Using Interactive Video Conferencing for Multi-Institution, Team-Teaching

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Using Interactive Video Conferencing for Multi-Institution, Team-Teaching

Abstract

The use of interactive video conferencing (IVC) and related technologies to teach courses over the Internet is becoming more common. The typical model for a distance-learning course is a single instructor teaches students distributed in remote locations connected via IVC technology and a web-based learning management system to facilitate interactions. Our approach extends this model to include several instructors co-located with students at multiple locations (three locations in our case: Utah State University, the University of Utah, and Brigham Young University, who partnered to develop and offer a new, joint course on hydroinformatics to predominantly civil engineering graduate students at the three partner universities). The course was offered in the Fall 2012 semester to 28 students.

This paper describes the novel approaches used in the course, the challenges and benefits associated with the use of IVC technology across multiple universities, the effectiveness of IVC for student learning, and the complications and benefits of having multiple instructors. Novel approaches include having separate instructors and assessment at each site while sharing course content, live lectures, and discussion forums. Challenges identified include originating content from multiple locations, building rapport with remote students, communicating effectively within a multiple-classroom environment, engaging local and remote students, stimulating critical thinking during lectures and demonstrations, and addressing different institutional regulations and students at each university. Benefits include the efficiency of involving multiple instructors through IVC and sharing their combined knowledge and expertise with students at different universities. Students were surveyed at the midpoint of the semester and after the course concluded to solicit their assessment of the effectiveness of course content and delivery techniques. Instructors self-assessed the course conduct at the midpoint and conclusion to reflect on the effectiveness of course materials, delivery techniques, and student learning. We used the results gathered in this initial offering to identify areas to improve the delivery in subsequent offerings using this new *team teaching* IVC model. Specifically, we concluded the need to increase active learning and critical thinking when using IVC and to vary learning activities to include non-IVC elements and individual institution elements.

Interactive Video Conferencing

The use of IVC for engineering and pre-college engineering[1] education is not new nor is the assessment of its effectiveness. Numerous distance education courses make use of IVC and textbooks have been written with sections on the topic[2]. Moreover, there has been a recent proliferation of web-based courses offered for free (so-called Massive Open Online Courses, or MOOCs, such as Edx, Coursera, OpenCourseWare). For example, Coursera (https://www.coursera.org/) has offered more than 300 courses from more than 50 universities to millions of students.

Like its predecessor, instructional television, IVC has typically been used to distribute instruction from one instructor to multiple sites. This breadth approach has been lauded as a cost-efficient way to distribute traditional lectures and increase access for students at remote locations[3]. In the case of the hydroinformatics course described in this paper, we took the approach of involving multiple instructors through synchronous *team teaching*. Rather than one-to-many, we adopted a many-to-many approach where course sessions were divided among several instructors and each instructor took a lead teaching role at various times according to the objectives for that session and the expertise of the instructor. All instructors were also present in the classroom regardless of whether they were leading that session or not and engaged students at each location simultaneously through IVC. This synchronous, team teaching approach is a novel use of IVC and particularly well-suited to the interdisciplinary nature of this course.

Synchronous, team teaching has likely been part of previous distance education courses but the engineering education literature has yet to describe, assess, or recommend best practices to promote student learning. Several past studies have assessed the effectiveness of IVC technology in general for distance education or collaboration. One study concluded the effectiveness, in terms of increased attention, is dependent on the characteristics of the material being presented and the quality of the speakers making the presentation[4]. A meta-analysis comparing academic performances of distance education students relative to those in traditional settings over a 20-year period indicated that the probability of attaining higher learning outcomes, as determined by final course grades, is greater in the online environment than in the face-to-face environment[5]. Studies have also focused on particular areas of IVC that influence learning effectiveness including interactions[6].

Numerous past applications of IVC for engineering education have blended IVC with other learning activities and teaching techniques to accomplish course learning objectives. In one example, the instructors used IVC as a communication method for team projects[7].

