting on a hardhat, ability to operate under battery power, focal length for both close range and distance use, and shutter speed adjustment for use under variable lighting conditions. Recording ability was provided by a digital camcorder, and custom shipping cases were fabricated to allow the equipment to be protected if shipped to the job site. The total cost of the prototype field equipment as detailed in Table 1 was $20,164. This cost does not include the videoconferencing equipment on the Purdue campus used to receive the field trip transmission and communicate with the personnel giving the tour in the field.

Table 1

Wireless Webcam Equipment

Qty	Description	Unit Price	Ext. Price
	Premiere Wireless Video System		
1	5.8 GHz Video System consists of CS-302T Transmitter & CS-302R Receiver	$1,577.00	$1,577.00
1	5.8 GHz Linear TX Patch Antenna with Pigtail	$197.00	$197.00
1	5.8 GHz Linear Receive High Gain Sector Antenna with Pigtail	$809.00	$809.00
2	Universal Mounting Bracket	$125.00	$250.00
1	Bogen Tripod W/3130 Head & MBAG80 Bag for wireless transmitter	$349.00	$349.00
1	Bogen Tripod W/3130 Head & MBAG80 Bag for wireless receiver	$349.00	$349.00
	Battery System for Transmitter		
1	13.2V Battery Pack with 110V Charger (for transmitter)	$451.00	$451.00
1	Battery Cord with Locking Coax Plug (for transmitter)	$76.00	$76.00
	Camera for Wireless Systems		
1	Hitachi KPD20A 1/3-inch Single CCD Camera, 480TVL	$486.00	$486.00
1	Hitachi 2.8MM Auto Iris Lens	$156.00	$156.00
1	Hitachi 4MM Auto Iris Lens	$138.00	$138.00
1	Anton Bauer Single Snap-On Battery Holder.	$207.00	$207.00
2	Anton Bauer Logic Series Battery, 14.4 volts, 45 watt hours	$212.00	$424.00
1	Anton Bauer Two position simultaneous Interactive battery charger	$613.00	$613.00
	Telex Wireless Audio System		
1	BTR-700 UHF Single channel wireless synthesized base station	$2,770.00	$2,770.00
	TR-700 UHF Single channel receiver	$820.00	$820.00
1	PH-16 mic, earphones. Headband for under-helmet use.	$241.00	$241.00
	Video Conferencing CODEC & Recorder		
1	Tandberg 880 integrated CODEC (IP standard 768Kbps)	$7,360.00	$7,360.00
1	Viewsonic 20" LCD TV	$549.00	$549.00
1	JVC GRD27US MiniDV Camcorder, batteries, & case	$667.00	$667.00
	Canopus ADVC-55 analog/digital converter	$284.00	$284.00
	Shipping Cases		
1	Custom road cases for wireless & video conferencing equipment	$1,391.00	$1,391.00
		TOTAL	$20,164.00

The equipment was piloted extensively at three sites prior to use with students. At these three initial site trials, signal blocking was experienced due to a firewall, equipment configuration, restrictions to communication out of a private network, and limitations in Internet upload speed.

In addition, a delay echo, audio distortion, difficulty feeding sound to recording equipment, challenges in adjusting the helmet camera for proper light exposure, and limited resolution of text when using input from a PC were encountered during the pilot activities. These issues were ultimately resolved. Nevertheless, since the equipment was purchased from six different manufacturers, the researcher found it necessary to consult multiple individuals and manuals to obtain sufficient understanding of the issues prior to resolution. In addition, no single consultant was available that understood all of the broadcast media, microwave wireless, videoconferencing, and Internet problems encountered.

Wireless webcam field trips were implemented in two courses in November of 2006. The first course was an elective covering hospital and healthcare construction. The field trip was designed to demonstrate infection control planning and procedures for construction activities taking place in an occupied healthcare facility. The field trip consisted of an introduction and facility tour by representatives of the facility's owner, a construction consultant to the owner, and the contractor. Students questioned the tour guides prior to, during, and after the tour of an area of active construction within the healthcare facility. During the field trip traffic control, signage, infection control barriers, negative air pressure and filtration equipment, and several types of infection control enclosures were demonstrated.

