AC 2011-1326: AVOIDING ANOTHER TOWER OF BABEL: BRIDGING COMMUNICATION BARRIERS AMONG STUDENTS AND INSTRUCTORS FROM CIVIL ENGINEERING, HUMANITIES, AND OTHER DISCIPLINES IN A MULTIDISCIPLINARY COURSE

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Avoiding Another Tower of Babel: Bridging Communication Barriers Among Students and Instructors from Civil Engineering, Humanities, and Other Disciplines in a Multidisciplinary Course

Abstract

Communication among students and faculty from different disciplines – sometimes widely different disciplines – is one of the major challenges facing those trying to mingle civil engineering students with students from other disciplines in multidisciplinary and interdisciplinary classrooms. Of particular difficulty is trying to bridge the chasm that seems to separate engineering and humanities students, both in terms of their respective worldviews and the language by which they tend to express those views. Yet when such students are put together into multidisciplinary courses, regardless of the level, a common foundation in terminology, concepts, and techniques is needed to bridge that chasm. Establishing such a foundation is difficult: not only is there a risk of overwhelming students new to the topics, there is also the hazard of losing the interest of students who may already have an established interest in it.

This paper describes the techniques used in a water resources management course offered at the University of Utah to bridge the communication barriers among students from civil engineering, humanities, and other disciplines. The strategies and techniques employed in a second offering of the course are described, and the successes and areas for improvement identified through the assessment are highlighted. New tactics applied include lesson learning objectives, student journals, outside events (e.g., conferences and seminars), instructor interaction and disciplinary role playing, and multidisciplinary teams for in-class exercises and the semester project. The course was assessed using an opinion survey of students, an embedded assessor, and instructor reflection on student performance and feedback. The assessment identified several methods to be effective for improving communication among disciplines. Based on a synthesis of assessment tools, guided class discussions, access to outside water resources related events, pre-planned instructor interaction and disciplinary role playing, and multidiscipline teams were found to be the most effective methods to improve communication between students from civil engineering, humanities, and other disciplines.

Introduction

Civil engineering educational objectives have been broadened in the past decade to include greater non-technical and multidisciplinary coverage. For example, the American Society of Civil Engineers (ASCE) Body of Knowledge was recently refined to highlight humanities and social sciences as foundation outcomes[1,2]; include sustainability, history, contemporary issues, and project management as technical outcomes; and add a wide range of professional outcomes such as leadership, communication, and teamwork[3]. The motivation for incorporating humanities and the other topics into engineering education has been further emphasized in the future outlook of engineers in visions published by the National Academy of Engineering[4] and ASCE[5]. The perceived value for engineers is an improved ability to envision and adapt engineering projects to fit within societal, ethical, and cultural contexts. Interestingly, analogous discussions are taking place in humanities disciplines, such as philosophy, where applied philosophy is in some circles considered essential for making the discipline more relevant. Historically, arguments about environmental ethics within philosophy have narrowly focused on how best to think about "nature" in order to protect it: should it be viewed as a set of resources to be utilized for human-centered ends or does nature have some "intrinsic value" apart from how it can be utilized by humans. But the increasingly shrill, narrow and pedantic tone of these arguments has only served to alienate philosophers from those actually working in the field. Recognizing this disconnect, some in the discipline have begun reaching out beyond the ivory tower, to talk about the practical applications of their discussions for concrete environmental policies[6,7].

The clear motivation to increase exposure of civil engineering students to content beyond traditional technical civil engineering skills has created a number of approaches to accomplish this objective. Three common approaches are (1) requiring humanities courses to be taken as general education requirements as part of the Bachelor of Science degree, (2) exposing civil engineering students to the humanities in civil engineering courses taught by broadly read civil engineering professors[8], and (3) introducing modules or blocks of learning in the civil engineering curriculum[9]. Another avenue for integrating humanities into civil engineering education is through multidisciplinary and interdisciplinary courses, which can more deeply explore the intersection of humanities and civil engineering and the depth of the relationship within a specific problem context rather than relying on tangents or superficial discussions. It has been proposed that instructing such courses by a multidisciplinary team may be the most effective approach to capture the previously identified need for interaction among educators from engineering and the humanities[10,11].