Overall, the literature on the use of IVC for engineering education is extensive, and even more so for distance education in general. However, the use in courses team taught with multiple instructors offered simultaneously at multiple institutions is limited. IVC in the course described in this paper involved simultaneous two-way video and audio communication connecting classrooms via internet protocol (IP) at the three participating universities. The core technology relies on digital compression of audio and video streams in real time and used H.264/MPEG 4 video-coding standards[8]. The universities shared a multiple control unit (MCU), routing, and scheduling was facilitated by the Utah Education Network. Course sessions were also recorded centrally and made available for asynchronous viewing over the online common learning management system (LMS). To facilitate student engagement during class time, the course operated with continuous presence, meaning all classrooms could be seen on the screen at the same time, rather than switching based on voice activation or manually. The IVC capabilities varied across institutions, from temporary equipment to a new building installation. The remainder of the paper describes the course offered and the assessment of the effectiveness of IVC for synchronous, team teaching.

Course Description

This paper describes the first offering and assessment of a semester-long, 15-week, graduate-level course that was taught by multiple instructors and multiple locations using IVC in Fall 2012. The course topic was Hydroinformatics (https://usu.instructure.com/courses/127332) which involves the study, design, development, and deployment of hardware and software systems for hydrologic data collection, distribution, interpretation, and analysis to aid in the understanding and management of water in the natural and built environment. It addresses emerging areas related to Big Data, cyberinfrastructure[9, 10], real-time water infrastructure monitoring, and other technical applications being integrated into water resources engineering research and practice.

The course evolved from a need to train students at multiple universities to conduct cyberinfrastructure (CI) research in the water resources area. The impetus was a NSF-funded project (EPS-1135482 and EPS-1135483) to provide and use CI tools, especially high-performance computing, to enhance the capacity for water resource planning and management in the two-state region of Utah and Wyoming. The project has as a goal to link technical experts, modelers, analysts, high-performance computing experts, stakeholders, and the public through CI implementation (Figure 1). Approximately 25% of the graduate students in the course also are working on the research project as funded research assistants. However, the course is not exclusively designed to train graduate students working on the project. The more general goal is to train students to work with the water management CI framework illustrated in Figure 1 that the research project is creating. This training will usher in a new paradigm for hydroinformatics use in professional practice including students trained to operate and advance the new paradigm.

The grant teamed Utah State University, Brigham Young University, University of Wyoming, and the University of Utah, with part of the effort identified in the proposal including the development of a graduate level course to provide student training to conduct the high level computational research in the water resources engineering and management discipline of civil engineering. Rather than each school develop and offer their own independent course, the project co-PIs decided to develop a single course to be team taught by instructors from the universities participating in the project. The instructors had a range of teaching experience from less than 2 years to more than 12 years, but none had taught via IVC previously. The objective of the partnership was to find a way to enhance the educational experiences through team teaching activities using IVC technology.

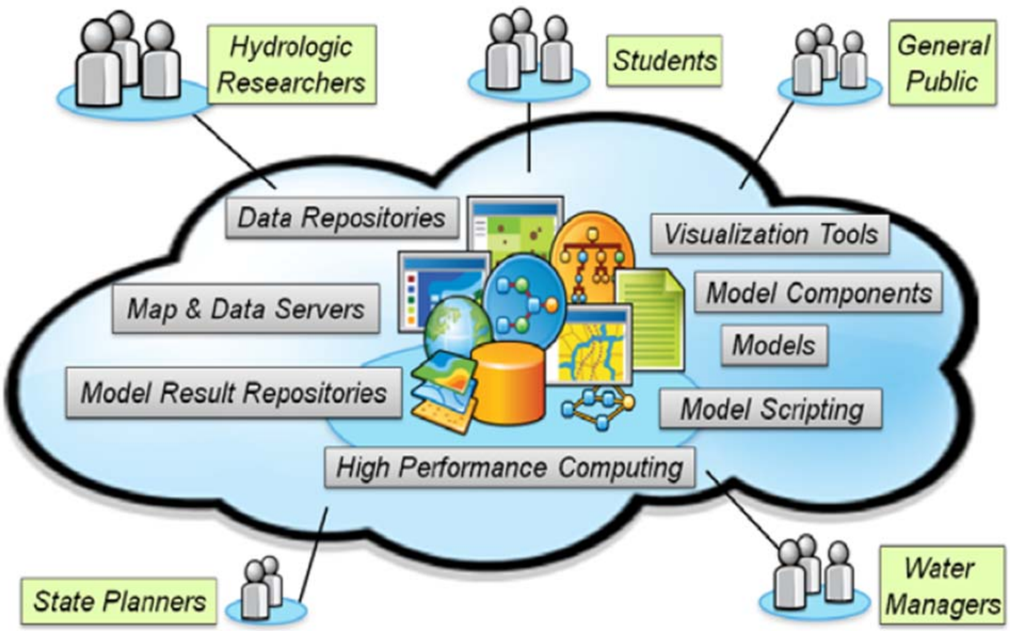

Figure 1. Components and people involved in the research project supporting the development of the hydroinformatics IVC course.

