AC 2009-2324: VIDEO TECHNOLOGY FOR INTERUNIVERSITY COLLABORATION IN A GEOTECHNICAL ENGINEERING LABORATORY

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Video Technology for Inter-University Collaboration in a Geotechnical Engineering Laboratory

Abstract

Advanced video technology was used to incorporate multi-component (inter-university and university-industry) collaborations in geotechnical engineering laboratory courses. The project was conducted between California Polytechnic State University (California), Auburn University (Alabama), and Nippon Koei Co., Ltd. (Japan). Synchronous video conferencing and asynchronous video communications were used between the partners. The conferencing activities included guest lectures and exchange of assignments. New assignments developed in the study included role-playing whereby one class acted as a client on a project that was ordering geotechnical testing to be completed by the students at the other university acting as a consulting firm. New assignments also included a practitioner from Japan and practical design problems. Students were required to complete assignments in unconventional formats that included video components. The student video productions were created for universal accessibility (e.g., captioning used for videos). Having students formulate practical design scenarios in their local environment was beneficial for development of students' perspective on the construction industry and regulatory issues. The role-playing associated with the exercises was entertaining and demanded professional communications by the students. For the international activities, cross-cultural discussions at a professional level provided appreciation for the global context of civil engineering practice, and differences in approaching design problems in different countries. Production of films in lieu of written laboratory reports incorporated new learning styles. Students were more careful with experimental procedures when videotaping themselves than during conventional laboratory sessions and team dynamics were affected by incorporating video technology. Universal access concept was incorporated into the curricula at the two universities.

Introduction

Conventional geotechnical engineering teaching methods include a one-way lecture presentation directed at students with low participation from students. Conventional geotechnical engineering laboratory courses have similar attributes, but incorporate enhanced teaching and learning styles with hands-on experiments and work that is conducted in teams. Various systems have been developed to describe teaching and learning styles[1]. A common general distinction is made between technical, detailed, or mathematical modes and feeling, artistic, or personal modes of teaching and learning using all the different systems. While the systems vary in terminology and origin of categories, common traits exist in the learning style identified for the majority of engineering faculty. This learning style is then reflected in the teaching style of the faculty and leads to predominance of a single teaching style for much of engineering curricula. In this regard, engineering is generally taught using exclusively technical and mathematical modes. However, student learning occurs using a broad variety of learning styles.

Educational research indicates that active student participation in the classroom experience is beneficial to learning effectiveness. Novel use of technology has been demonstrated to be highly successful at engaging engineering students[2]. Development of professional skills and awareness of broad societal context for engineering projects are becoming increasingly important in civil engineering education[3]. Professional perspectives are typically not adequately included in classroom experiences in upper level undergraduate or graduate geotechnical engineering coursework.

This project was conducted to investigate the inclusion of advanced technology and international practitioner involvement to enhance teaching and learning in geotechnical engineering laboratory courses. A teaching method incorporating novel use of video technology was used. A collaboration was established between two universities in the U.S. and an industrial partner in Japan. The new method described in this paper can provide critical insight and opportunity well suited to teaching the professional aspects of engineering education (e.g., teamwork, communication skills, global and societal context of problems) that are included in the ASCE BOK, ABET Criteria, and the International Technology Education Association's Standards for Technological Literacy: Content for the Study of Technology. These aspects have commonly been reported to be challenging to implement into engineering curricula[4, 5]. The teaching methods described in this paper support broad curricular efforts to provide pedagogies of engagement[6], preparing students who have highly adaptive skills for rapidly changing environments[7], and supporting the notion that academia is a center of innovation, creativity, and energetic activities[8]. An overview of the implementation of this teaching method, a description of the exercises, perceptions of stakeholders, plans for learning-style-specific assessment, and suggestions for successful adoption of similar efforts are provided in this paper.