Although potentially highly effective in achieving a range of educational objectives, teaching a multidisciplinary course for students from civil engineering, humanities, and other disciplines and instructing with a multidisciplinary team is a challenging endeavor requiring effort to define a single educational philosophy[10], appealing to a wide range of learning styles, operating with a widely disparate knowledge base, and overcoming communication barriers. This paper describes a multidisciplinary course taught by a multidisciplinary team bringing together students from civil engineering, humanities, and other disciplines to study, analyze, and create an integrated set of technical and non-technical solutions to water management problems in the western U.S.[12] The second offering of the course was modified to address communication barriers identified in the first offering. Communication among the disparate disciplines is addressed with several tactics that are described and assessed in this paper.

Course Description

Historically, civil engineers have planned and designed water infrastructure to prevent floods, supply water, collect stormwater and wastewater, generate hydropower, and manage waterways. Recently, challenges facing water resources projects have intensified and diversified because growing metropolitan populations, aging infrastructure, changing climate, improved awareness of environmental impacts, and policy have become much more nuanced and complex. Nowhere is this more evident than in the western United States, particularly in that region served by the Colorado River. In essence, even if the skills, technologies, and solutions available to water resources engineers, either alone or in concert, were technologically, economically, and environmentally feasible, there would have to be massive changes to the region's political and social institutions to implement them effectively[13]. The major limitations in the future will be developing creative solutions addressing multiple objectives and implementing the solutions by engaging policy makers, economists, government agencies, the public, and others. The multidisciplinary water management course at the University of Utah described in this paper is meant to address this challenge.

Hydrotopia, the name we have given our multidisciplinary water management course, combines concepts from water resources engineering, philosophy, law, planning, economics, political science, and social sciences. The goal of the course is to develop the next generation of professionals responsible for planning, designing, managing, and operating water resources systems and facilitating the interaction of those systems with society in the western U.S. It is designed to cultivate in the next generation of water engineering professionals a broader sensibility about the cultural climate in which they will operate and to develop in humanists, social scientists and others who will be responsible for shaping and articulating that cultural climate a more grounded understanding of the solutions available to address water resources problems. The course learning objectives are:

1. Explain water projects to non-technical people
2. Navigate water rights administration process
3. Describe multidisciplinary elements of water projects
4. Analyze water management decisions using modeling tools
5. Assess implications of technical and non-technical water project solutions and decisions in a societal context
6. Effectively communicate with others to develop, judge, and recommend *multi-objective solutions* to water resources challenges

The course is designed to meet learning objectives for a multidisciplinary student population and to be co-taught by professors from civil engineering and philosophy (or other humanities discipline).

The spring 2009 course (first offering) had 22 students. Of the 22, ten were Civil Engineering majors (four graduate students), five Philosophy (one graduate), two Environmental Studies, one Economics, one City and Metropolitan Planning, one Communication Studies, one Political Science, and one Environmental Engineering. The current (spring 2011) offering has 31 students, of which 15 are Civil Engineering students. The remaining students are majoring in one or more of the following: Philosophy, Environmental Humanities, Communication Studies, Environmental Studies, City and Metropolitan Planning, Economics, Public Administration, and English.

Within the context of the course assignments, discussions, and guest speakers, students are exposed to philosophical and legal concepts, hydrologic principles, metropolitan planning methods, water resources engineering design and management techniques, water management modeling and analysis tools, social and behavioral science theories, and more. Specific topics include water development in the western U.S., water scarcity, water conflict, water law, hydrologic cycle, water planning, water infrastructure, water management modeling, water-energy nexus, technological solutions, environmental impacts, aging water infrastructure, climate change impacts on urban water supply, city planning for water, restoration, and international water projects.

Our pedagogical approach engages students in guided class discussions, in-class team exercises, guest speaker and instructor presentations, case study analyses, and a team project related to historical and emerging water resources engineering issues in the western U.S. Projects and case studies are based on current events of controversial or high-profile water projects including the Snake Valley conflict, Green River Nuclear Power Facility, Lake Powell Pipeline, Klamath Dam Removal, Toiler-to-Tap in Southern California, and others. Guest speakers come from the highest ranks of environmental organizations and state agencies responsible for water management in the western U.S. including directors of Utah State Department of Natural Resources, Utah State Divisions of Water Resources and Water Rights, General Manager of a Major Water Conservancy District, Executive Director of the Upper Colorado River Commission, Executive Directors of Environmental Nonprofit Organizations, Professors of Law, Planning, and Political Science, and more. Their backgrounds cover a broad range of disciplines that have a role in water management, similar to the student composition in the class. Readings range across water engineering, philosophy, planning, and policy (a full reading list is included in appendix A). Assignments include maintaining a journal, completing water management modeling exercises, writing position papers individually and in multidisciplinary teams, defining the concept of *Hydrotopia*, and completing a multidisciplinary team project. The assignments are designed to stimulate critical thinking, encourage analysis of water resources projects from multiple perspectives, and encourage interaction among disciplines.