The course was designed to introduce students to core concepts within the field of hydroinformatics, including data management, data transformations, and automating these tasks to support modeling and analysis. The course was meant to prepare students to work in data-intensive research and project work environments and emphasize development of reproducible processes for managing and transforming data in ways that others can easily and completely reproduce on their own to support analyses and modeling. The Fall 2012 course included both (i) 9 individual learning opportunities (generally weekly) focused on specific data management, transformation, and automation tasks, and (ii) an open, semester-long project where students worked individually or in small groups over the semester to discover, organize and manage data for a hydrology or water resources problem of their interest. The course learning objectives were:

a. Describe the data life cycle
b. Determine the dimensionality of a dataset, including the scale triplet of support, spacing extent for both space and time
c. Generate metadata and describe datasets to support data sharing
d. Discover and access data from major data sources
e. Store, retrieve and use data from important data models used in Hydrology such as ArcHydro, NetCDF, and the Observations Data Model (ODM)
f. Develop data models to represent, organize, and store data
g. Design and use relational databases to organize, store, and manipulate data
h. Query, aggregate, and pivot data using Structured Query Language (SQL), Excel, R, and other software systems
i. Create reproducible data visualizations
j. Write and execute computer code to automate difficult and repetitive data related tasks

k. Manipulate data and transform it across file systems, flat files, databases, programming languages, etc.
l. Retrieve and use data from Web services
m. Organize data in a variety of platforms and systems common in hydrology and engineering
n. Prepare data to support hydrologic, water resources, and/or water quality modeling

Semester projects, which were developed by both individuals and student teams, included designing appropriate data models and automating data loading, manipulation, and transformations in support of data intensive analyses or modeling. Class time included lectures delivered by IVC focused on learning and developing data management, transformation, and task automation skills, class discussions, code writing exercises to solve data manipulation tasks, demonstration of software and data systems, and student presentations of their project work. The initial offering had four instructors at three institutions with 28 students (seven at Utah State University, fifteen at Brigham Young University, and six at the University of Utah).

This course was designed using two tenets of an integrated theory of learning, mental representation, and instruction termed Cognitive Flexibility[11]. First, the course prepared students to select, adapt, and combine knowledge and experience in new ways to solve problems unlike other constructivist-oriented methods that stress retrieval of organized packets of knowledge, or schemas, from memory[12]. Here, students navigated the conceptual complexities of ill-structured domains to solve problems. Students were taught numerous conditions, each of which is individually complex, that need to be simultaneously interpreted and juxtaposed to arrive at solutions. While some course objectives were designed to establish clear knowledge structures that can be reused, such as established hydrologic data models, the course also focused on preparing students to be flexible and develop their own solutions in ill-structured situations.

Second, the delivery of the course was also inherently multi-faceted. If the course was offered by one instructor to a broad number of students, as is typical in distance learning environments, the instructor would likely present issues from a single perspective. By relying on four instructors at three institutions with varying experiences and expertise, students drew upon the multiple representations and inherent complexity offered by four instructors to combine hydrologic data, model, and analyze results. It is challenging to find a balance between instruction that allows for this flexibility and that imparts specific skills[13]. Adding the IVC distance education components presented additional cognitive overload for students that instructors worked to mitigate throughout the course.

The instructor team identified several potential benefits of the team teaching IVC approach. First, multiple instructors could attend each class period and offer their broad and deep knowledge base in several areas. These offerings could provide for a greater opportunity for enhanced experiences for the students in multiple areas of knowledge. Second, multiple instructors could respond in real-time to student questions and offer their varying expert perspectives. Third, students could interact with students and faculty from different institutions to expand their range of experiences and broaden their professional network. The assessment of the course sought to identify if these hypothesized benefits were realized.