The second field trip was for a course in construction contracts and administration. This field trip began with a tour of the site (foundation stage of a large hospital addition) followed by a discussion by the project manager who has responsibility for project documentation on this job. A PC was connected to the videoconferencing equipment so the project manager could show web-based project management software used on the project in her discussion. This field trip combined field visuals, actual project documentation, a different but complementary form of web-based software than used in the course, and significant question and answer interaction to tie into the topics covered in this course. Since this course meets in two separate sections, and the meeting room was inadequate for both sections to participate in the "live" field trip, one section viewed the recording of the field trip.

A tabulation of the student responses to the questionnaire given to the participants of the live webcam field trips is included in Appendix B. Overall the responses indicate that the students perceived all aspects of the experience to be either good or very good. The range of response values was small as indicated by question response value standard deviation of less than one for all questions with the exception of the two and three choice questions that were converted to a five point scale for ease of comparison. The only slight deviation from this pattern was in the area of sound quality where more students rated the quality average than any other response. To check the reliability of the survey instrument, the value of Chronbach alpha was calculated for the 21 questions with the same response format (five response choices). The resultant value of .88 is in a range normally considered to be an acceptable reliability coefficient.

The survey response data was graphed as stem plots and box plots to look for potential patterns, and comparisons were made based on demographic information collected about the student sample. The homogeneity of the sample limited comparisons to grade point average and work experience. Chi square analysis of the hypothesis that there is some relationship between these factors and the responses to each of the overall satisfaction questions was conducted. The only relationship with statistical significance ($p<.12$) was between grade point average and the response to question 26. Students with a high grade point average (>3.0) appear more likely to respond “no” when asked if the webcam field trip is better than no field visit at all. Nevertheless, the Pearson’s R for this comparison is only .20 indicating a low correlation.

Discussion

Students, faculty, and the field personnel who experienced the initial wireless webcam field trips in addition to faculty that have viewed recorded materials from these trips have expressed enthusiasm for continued use of the equipment for field trips. Nevertheless, some potential impediments to full scale use must still be resolved. The original intent was to ship the equipment to the jobsite for operation by the field personnel who would give the tour after some limited instruction. The initial trials indicate that someone with a degree of understanding of the technology being used must be at the site when the field trip is conducted. In addition, since initial connectivity problems occurred at each site the equipment has been used to-date, it is likely that a pilot use of the equipment must be planned for each new site used for a field trip. This constraint, combined with the fact that the equipment as currently configured is somewhat cumbersome to transport and setup, introduces complexity that may limit use. There is some possibility that the use of additional Internet hardware (such as a border controller) may increase the likelihood of connectivity at new sites. These and other usability issues will need to be tested further during future webcam based field trips.

The initial equipment cost to facilitate wireless webcam field trips is substantial. Some educators may consider this to be an impediment to large scale use. However, the videoconference based equipment has been shown to be beneficial in providing real-world relevance to the study of contract administration and has the potential to supplement and reinforce course topics across the CM curriculum. A lesson plan guide for planning a webcam field trip that includes educational objectives, project description and timing, coordination with course lectures and labs, points of emphasis and instructions for field tour guide, as well as several suggestions for exercises that can be used to prompt questions and interaction between the students and the field trip tour guide was created for the initial use of the equipment. This guide is available to promote and facilitate field trips in all CM courses. In addition to use for field trips, the equipment can be put to use as a synchronous distance learning platform or be used for distance meetings of many types. It is anticipated that the equipment could be utilized weekly if made available to all faculty on a department-wide basis.