The position papers are a key element of this class. We assign positions to the students randomly, leading to papers being written from positions that the students may not agree personally or professionally. This forces the student to focus on facts and logical reasoning. Past student feedback suggest the assignments force them to appreciate the opinions of others. Writing and speaking skills are stressed in all assignments and activities.

The course was first offered in the spring 2009 semester. Although successful, one area for improvement noted was enhancing communication among disciplines. Based on feedback students of different disciplines failed to effectively communicate and many felt the instructors failed to relate to the other disciplines. In general, the students felt they (1) were not given enough opportunity to work with the other disciplines, (1) did not understand class activities and how they related to their discipline, (3) misunderstood discipline-specific terms, and (4) should have been exposed to more real-world projects. Misunderstanding of terminology was especially critical because the same words were being used by the different disciplines but the connotation was different. For example, the term ‘water right’ may imply a legal construct to those in engineering, planning, and law. But to environmental humanities and philosophy majors it may imply a human right. In some cases students gain an understanding as the discussion progresses, but it causes initial confusion, which may lead to reduced learning and in some cases confusion throughout the discussion. Another area that needs addressing is the disciplinary jargon – terms such as ‘worldview’ and ‘precautionary principle’ in philosophy may need definition to the civil engineers, while terms such as ‘water demand’ and ‘acre-foot’ may need definition for those in humanities. In general, civil engineers need to find ways to eliminate use of jargon terms to improve their communication to clients and stakeholders so the awareness developed in this course contributes to the civil engineering program outcomes.

Additionally, there was a two-cultures model assumed from the get-go that, although it was seriously and effectively attacked, was never fully vanquished: the engineers were saddled by the humanists as universally ascribing to the "we should build it if we can" mentality, and the humanists were burdened with the "we should leave nature alone" sentiment.

We surmised from the comments and discussing with students after completion of the first offering of the course that part of the problem was students were not in tune with the teaching styles employed by the instructor team. The lack of understanding was partially driven by the disciplinary approach to teaching employed by each instructor. In Philosophy, instructors follow a Socratic approach where questions are posed related to a reading assignment, relevant issue, etc. and students are conditioned to respond with comments, questions, and ideas in a guided discussion format. In Civil Engineering, the teaching style incorporates greater use of examples, demonstrations, physical models, and direct questioning. In both cases the instructors seek to stimulate critical thought, but in different ways. Many students found it challenging to relate or adapt to the different teaching styles during the spring 2009 semester. For the spring 2011 offering, we explained our teaching styles and made it clear that the objectives are the same and they were not discipline specific approaches. We also implemented several other methods (described in the next section) to avoid the communication barriers we experienced in the first offering.

Methods Implemented to Overcome Communication Barriers

Assessment of the spring 2009 offering identified communication challenges among students from civil engineering, humanities, and other disciplines and led to the inclusion or enhancement in the spring 2011 offering of the following seven class elements and teaching techniques to bridge communication barriers:

- Learning Objectives
- Journal
- Outside Events (conferences, speakers, movies, and activities)
- Instructor Interaction and Disciplinary Role Playing
- Case Studies
- Multidisciplinary In-Class Exercises
- Multidisciplinary Team Project

In addition, with experience from the first offering, the instructors pre-planned overt efforts to connect functionally similar but discipline-specific concepts (e.g., precautionary principle with safety factors, worldviews with design constraints, etc.). These techniques were implemented in the spring 2011 semester, in addition to including assigned readings, guest speakers, instructor presentations, instructor-led class discussions, and individual position papers as in the previous offering. The following sub-sections contain brief explanations of the techniques new (or significantly modified) to the spring 2011 course offering.