The instructor team also anticipated several challenges with the course offering due to its topic area being outside of the traditional civil and environmental engineering area. These anticipated challenges included trying to integrate students and instructors from multiple universities, technical difficulties with IVC technology, learning the IVC system (a first for all instructors) while implementing a new course and teaching approach, building rapport with remote students, communicating effectively within a multiple-classroom environment, engaging local and remote students, stimulating critical thinking during lectures and demonstrations, and addressing institutional differences and differences among students at different universities. The assessment of the course sought to determine if these anticipated challenges occurred and then solicit student suggestions for improvement.

Assessment

Methods

The assessment of the initial course offering involved (i) administering mid-semester and end of class surveys to the students, and (ii) instructor reflections. The midterm and final surveys were both anonymous and similar (words were changed slightly to improve meaning of questions and a couple of additional questions were added to the final assessment survey). The open-ended questions were:

- What went well in class? What contributed most to your learning?
- What could have been improved? How could this course be more effective to help you learn?

Surveys also requested students to rate their relative agreement to several statements following a Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree; NA = not applicable or no comment):

_____ I learned a great deal in this course.

_____ Course materials and learning activities were effective in helping me learn.

_____ This course helped me develop intellectual skills (such as critical thinking, analytical reasoning, integration of knowledge).

_____ The instructor showed genuine interest in students and their learning.

_____ The use of the interactive video conferencing format for the course helped my learning.

_____ Having multiple instructors from multiple universities helped me learn more.

_____ The interactive video helped me to establish a positive rapport with the instructors that are located away from my home university.

_____ The interactive video facilitates effective communication between me and instructors located away from my home university.

_____ The class sessions stimulated me to think critical about the material.

_____ The interactive video helped me meet and interact with students from other universities.

_____ It would have been helpful for my learning to have more time in class with the interactive video off, and planned activities having me work with classmates and local instructor.

Some of the statements assessed student opinions of general learning while others focused on multiple instructors or the IVC effectiveness. The final two statements were added for the end of class survey because the instructors were interested in these two particular aspects of the class that were noted as possible improvements in the future. Instructor reflection occurred at the semester midpoint and conclusion before and after reviewing survey data. Instructors shared their reflections through email exchanges and a teleconference.

Results

The midterm survey was completed by 25 (of 28) students. The final survey was completed by 20 students. The numerical summary of results to the statement responses are shown in Table 1. The results of the midterm survey indicated students agreed that they were learning in the course. However, their responses only slightly agreed that the learning was being enhanced by the use of IVC. In addition, there was only slight agreement that the use of multiple instructors was helping them learn. The comments from the students in the survey suggested the IVC was actually reducing the interaction among students and instructors at the three institutions. This was opposite of the instructor team objective.

The student feedback in the midterm assessment led to changes in the instructor team's approach to using the IVC for team teaching. The instructors integrated direct questioning across institutions, involved multiple instructors in class sessions more frequently, and engaged students to provide project summaries and presentations. End of course surveys and comments from students indicated that the modified activities and approach raised the value of the IVC and multiple instructors.

One of the more telling conclusions shown in Table 1 is that students largely agreed or strongly agreed that they learned a great deal in the course. However, they were less agreed on the effectiveness of the IVC as implemented for this course. The standard deviations shown indicate there is greater student rating variability at the mid-point in the semester than at the end of the semester. Responses to questions #5-7 suggest students felt the synchronous, team-teaching approach using IVC technology furthered their learning, but that more needs to be done to facilitate interactions with students at other universities (question 10) and the approach is not a complete substitute for offline, in-class activities with the local instructor and classmates (question 11). Overall, the midterm and end of semester ratings are not significantly different for questions 1-4, 6, 7 using the two-tailed Mann-Whitney test ($P \geq 0.05$), while marginally significant for question 5 ($P<0.05$). We expand upon these quantitative findings with additional qualitative observations.

Table 1. Mean rating of student responses to survey questions (standard deviation shown in parentheses).