Although the initial use of wireless audio and video on the jobsite was successful in transmitting through some walls with no echo or ghosting from reflected signals, the ultimate performance of the equipment is somewhat unpredictable. The maximum clear transmission distance and freedom from interference by large objects at the jobsite may be variable over time due to changing conditions at the jobsite. The helmet mounted camera frees the tour guide from the need to consciously work as a video photographer, yet proper aim and lighting are difficult for the tour guide to control. In addition, the ability to utilize all of the available features of the equipment during a field trip requires monitoring, some switching, and possible changes in cable connections. Expanded training materials and best practices are being developed that will guide future users of the equipment in lessons learned in early uses of the equipment.

During the spring semester of 2007 the Department of Building Construction Management at Purdue University will be offering the use of wireless webcam field trips to professors on a department wide basis. This extended use of the wireless webcam equipment for field trips will help demonstrate the strengths and weaknesses of the system and will address some of the usability issues. An additional wireless headset will be purchased for better communication during tours that utilize multiple field personnel. This extended implementation will allow additional research and assessment of the equipment as an instructional aid. Initial use of the equipment in the contracts and administration course showed some preference for the interactivity provided by the live field trips as opposed to viewing a recording of the field trip. Since all field trips will be recorded and copied to DVD for future use or for use in multiple division courses, student satisfaction with webcam field trips vs. recordings of these field trips will be compared. In addition, long term student satisfaction with wireless webcam field trips will be measured (utilizing the existing survey instrument) to determine if enthusiasm for the concept is diminished after the novelty of the process is gone.

Conclusion

The initial use of wireless webcam for CM field trips was received with enthusiasm by students, faculty, and the field personnel that worked with the equipment. Through continued use and assessment of the equipment, its ultimate value as a tool to enhance the educational experiences of students will be revealed. Documentation of field trip experiences and training material for equipment use that will assure that the use of the equipment can be sustained when personnel changes take place will help to advance continuity of use. It is anticipated that further improvements in wireless Internet connectivity will enhance the ability to utilize webcam equipment for field trips in CM education as well as other educational programs with significant field operations. Ultimately integrated wireless webcam equipment has promise for communications within and between construction organizations.

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Appendix A

1. **Educational Objectives of the Site Visit**
   Develop one or two primary (important to accomplish) and one or two secondary (desirable but not critical) objectives.
   Example – Students will observe placement of the tower crane for efficient handling of materials on the site.

2. **Project and Phase of Construction Taking Place During Site Visit**
   Describe project type, size, stage of construction, and any other pertinent details required for a successful site visit.
   Example – Project should be minimum seven story steel framed building with frame erection of first or second floor underway.

3. **Timing**
   Describe the range of weeks, day of the week, and time site visit should take place.
   Example – Second or third week of October, Tuesday at 1:30.

4. **Coordination with Lecture or Lab**
   List lectures or labs with subject matter that relate to expected site visit observations.
   Example – Lecture #3 on September 29.

   List relevant topics covered in that lecture or lab.
   Example – Jobsite material handling and storage.

5. **Points of Emphasis**
   Describe desired site visit visual reinforcement of topics covered.
   Example – Material placement and tower crane reach.

6. **Field Personnel or Field Tour Guide Instruction**
   What should the individual conducting the tour know about your educational objectives?
   Example – The tour should include an overall view of the site showing material placement and use of the tower crane in the steel erection process.

7. **Instructors Plan to Prompt Interaction During Site Visit**
   a. List questions to ask students during the site visit.
      Example – How has site access influenced material placement?

   b. List questions for the tour guide.
      Example – What are the limitations of reach for your tower crane?

   c. [1]Require students (or teams of 2 or 3 students) to list two expectations of the site visit and six corresponding questions prior to the visit.
      Note: Provide students with site visit background information, class discussion, and a review of relevant topics covered in a previous lecture or lab.
      Example – I would like to observe safety measures being taken.
      What type of safety restraints do the steel erectors use when walking the framework?