Learning Objectives

Lesson learning objectives were not used by the instructors in the first offering. In general, the definition of course educational outcomes and program outcomes for disciplines in the humanities is more challenging than in engineering. At the University of Utah, the humanities disciplines have started this trend towards defining educational outcomes for their programs and courses, but lesson objectives have remained underutilized. Thus, we did not include them in the original offering. We incorporated them into this second offering. *Course* learning objectives were carefully constructed in the original offering and referenced throughout the course and each lesson was related to one of the *course* learning objectives (presented above). However, feedback from the spring 2009 course acquired through the end-of-semester surveys and instructor reflection indicated students in general were unable to make the connection from lesson activities and objectives for activities. This led to students from different disciplines interpreting the objectives of the activities differently and in many cases seeing them as discipline specific. For example, lessons on water management infrastructure and administration, water planning, technologies, and water rights were identified as too engineering focused by several of the humanities students in the course. And the civil engineers commented on the lack of importance of the lessons on perspectives of water, water development history, and water conflict. Essentially, we were poorly communicating the relationship of activities and lesson topics to lesson learning objectives and this was causing students to interpret the objectives and relevance of the activities differently. We therefore created learning objectives for each lesson and made a direct connection to the topic of the lesson and activities in the lesson.

Journal

Students were supplied with notebooks and required to record their thoughts, notes, discussions, etc. in journal. The objective was to encourage them to reflect during class and recall or share their journals with others in the class. We anticipated more sharing of thoughts from journals in small group discussions in class.

Outside Events

Water issues in the western U.S. are mainstream and a plethora of seminars, activities, conferences, speaker series and other events related to water in the west occurred at the University of Utah or in Salt Lake City during the spring 2011 semester. The students were kept informed of the events, encouraged to attend, and in some cases offered extra credit for attending and summarizing the event in a written submission. An optional evening screening of the movie *Liquid Assets* was also hosted for the class by the professors. An especially fortunate coincidence was the timing of the course with an International Water Conference hosted at the University of Utah. The *Water, Conflict, and Human Rights: Emerging Challenges and Solutions* conference took place February 23-25, 2011 and the topics of the panels and keynotes aligned perfectly with class topics. The two instructors were moderators for two of the four panels providing additional insight and extended discussions on the topics. A large majority of the students participated in one or more of these outside events. In fact, the optional movie attendance was above 90% and more than half of the students participated in the conference, several extensively.

Instructor Interaction and Role Playing

Another tactic implemented in the spring 2011 course offering took advantage of the co-taught instructor format to role model multidisciplinary interaction and elucidate complex humanist and social contexts within which engineering solutions reside. For example, on the first day of class we decided to begin a discussion of water scarcity in the west U.S. by highlighting from a civil engineering perspective the potential for supply side solutions and from a philosophy perspective the potential of demand side solutions that would require lifestyle adjustment. We preplanned the interlude to display the interaction of engineers and humanists in a civil and reasoned manner. After we completed this element in the class, we described our effort and objectives by presenting a quote by the famous planner and scientist Aldo Leopold:

> *"The engineer has respect for mechanical wisdom because he created it. He has disrespect for ecological wisdom, not because he is contemptuous of it, but because he is unaware of it. We have, in short, two professions (Engineer and Ecologist) whose responsibilities for land use overlap much, but whose respective zones of awareness overlap only a little. What can we say about their future relationship? About the direction of possible adjustment?"*

The objective was to establish at the beginning of the course the goal of facilitating interaction among the disciplines to improve awareness of each other and their roles, talents, and insights related to water issues and projects.

Case Studies

One key lesson learned from the original offering of the course was the need to use relevant and local real-world projects as case studies to provide a context to terminology, concepts, and techniques. In particular, the need to provide case study projects and in-class activities was essential to introducing terminology and concepts in an open ended way that could provide a solid foundation for those that were new to the topic and yet still permitted greater exploration for those individuals who had previous exposure to water resources and civil engineering. For the spring 2011 offering we engaged the students in a real project to define the concept of water neutrality for the University of Utah campus and to work with a computer model to analyze alternative solutions to water management. The students worked on this exercise in three class periods over a 3-week period (mixed in with guest speakers and instructor-led discussions and presentations). The student teams were organized to encourage multi-disciplinary interaction. The teams were required to present their definition, plan, and judgment of the plan to the class. During the class period they were presenting, the project manager (a civil engineering consultant) attended the session to observe and then present the definition and plan developed by the University and consultant team.

Multidisciplinary In-Class Assignments

In the first offering we relied too much on open class discussions. We decided to integrate into the class activities greater use of small group activities and discussions, but required the groups when possible to be comprised of multiple disciplines. The objectives for the group activities were clearly defined and expectations for producing ideas, answers, etc. were provided.