Statement	Midterm Average Rating*	End of Class Average Rating*
1. I learned a great deal in this course	4.2 (0.91)	4.5 (0.77)
2. Course materials and learning activities were effective in helping me learn	4.0 (1.02)	4.3 (0.65)
3. This course helped me develop intellectual skills (such as critical thinking, analytical reasoning, integration of knowledge)	3.9 (0.81)	4.4 (0.69)
4. The instructor showed genuine interest in students and their learning	4.3 (0.92)	4.5 (0.77)
5. The use of the interactive video conferencing format for the course helped my learning	3.4 (1.08)	4.2 (1.12)
6. Having multiple instructors from multiple universities helped me learn more	3.6 (1.12)	4.3 (0.87)
7. The interactive video helped me to establish a positive rapport with the instructors that are located away from my home university	3.5 (1.30)	4.0 (1.03)
8. The IVC facilitates effective communication between me and instructors located away from my home university	3.6 (1.04)	
9. The class sessions stimulated me to think critical about the material	4.1 (0.83)	4.2 (0.79)
10. The interactive video helped me meet and interact with students from other universities		3.3 (1.20)
11. It would have been helpful for my learning to have more time in class with the interactive video off, and planned activities having me work with classmates and local instructor		3.7 (1.10)

*(Likert Scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

The anonymous survey results were confirmed with a course summary discussion held the last class session where students noted the key topics they learned in the semester – data life cycle, metadata, data models, Python programming, Hydrologic Information System tools, and data preparation and modeling. These topics aligned with the learning objectives for the course and suggest students accomplished the objectives. Accomplishments were further confirmed with the final team projects where student teams demonstrated these skills successfully.

The IVC effectiveness questions in general suggested the students were positive on its value for learning and their satisfaction increased the second half of the semester. The instructor team was aware of student feedback at the semester midpoint regarding the IVC approach, which led to changes in the course delivery to engage students more through IVC with direct questioning, in-class exercises, and student presentations. It is interesting to note that the change in mean rating from the midterm to the conclusion increased the greatest for the questions on IVC effectiveness and having multiple instructors. The final class discussion validated the efforts made by the instructors to improve the team teaching IVC approach to specifically enhance the engagement of students. The feedback suggested greater satisfaction in learning from the course, but also improved assessment of the IVC technology and having multiple instructors.

On the survey comments, students noted that the multiple perspectives offered by the instructor team were valuable. The students felt that, although they might not have become proficient in all the areas of the instructors' expertise as a result of the class, it was valuable to have been exposed to that expertise to see the possibilities and gain ideas. The value of multiple instructors was noted in the instructor end of class reflection. By design one of the instructors did not provide prepared lecture material because of time commitment limits for this offering. At the end of the semester it felt as if an opportunity to share a specific hydroinformatics application area had been lost. However, the instructors noted that these strengths were not well integrated into the lesson plans, but rather left to occur in an *ad hoc* manner through in-class comments and questions. This is an area to be improved in future offerings of the class – to explicitly take advantage of the instructor strengths, and part of this process is for the instructors to better learn the strengths of the others.

The instructor reflection noted that the value of team teaching extended beyond student learning. It also has had a significant positive influence on the instructors. Teaming provided opportunities to learn hydroinformatics skills from other instructors, critique methods of teaching, provide constructive feedback, as well as stimulate ideas and thoughts related to teaching, learning, and research. There is broader value for an instructor to be involved in a course, yet not directly providing the instruction, in terms of improving the course delivery at the time and in the future. There were a few instances when one instructor not actively teaching at the time could be following up on a student question or comment to provide a detailed response, web link, or other value to the lecture at a later time. Following from the improved ability of instructors to interact, student interactions across institutions were not well facilitated in the course. In future offerings of the course, student interactions could be encouraged by hosting in-person mixers or encouraging or requiring cross-institution student collaborations on one or more class activities.

A substantial challenge with IVC is to engage students at remote sites. Student survey results indicated that students felt the IVC was slightly positive in effectiveness of facilitating interaction and enhancing student learning. This response on the midterm survey led instructors to call out by name and question individual students at all locations during the second half of the semester; this questioning did help as the improvement in student response confirmed. However it was a bit cumbersome because there were slight delays in the IVC system, the system prevented eye contact, and instructors could not always see (or recognize) students at remote locations.