Project Description

The project included use of advanced video technology for inter-university and university-industry collaboration; use of video technology for both teaching and learning in a laboratory setting; and incorporation of professional collaboration and active discourse in classroom settings. These teaching methods were applied to undergraduate level Geotechnical Engineering Laboratory course at California Polytechnic State University and Auburn University. California Polytechnic State University is a predominantly undergraduate institution, while Auburn University is a Tier 1 research institution. The industrial partner in this study was the Japanese civil engineering research and consultancy firm Nippon Koei Co., Ltd. The company employs approximately 700 technical specialists working on both domestic and international projects. Nippon Koei is headquartered in Tokyo Japan with offices throughout the country as well as overseas in North African and East Asian countries.

The universities initiated this project to enhance student learning in geotechnical engineering. Specifically, these exercises were conducted to challenge students in new ways and broaden their fundamental skill sets including professional skills associated with communication and global awareness. These components, which are critical in the ASCE Body of Knowledge (BOK) and ABET Criteria, are generally difficult to integrate across the curriculum in conventional classroom environments. Interaction between the universities provided a novel approach for highlighting the importance of local geologic conditions, promoting unique teamwork exercises, and incorporating recent technologies in a laboratory learning environment.

The industrial partner collaborated on the project to positively affect engineering education and the civil engineering profession. Japan faces new challenges due to declining population, global warming, and aging infrastructure at the onset of the 21st century. These new challenges are not present only for Japan but also problematic for the countries in Europe and North America. Nippon Koei is interested in helping develop new strategies to educate stakeholders and promote discussion related to these global problems. Nippon Koei recognizes that private companies need to take active role in promoting education in civil engineering, as it is vital to generate competitive young engineers who are needed in maintaining a sustainable society. Also, it is important to allow students and young engineers to experience contact with international organizations, as engineers face global civil engineering issues that require international collaboration. The technical staff at Nippon Koei provided a connection to real projects allowing students an opportunity to better understand the concepts and theories of geotechnical engineering as well as develop appreciation for the importance of laboratory testing techniques.

The advanced video technology used in the investigation included two main components: video conferencing and video production. The video conferencing was used for guest lectures provided during the laboratory courses. Synchronous video conferencing was conducted between both universities and the industrial partner. The video production was used for completion of laboratory assignments as films. Also, video production was used for role-playing exercises conducted by the students to act as owners on projects to develop laboratory testing requests.

The configuration for the video conferencing equipment included a webcam at each participating location (classroom laboratories and Nippon Koei). Widely available freeware was used for the internet-based video conferencing. In the classroom, two LCD projectors were operated, one to display the slides for the presentation (previously downloaded file to achieve high resolution with images) and a second to display a full-screen image of the face of the guest lecturer. To date, only two-way video conferencing has been conducted (either between universities or between a single university and Nippon Koei).

The topic selected for university-industry collaboration was rockfall analysis. Dr. Senro Kuraoka of Nippon Koei provided a lecture that included a broad overview of the firm's activities and facilities, followed by a detailed description of rockfall analysis and mitigation strategies in Japan (Fig. 1). Dr. Kuraoka presented examples of rockfall problems and design options for energy absorption (e.g., netting, fences, and berms). Details of large-scale research-grade experimental testing for determining coefficient of restitution and rockfall dynamics were also presented. Time was permitted for a formal presentation followed by discussion with the students. A related laboratory assignment that included video recording was then completed by the students based on the technical material presented by Dr. Kuraoka.

The assignment related to rockfall involved the determination of the coefficient of restitution of rocks falling from various heights onto different surfaces. The analysis included use of imaging technology and basic physics concepts. The images of the experiments were recorded using digital camcorders to characterize shape of rocks and rebound behavior in experimental tests. The physics concepts included in the assignment related to trajectory motion and coefficient of restitution. This aspect provided a specific opportunity to evaluate students' retention of these concepts from previous courses.

Fig. 1. Rockfall applications presented by industrial partner

These collaborative activities (between universities and with the industrial partner) represented an extension to an existing sequence of laboratory assignments written from a hypothetical client to a consulting firm (student teams) to request tests to be conducted and for test results and interpretation associated with a specific project[9]. The assignments were provided to the students in business letter format (outlining the request for experimental testing) from Nippon Koei. Dr. Kuraoka described the specific request for test results during the video conference. These were similar to other assignments during the term with the exception that for this assignment, a "real client" was associated with the project (Nippon Koei). For this assignment, the students knew that both the professor and the industrial partner would review their work.