Multidisciplinary Team Project

Students in the first course offering strongly noted the lack of interaction with other disciplines in the team project. We mistakenly permitted students to self-select their teams for the project, which resulted in many interesting projects that were unfortunately too disciplinary. Although effective projects for the participants we were unable to fully achieve our goal of multidisciplinary problem solving. To improve the interaction among disciplines with the intent of improving communication we decided to assign teams, and make them have disciplinary balance. We created the teams using several quantitative and qualitative metrics. We collected information about GPA, major, number of water-related courses completed, water-related extra-curricular and service activities, educational interests, and career objectives. With this information we formed teams that were as balanced (meaning varied as evenly as possible) by major, GPA, background experience with water projects, and gender.

Assessment

The methods employed in the spring 2011 course offering to overcome communication barriers included the teaching techniques used in the first offering plus the new or revised methods described in the previous section. All methods were assessed using a survey of student opinions of method effectiveness, an embedded assessor, student performance and feedback, and instructor reflection.

The survey of student opinions had two parts. First, students were asked to select their relative agreement or disagreement (Likert Scale – Strongly Agree, Agree, Neither Agree or Disagree, Disagree, Strongly Disagree) regarding the effectiveness of the seven methods described in the previous section. The second part of the survey asked the students to rank from most effective to least effective twelve methods:

- *New Methods:* learning objectives, journal, instructor interaction/role playing, outside events, case studies, multidisciplinary team project, multidisciplinary class exercises
- *Previous Methods:* assigned readings, guest speakers, class discussions, instructor presentations, position papers

Students were also asked to provide additional suggestions and comments. This survey was administered in the ninth week of classes.

The second form of assessment was the product of a unique opportunity. A doctoral student from Communication was auditing the course in the spring 2011. She has a background in conflict resolution and water issues and is focusing her dissertation research on public meeting communication related to water resources. We arranged to have her provide independent analysis of the effectiveness of techniques to improve communication among disciplines based on her observations and independent discussions with students. We also asked her to monitor the dynamics in the multidisciplinary teams to identify conflict and miscommunication and pinpoint causes.

The final assessment method is a compilation of observations and reflections from the instructors. Student performance on assignments and informal student feedback was considered in combination with instructor reflection on the improvement in communication among disciplines in this offering compared to the previous offering.

Effectiveness Survey

The survey netted 28 responses from 31 students. The results are displayed in Table 1. An effectiveness value represents the average of the 28 responses. An effectiveness value of 1.0 indicates a unanimous *Strongly Agree* (that the method is effective) response from the students, while a value of 5.0 indicates a unanimous *Strongly Disagree* (that method is not effective).

The results indicate students for the most part found the methods employed to be effective to improve communication among disciplines. There was general consensus that the journal was the least effective technique. This makes sense because it is primarily an individual activity. Lesson learning objectives also were found to be less effective than the other techniques, which again is likely due to the objectives helping students to connect activities to their expected outcomes which is indirectly connected to improving communication among disciplines. Students agreed that outside events, the instructor interaction and role playing, case studies, and team project were the most effective (these techniques were given the most *Strongly Agree* ratings). It is interesting to note the student opinion that the multidiscipline teams for in-class exercises were less effective. This rating makes sense knowing the in-class exercises required rapid compromise with less time to discuss concepts, which led to greater incidence of conflict observed in the classroom. Upon viewing the results of this midterm survey we decided to use the project teams more often for the in-class team assignments to eliminate the increased incidence of conflict caused by lack of familiarity among some students.

The effectiveness ratings were also averaged for Civil Engineering (CE) students and non-CE students and the results are shown in Table 1. It is interesting to note the lower rating (less effective = higher number) in general from the CE students. This suggests the non-CE students have perceived communication among the disciplines is better than that perceived by the CE students. The key finding from the separation of the CE and non-CE students is the very close agreement on effectiveness for the Instructor Interaction and Role Playing element. Essentially, most students *Strongly Agreed* this was effective.

Table 1. Results from student survey of effectiveness.