The instructors noted numerous challenges with the team teaching IVC approach. Technology was a hurdle to the success of the course. The classrooms had to connect and stay connected with video and sound. But the equipment and rooms varied across institutions and it was not always possible to connect or maintain a connection during the class period. There also were teaching challenges including how to grade consistently (we developed a consistent rubric), address out of class questions (which instructor handles them), and, as noted above, get and keep students active. Some—but not all—of these problems were addressed in real time by an employee of the Utah Education Network who facilitated the live broadcasts.

A major challenge with this course not related to IVC was teaching to a wide range of backgrounds at different universities. The course was offered by civil and environmental engineering professors. Although open to other majors, the student population was predominantly from civil and environmental engineering. In fact, 27 of the 28 students were in civil and environmental engineering, although advertisement was made to many majors. The instructor team felt that civil and environmental engineering graduate students might struggle to see the importance of material at the interface of computer science. To overcome this challenge, the team set out to make it clear that collection, quality checking, analysis, visualization, storage, and management of data are critical for civil and environment engineering research and are becoming more common in practice. The team provided numerous examples of how this is the case, not only related to the project funding the course development but also to other projects both indirectly related and totally unrelated. We assessed at the midterm and at the conclusion of the course whether the students felt the course content was relevant for their major.

Students did appreciate the broad scope of the project and forcing people out of their comfort zone. Students undertook a broad range of projects (see final write-ups at https://usu.instructure.com/courses/127332/wiki/student-final-project-results) and learned that there is commonality and tools to bridge gaps.

Another challenge was logistical in terms of finding common days and a time to meet that fit the varied university class and holiday schedules. A further logistical challenge was settling on a common course content system to deliver course materials (handouts, lecture materials, assignments, post videos of lectures. etc.). This required support and assistance from University distance learning staff.

Although the course instructors were motivated to train engineering students in computer science and informatics oriented areas, we were less sure how to do this with a cross section of students having varied experience in computer science type courses and research. Essentially, it raised a challenge of having to teach to an advanced set of students with different levels of entering knowledge and skills in a topic area that requires computer programming, database management, and web-based analysis and visualization not typically included in civil and environmental engineering coursework or research.

The team plans to again offer the course in Fall 2013 and add a fourth university. This addition will likely exacerbate several of the logistical challenges discussed above. But the addition also offers an opportunity to improve upon the strong foundation and increase the reach of this new hydroinformatics course and synchronous, team-taught method to offer it.

Conclusion

This paper described a new hydroinformatics course and synchronous, team-taught method to offer the course simultaneously at three universities. The course includes instructors and students at each location and uses IVC technology to synchronously and interactively offer the course at each institution. Entering the semester, the instructors had little prior experience with IVC. Student attitudes were surveyed and instructor reflection was used to assess the use of IVC, multiple instructors, and other course elements.

The results indicated that students largely agreed or strongly agreed that they learned a great deal in the course. Overall, the student agreement with the assessment questions increased from the midpoint to the course conclusion – as noted in the rating means increasing and the variances decreasing. This improved student rating likely was due to changes the instructors implemented in response to student comments at the midterm. Specifically, the instructors become more interactive through the IVC and developed activities to get students more active. In addition, students and instructors became more comfortable with the IVC technology over time. This improved use of IVC led to increased ratings that were marginally statistically significant (question 5 from the survey results report in Table 1). In sum, the survey responses suggest students felt the synchronous team-teaching approach using IVC technology furthered their learning, but more needs to be done to facilitate interactions with students at other universities (question 10) and the approach is not a complete substitute for offline, in-class activities with the local instructor and classmates.

Post-class instructor reflection and a recent review of the literature led the instructor team to conclude that the new team-teaching IVC approach must make the IVC activities more interactive across institutions. Moreover, the instructors believe the course will be more effective if the IVC activities are blended with individual institution activities in a way that creates focus during an alternating sequence of activities and discussions strategically transitioning from all institutions to single institutions.

The assessment of the first offering of the course focused on the attitudes of the students and reflections of the instructors. The instructor team has already begun to develop assessment techniques that target learning and achievement of objectives. These instruments will be implemented in the Fall 2013 offering with results to be reported in the future.

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