8. **[2]Understanding and Analyzing Course and Site Visit Concepts**
   Apply one of the following active learning techniques.
   a. Create a list of questions that students should be able to answer about the site visit in a brief study guide, give the students a few minutes to study the questions before the site visit, and ask them to complete the guide during or after the site visit.
      Example – How was the site organized that created or avoided problems in material storage.

b. Divide a list of objectives, concepts, or questions into separate topics. Divide the class into groups and have each group become an "expert" on one of the topics by observing the site and questioning the tour guide. Assign the group topics in a confidential manner to ensure that the students are not aware of the topics others are concentrating on. Have each group share what they learned with the full class.

9. [2]**Review by Applying Course and Site Visit Concepts**

Provide the class with a list of concepts you expect them to observe during the site visit. As an assignment have students prepare examples of observations that they made during the site visit. Have them share the observations in a full-class discussion at a later date.

Example Topics – Space planning, material sequencing, site layout, etc.

[1]Adapted from #60 Action Learning in Silberman (1996).
[2]Adapted from Richardson & Glosenger (2006).

Appendix B

Survey Question Response Values by Category

	Question by Category	Mean Resp. Value	Most Freq. Resp.	Stand. Dev.
	Overall Satisfaction			
20.	Overall, the video-based site visit was:	4.23	4	0.62
24.	**Would you enroll in another course using video-based site visits?	4.80	5	0.88
25.	*Compared to conventional field trips, the video-based site visit was:	3.00	3	1.15
26.	**Is using video-based site visits better than using no field visits at all?	4.20	5	1.60
27.	*Compared to prerecorded video, photographic, or audio site information presented in CM courses, the interactive video-based site visit was:	4.69	5	0.81
	Technical Quality			
5.	The extent to which the room in which the class viewed the video-based site visits was free of distractions.	3.78	4	0.97
12.	The quality of the video picture.	3.45	4	0.97
13.	The quality of the sound.	3.45	3	0.80
14.	The adequacy of the screen size used to view the site visit broadcasts.	3.88	4	0.80
15.	The clarity of the two-way audio.	3.62	4	0.90
17.	The prevention of talkback delays when communicating with the site visit personnel over the two-way audio system.	4.07	4	0.57
19.	The degree to which the site visit equipment was operated without technical problems was:	3.50	4	0.89
	Tour Guide Quality			
1.	The clarity with which the site-visit commentary was communicated.	3.80	4	0.63
16.	The conversational skills of the personnel conducting the site visit.	4.38	4	0.58
18.	The promptness with which the site visit personnel answered students' questions over the two-way audio system.	4.47	5	0.62
	Length of Tour			
22.	*The time devoted to each video-based site visit was:	4.66	5	1.11
23.	*The typical amount of time the video of each construction activity was on the screen during the site visit(s) was:	4.67	5	1.11
	Instructor Skills			
6.	The extent to which the instructor made the students feel that they were part of the video-based site visit.	4.23	4	0.67
7.	The instructor's communication skills for the video-based site visit.	4.31	4	0.50
8.	The instructor's preparation for the video-based site visit.	4.29	4	0.64
9.	The instructor's general level of enthusiasm for the video-based site visit.	4.33	5	0.67

10.	The instructor's teaching ability related to the video-based site visit.	4.19	4	0.57
11.	The extent to which class interaction was encouraged during the site visit.	4.17	4	0.76
	Connection to Course Content			
3.	The degree to which the video-based site visit(s) coordinated with other course material.	4.15	4	0.60
4.	The degree to which the classroom activities used in preparation for the video-based site visit(s) (e.g., lectures, demonstrations, group discussions, case studies, etc.) helped you gain a better understanding of the site activities you observed.	4.00	4	0.82
	Learning from Field Trip			
2.	The degree to which the video-based site visit(s) helped you gain a better understanding of the course material.	3.85	4	0.60
21.	The extent to which, in your judgment, you learned from the video-based site visit(s) was:	3.93	4	0.73

*Questions with 3 response choices converted to 5 point scale to clarify comparison
**Questions with yes/no response converted to 5 point scale to clarify comparison

Author Notes

Mark Shaurette is an instructor and Ph.D. candidate in Purdue University's College of Technology, concentrating on reconstruction and demolition with a cognate specialty in education. mshauret@purdue.edu