Method/Technique	Effectiveness* All Students	CE Students	Non-CE Students
Learning Objective	1.96	2.13	1.73
Journal	2.38	2.67	2.00
Outside Events	1.62	1.87	1.27
Instructor Interaction/Role Playing	1.65	1.73	1.55
Case Studies	1.62	1.73	1.45
Multidiscipline In-Class Teams	2.04	2.33	1.64
Multidiscipline Team Project	1.69	1.93	1.36

*Likert Scale Average; 1 = Strongly Agree to 5 = Strongly Disagree

The results of the second part of the survey are shown in Table 2. Class discussions were the method students felt were the most effective at helping them bridge communication barriers. Next, Instructor Interaction, Guest Speakers, and Multidiscipline Team Project were identified as more effective than other methods. As found with the individual questions focused on new techniques, the use of Lesson Learning Objectives and student Journals were found to be the least effective for improving communication among disciplines. It is interesting to note the standard deviation, which indicates the variation of student opinions. The largest variation was found for the Assigned Readings, the Multidiscipline Team Activities, and the Team Project. The different learning styles of students (verbal, global, etc.) likely were a reason behind this observation. In addition to the ranking of each method, we also asked the students to respond if the methods were effective or ineffective. These responses were consistent with the others --- the Journal and Multidiscipline Team In-Class Exercises were identified occasionally as ineffective. Several students rated Learning Objectives as *Undecided*, again indicating the perceived lack of connection of the technique to communication improvement.

When the rating results are divided into responses from CE students and those from non-CE majors a few important observations emerge. Although both the CE and non-CE students were agreed that class discussions were the most effective, it is interesting to note that the multidiscipline team project was identified by the non-CE students as highly effective, nearly the most effective technique. The CE students agreed it was effective, but it was not among the top 3 most effective. The explanation for this observation was elucidated through discussions with some of the individuals. In a few instances CE students expressed mild frustration with the non-CE team members, but non-CE majors questioned did not indicate frustration with the CE majors. It was not an issue for the teams or their projects because it was not a disappointed feeling, but rather an “it could be better” feeling. This is described further by the embedded assessor comments below.

Table 2. Student rating of teaching methods effectiveness

Method/Technique	All Students Rating Average*	All Students Rating Stan. Dev.*	CE Students Rating Average*	CE Students Rating Stan. Dev.*	Non-CE Students Rating Average*	Non-CE Students Rating Stan. Dev.*
Learning Objective	10.0	1.7	10.2	1.8	9.6	1.4
Assigned Reading	7.3	3.1	6.7	3.0	8.1	3.4
Journal	10.6	2.4	10.1	3.0	11.2	1.0
Instructor Interaction/Role Playing	5.1	2.8	4.4	2.3	6.0	3.2
Outside Events	8.6	2.6	8.9	2.6	8.2	2.7
Guest Speakers	4.5	2.8	4.1	3.1	5.1	2.2
Class Discussions	2.8	2.1	2.6	2.0	2.9	2.2
Instructor Presentations	6.4	2.4	6.3	2.3	6.6	2.6
Case Studies	5.9	2.8	6.1	2.8	5.6	3.0
Team Project	4.6	3.2	5.8	3.3	3.0	2.3
Multidisciplinary Exercises	5.8	3.6	6.3	3.6	5.0	3.8
Position Papers	6.5	2.5	6.4	2.7	6.7	2.5

*Methods were ranked from 1 (most effective) to 12 (least effective); the average and standard deviation are included

Embedded Assessor Analysis

The embedded assessor (third co-author to this paper) compiled copious notes on course conduct and effectiveness. The distilled analysis contained here reflects the key observations of the methods targeting improved communication among disciplines.

The journals offer an opportunity for students to combine thoughts, notes, and information they acquire in and out of class. During lectures and conferences outside of class students have been observed at events around Salt Lake City consulting their journals to compose thoughtful and informed questions to speakers and public officials. They are effective learning tools, but as the surveys show they are not perceived as effective for improving communication among the disciplines.

Bringing attention to the many outside activities improved the course and its enhancement of communication among disciplines. Being made aware of the vast offerings throughout the community has demonstrated the larger discussion of water issues that is occurring in the community. Additionally, the students from this class that have been reading and thinking about water resource issues have made interested and engaged audience members at local events about water issues. The quality of questions the students present have made the events more interesting for all of the participants. Although not every student has taken advantage of the outside events, the ones that have supplemented the course readings and lectures with community events have gained a perspective offered from experts participating in the global discourse around water. It is clear the students engaged in these outside activities are improving their ability to communicate with a much broader audience than found in the classroom.

Although collaborative multidisciplinary teaching is a great idea, it is difficult to execute. The embedded assessor noted the professors demonstrate team teaching in way that makes it appear effortless: “The expertise of both instructors helped to establish an ethos in which students from varying disciplines respect the knowledge presented even if they are not familiar with the subject matter.”