The video conferencing was repeated multiple times using different configurations. Due to technical difficulties with the video conferencing equipment and overall room configuration, unintended variables were introduced to the investigation. In one session, we lost the video portion of communication, but audio communication remained intact. When conducted in a different classroom, the two screens were spread out a great distance at the front of the room.

For the second main component of the advanced video technology use in geotechnical engineering laboratory, students were required to videotape and produce films to either a) document test procedures and associated analysis (i.e., produce a short film in lieu of a conventional written laboratory report for some laboratory assignments) or b) act as owners of a project and develop testing request to provide to the students at the partner university. Student groups were each provided camcorders for use in the classroom as well as for outside the classroom for studio and field work. Facilities were available at both universities for video editing and production. Students were provided training in how to use the video editing equipment.

For the video laboratory report, students were required to document laboratory testing procedures on video, provide summary and analysis of results in video format, and finally produce a film that compiled this information. The films were expected to contain all relevant information in a typical written laboratory report. Students videotaped their test procedures during their normal laboratory sessions. The test procedures were not significantly affected by the videotaping. In some cases, students provided narration as to the steps involved in the test procedures.

For the role-playing exercise, the students acted as owners of hypothetical projects and assigned laboratory work to the students at the partner university. The students were required to select a potential site for construction and gather a soil sample that was representative of that location. The testing request included video footage of the selected site. Some groups selected to film their official request on site whereas other groups worked in a studio and included images and video content related to the site.

In both cases of film productions (making laboratory reports and role-playing for assigning laboratory work), students were responsible for video editing and production to complete an archival video of the assignment. Expectations for the final films were discussed in class prior to the taping and during the period while the students were completing production work on their videos. A ten-minute maximum duration was imposed in an effort to the keep the workload associated with this assignment at a manageable level for the students. Special video effects, including sound, captioning, and fade-ins were encouraged to be included in the film productions.

Results

Advanced video technology incorporated to a geotechnical engineering laboratory course broadened the scope and technical content of the course as well as allowed for inclusion of new teaching and learning styles. The greatest fundamental benefit was demonstrating to the students that theoretical soil mechanics taught in the geotechnical engineering courses has application to large-scale and real-world projects. The technical benefits to the curriculum included: 1) development of a new experiment for the geotechnical engineering laboratory, 2) drawing connection between theory and case histories, 3) establishing the importance of standardized testing methods and scale of experiments, and 4) higher level technical content related to geotechnical analysis and design. Pedagogical benefits included: 1) exploring the importance of the global engineering community, 2) bringing use of advanced video technology into the classroom (both for conferencing and film productions), 3) technical, yet casual interaction with a practicing professional, 3) requiring students to use different learning styles in completing the assignments, and 4) requiring students to utilize unconventional communication and graphics modes in team settings.

The participation of Nippon Koei in the classroom led directly to the development of a new experiment included in the laboratory course – analysis of rockfall. Rockfall had not previously been included as a topic in the course. The topic was well suited for the course as rockfall provided an experiment related to a subject of particular local interest in California. In addition, determination of the coefficient of restitution of rocks involved the use of videotaping as part of the normal test procedure (in order to view the rebound of rocks in slow motion). The students recognized that the test procedures were scaled down in comparison to what was being conducted in Japan for consulting and research purposes, but nevertheless learned the basic concepts of rockfall analysis during the laboratory session through this added experiment.