Additionally, the embedded assessor noted the instructors are able to communicate complex ideas without relying on jargon or technical language that would alienate students not of the discipline. “The instructors have done a good job of explaining the justification of the class, and made the students aware of pedagogical processes that are used to fulfill the class objectives.” The reading list compiled for the class was noted as outstanding and spanning many disciplines (see Appendix A). These well considered assigned readings insure the students come to class ready to discuss a wide variety of water related issues. This reading is presented on a web site that is easy to use, informative, and has a terrific supply of resources outside of the assigned reading. Additionally, the guest speakers represent a variety of prerogatives and positions within water resource management. The caliber of speakers is such that these individuals would be difficult or impossible for students to access outside of the class.

The embedded assessor was very impressed with the multidiscipline team in-class exercises, especially the University of Utah Water Neutrality Project. It was noted that students (especially those in smaller groups) enjoyed integrating the computer technology into the analysis. This observation is especially interesting because it is contrary to some extent with the student ratings, which placed the multidiscipline team in-class activities as less effective than other techniques.

Group projects involving students studying the same thing are difficult, adding the dimension of multidisciplinary teams in this class is a daunting request. The embedded assessor noted that in this setting it appeared that team formation was especially difficult. Because teams were strategically assigned to have variation of skills, disciplines, and experience in each group, at the beginning team members were hyper aware of what they were bringing to the group. Interestingly, none of the teams took the time to introduce themselves and determine what specific skill sets they had been equipped with.

The other challenge to communication that was observed by the embedded assessor is that assumptions have been made about how engineers view the world and how humanities students view the world. Without taking time to evaluate the accuracy of those assumptions, discussions are held. These assumptions limit the creativity available to the groups and class as a whole. As the students are required to work together and develop a history of shared experience, the embedded assessor feels confident they will be able to represent a more holistic version of themselves to the group.

This class is composed of self selecting students that have prioritized this transdisciplinary experience as part of their curriculum. As the class nears conclusion and the complexity of water issues become more apparent it will be interesting if the multidisciplinary teams focus on technology/engineering solutions or philosophical changes in human behavior.

The embedded assessor noted that although this class proves an exemplar in multidisciplinary teaching there are some aspects that could be improved in the next iteration of the class. Suggestions include:

- Facilitating a discussion in which students can define what characteristics identify them as a member of their field.
- Not encouraging the assumption that privileges the idea that engineering is more “logical” then the humanities.
- Offering some instruction on group dynamics and how effective team work is accomplished. It seemed that as teams were formed they had difficulty in the first steps of group formation.
- Open more space in class for discussion, and allow it to be more student directed.
- Encourage a more critical evaluation of movies, readings, and speakers in class discussion.

As someone with a background in water conflict, the additional knowledge and perspective of engineering has changed the way the embedded assessor personally perceives water issues. Additionally, it was noted that focusing the problem solving skills of multiple disciplines models the integrative way that complex problems need to be solved in the future. Students are not only being exposed to water resources management they are being socialized to participate in transdiscipline problem solving. Learning the skills necessary to communicate with those outside of the field will be a lifelong skill that will serve these students well.

Instructor Observations

The class is more successful this offering than the spring 2009 offering. The students are extremely enthusiastic, eager to attend outside events for no additional “extra” credit, and interested to learn about other disciplines. And we have witnessed much better communication among disciplines before, during, and after each class in very positive ways. This is much different than the first offering when the interaction between disciplines was less positive and less frequent, although in many ways the course objectives were being met.

The class discussions have been much more interactive with less prompting of students. In the first offering the class discussions were difficult to initiate and often were dominated by a small number of students. In the current offering the class discussions are lively, positive, and reflect an inquisitive tone where students are seeking to learn from the other students rather than dismiss or overrule other perspectives with their own. Visitors/guest speakers that attended both offerings have made similar observations, mostly in the form of how interested students were following their seminars and how much they enjoyed the interaction. We attribute the improved class discussions to the new methods incorporated to enhance communication including making the objectives of each lesson clear and providing a better example of multidisciplinary discussion with our exchanges and role playing of an engineer and philosopher.

The position papers have had much better structure and much improved writing. The preliminary work on the team projects has also been exceptional. The project topics are well rounded, stretching across disciplines. The topics even display creative integration of disciplines in project topics. For example, one team is analyzing the effectiveness of a rainwater harvesting program in Salt Lake City using a very quantified engineering analysis, and that analysis is being integrated with an analysis of attitudes towards rainwater harvesting and how people's value of water is affected.