The video conferencing sessions provided engaging additions to both laboratory and lecture learning environments. The project activities challenged students with entirely new learning modes currently not present in most engineering education environments. The video conferencing provided an opportunity to evaluate student performance in an unscripted interaction with a senior practitioner. A video image of the entire class was being broadcast to the industrial partner. The pressure of being taped kept students generally alert for the presentation. Discussion at the end of the formal presentation provided an opportunity to evaluate students' oral communication skills while they asked questions to the practitioner. Questions from the students at the end of the video conference included both technical aspects of the subject as well as broader and relatively non-technical issues related to comparisons between working experiences in the U.S. and Japan. The overall level of engagement and level and scope of questioning was noticeably higher during the sessions that included working audio and video networking compared to the session that had only audio communication. In addition, the presence of dual projectors was determined to be a critical component of successful implementation of this method. Being able to view both the presenter and the technical material duplicated the experience of attending an in-person presentation. The connection between the live speaker and the slide presentation was somewhat weakened in the trial that had the two screens spread out at the front of the classroom. These results are generally consistent with the findings of Pullen[10], who reported that distance learning activities containing live video are most effective.

Nippon Koei Co., Ltd. had positive experiences with live video-conferencing with the classroom. Nippon Koei did not directly use the students' results as the level of experimentation conducted by undergraduates in one hour was simplified in comparison to the large-scale research-grade coefficient of restitution testing conducted at the company for consulting projects. The video conferencing activity provided exposure of the multinational company to American students and provided opportunity for junior engineers at the company to review student work. Video conferencing also provided international exposure for Nippon Koei's projects and facilities. It was particularly interesting to have open discussions between the students and company representative after the formal presentation. The industrial partner was highly interested in students' inquiries about employment opportunities and internships at Nippon Koei.

Experiences with the video production (in lieu of written laboratory reports) were affected by the significant effort required to complete the video modules. The accountability for team participation was clearly enhanced as each team member was expected to participate and his or her participation was evident in the film for the assessment of team performance. It was observed that the students paid much closer attention to experimental test procedures and details while documenting the activities with digital cameras and narration than in a conventional laboratory setting.

The teaching methods used in this study involving video conferencing and video recording support a recommendation by Felder et al.[11] to "teach around the cycle". Such teaching employs a variety of styles that develops whole brain thinking skills[12]. The combination of factors needed for completion of the associated assignments (i.e., interaction with practitioners and professionals in a classroom setting, global perspective of engineering problems, and design) challenged students in new ways and broadened their fundamental skill sets, especially with professional skills such as communication and global awareness.

Student comments about the learning experiences were generally favorable. When asked to rate the level of enjoyment (from 0 to 10) for the video conference, students responded with an average rating of 9.13 (responses ranged from 7 to 10). When asked to rate the level of agreement (from 1 to 5, where 5 represents strongly agree) with the following statement: "Interacting with professionals from different institutions via video conference enhanced the learning experience", students responded with an average rating of 4.53 (responses ranged from 4 to 5). Students ranked their own skill development for "My ability to work effectively in a team improved because of the lab experience," using a scale 1 to 5 with an average rating of 4.00 (responses ranged from 3 to 5). Specific verbatim student comments related to these exercises are presented below:

Video Conference Experiences:

- The Japanese teleconference was interesting and added to the general knowledge and breadth of the topic.
- Topic of rockfall and collaboration is interesting.
- The video connection was well worth it, I recommend keeping it.
- Enjoyed/appreciated effort of live Japan feed.
- Live video conference is cool because we see how our material taught in class is applied in the real world.
- It's nice to get a real life perspective of the application of techniques we learn in class.
- Good insight not just into the topics but what it's like to be a professional.
- I think an industry perspective provides a deeper understanding of ground improvement.
- These kinds of presentations need to occur more often in upper division civil engineering courses.
- The Tokyo presentation was really cool and reinforced the notion of "global engineering" and how important these relationships are.

Video Production Mode for Laboratory Reports:

- Thought video labs would be long and tedious, but they turned out to be fairly interesting.
- Video presentation is an awesome idea, but very time consuming.
- The video presentation was very difficult and time consuming. Didn't feel like it was an effective way to demonstrate our group.
- Didn't really like the video lab report, but it was something new.
- The video lab took three times more work than the other labs. It is great that you want to challenge students and have them be innovative but not when it requires so much work.
- Role playing video was a good experience.
- The role playing video did not really enhance the course.
- Video taping the procedure reinforced the lab because we could see what we did a couple days later and explain to someone else what was done.
- I enjoyed the video content of the course.

Specific challenges associated with this teaching methodology relate to logistics of conducting synchronous video-conferencing and student perception of workload for the associated assignments. Software and hardware configurations caused some challenges, but alignment of timing of the sessions across time zones (14 hour time difference for the case of the international partner) was a more pronounced challenge. The broader curricular schedule was also challenging to arrange. The role-playing exercise was problematic from a curricular scheduling standpoint in that the "owners" of the project (students assigning work the to the other university) needed to be working on technical material nearly one month ahead of the normal course schedule to permit time for video production before sending to the partner university. This caused the students to be noticeably outside their comfort zone for describing the technical material at hand. Modification of the laboratory schedule at the two universities to provide alignment for the role-playing may provide a solution to this problem. The students found the video productions to be highly time consuming and this affected their interpretations of the value of this exercise.

Recommendations and Future Implementation

A summary of recommended practices for successful video conference experiences in classroom settings are outlined in Table 1.

Table 1. Recommended Practices for Integrating Video Conferencing into Geotechnical Engineering Classes

Recommended Practice	Comments
Use 2 closely-spaced projectors: 1 for slide presentation and 1 for live video-feed	Clarity and size of images is enhanced with 2 projectors
Use audio and video, not just audio	Students were noticeably more engaged when interacting with the image of a face and seeing expressions
Plan a subject that permits an experiment to directly relate to a real project that is described by a practitioner	Strong connection develops student appreciation for testing methods
Use external speakers for audio	Louder volume necessary for class environment
Use flexible and portable webcam	Student questions can be personalized with image of single student by moving camera around room

The author plans to further integrate this teaching method into the curriculum due to the depth and breadth of the inherent underlying pedagogical benefits. Specific advancements for this teaching methodology planned in the near future include multi-user video conferencing (more than 2-way), using lecture-capture software for student projects/presentations, grouping of students from the partner universities to form teams for completing laboratory assignments synchronously using video conferencing, and development of learning-style specific assessment techniques. Two separate software packages were recently acquired that will permit multi-user video conferencing and lecture capture. Incorporation of these tools will expand the interconnectedness of the project partners and reduce the video-editing workload for the students. Grouping of students from the partner universities for laboratory work has great potential for enhancing student communication and teamwork skills for the 21st century workplace. Baseline data are obtained for the students' predominant learning styles at both universities when the students are admitted to the engineering program. This will be used in conjunction with project results to evaluate impact of the newly developed teaching methodologies on various types of learners. In addition, within a specific type of learner (i.e., for a given student), the relative impact of the project on the effectiveness of their learning across different learning styles will be evaluated.

Summary and Conclusions

An innovative teaching method using advanced video technology that allowed for collaboration between partner universities and an international industrial partner (located in Japan) was implemented in a geotechnical engineering laboratory course. The main benefits of the innovative teaching method included broadening the scope and scale of problems considered in laboratory and lecture settings while directly including professional skills (e.g., communication) in the curriculum. Class assignments were completed as video productions in lieu of written laboratory reports and students employed role-playing in video productions for testing requests. These exercises enhanced team dynamics and challenged students to use new learning styles. The technical benefits to the curriculum included: 1) development of a new experiment for the geotechnical engineering laboratory, 2) drawing connection between theory and case histories, 3) establishing the importance of standardized testing methods and scale of experiments, and 4) higher level technical content related to geotechnical analysis and design. Pedagogical benefits included: 1) exploring the importance of the global engineering community, 2) bringing use of advanced video technology into the classroom (both for conferencing and film productions), 3) technical, yet casual interaction with a practicing professional, 3) requiring students to use different learning styles in completing the assignments, and 4) requiring students to utilize unconventional communication and graphics modes in team settings. This teaching method has promise for broader integration into engineering curricula to provide enhanced teaching and learning.

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