We attribute much of the improvements to the course this offering to retooling the course and focusing on the American West. We have enlisted an expansive and diversified set of guest speakers and we limited the scope of the kinds of things to bring into the conversation. The most important reason we feel is the two years of additional time for us to build a stronger relationship and become more aware of the other disciplines. We have had the opportunity to exchange readings, ideas, points, and even attend a water resources conference together. This "time on task" has led to a much improved interaction in the classroom leading to a much better flow to the class discussion. The students and the embedded assessor have noted this improved interaction. We quite simply have a better understanding through experience of how to teach together to a multidisciplinary set of students.

Summary and Conclusions

This paper described a multidisciplinary water management course bringing together students from civil engineering, humanities, and other disciplines to address water resources management challenges in the western U.S. The multidisciplinary approach has been found to be essential to create a realistic setting for addressing the totality of the water resources problems being faced now and in the future. Specifically, the course sought to explore the role of humanities in water resource engineering projects. The paper provided an overview of the course, described the pedagogical methods implemented to improve communication among the disciplines to better achieve the course learning objectives, and presented a summary of the assessment of the effectiveness of past and new teaching methods.

The course offering in the spring 2011 is nearly two-thirds complete and we feel it has been superior to the first offering and that we are avoiding the "Tower of Babel" that reduced the effectiveness of the first offering. From our assessment of the course, the major conclusions are:

- Based on student survey responses, class discussions are the most effective method to improve communication among disciplines.
- Based on the embedded assessor analysis the inclusion of numerous outside events (e.g., international water conference at the University of Utah) broadened the perspective of students and helped to improve their ability to interact and communicate with other disciplines.
- Based on instructor reflection, student surveys, student feedback the interaction of the instructors leading class discussions is a critical activity helping to enhance communication among disciplines.
- Effective multidiscipline team teaching requires developing a relationship personally and professionally between instructors.

Our success is a product of a lot of work and luck. The work is not the kind that most faculty traditionally do, which is consistently interacting collegially with someone well beyond their disciplines: the two instructors have been in regular and varied forms of contact over the last three years, and in almost every encounter, the subject of this course has come up. Formally, we met consistently for months, emailed each other regularly about ideas we had or articles we would read. The luck involved here is that ours is a partnership about something that we are both passionate about, both personally and intellectually. We have found a particularly appealing outlet in a hungry and ready audience, one that craves an interdisciplinary conversation about something as fascinating and timely as water. We happened to be in the right place at the right time.

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Appendix A. Class Reading List

1. Barbanell, *Taking Scarcity Seriously*; Barringer, *Lake Mead Drying Up*; Piechota, *Response to Lake Mead Drying Up*
2. Desert Wars Video; Arnold, *Moral Economy of Water in the West*
3. Selected Vision Statements from 2009; *Water is for Fightin'* Video
4. Barbanell, *Water Rights Doctrines*; Debuys, *Problem of Western Water*
5. Water Rights in Utah; Fort, *Water Policy of the West*; Henetz, *Whose Water Is It*
6. Green River Nuclear Power Plant Resources for Position Paper #1
7. Grigg, *Chapter 1 – Management in the Water Industry*; Grigg, *Chapter 24 – Water Management in the Western United States*, Draper, *Section 5 – Water Allocation Strategies*
8. AWWA 50, *Chapter 1 - Introduction to Water Resources Planning*; Grigg, *Chapter 4 – Planning and Decision-Making Processes*; Simms, *Making the Rain*; Steinberg, *Morton Salt Disaster*; Viessman, *Utah Water Planning Overview*
9. Grigg, *Chapter 3 - Water Infrastructure and Systems*; Geronis, *Dam Building May Not Be Over*
10. MODSIM Users Manual (Skim) and MODSIM Tutorial 1 (Poudre)
11. Chatham River Case Study, Warshall, *Watershed Governance: Checklists to Encourage Respect for Waterflows and People*; Grigg, *Denver Two Forks Case Study*
12. Grigg, *Chapter 8 – Water Industry Structure*; Cech, *Chapter 10 – Local, Regional, State, and Multistate Water Management Agencies*
13. Larsen and Burian, *Energy Requirements for Water Use in Utah*; Webber, *Catch 22 – Water vs. Energy* – in *Scientific American*, pages 34-41
14. Totty, *High-Tech Cures for Water Shortages*; Royte, *Tall Drink of Sewage*
15. Lake Powell Pipeline Resources for Position Paper #2
16. Liquid Assets video; Boyett, *65 Percent Rate Increase*; Salt Lake Trib Water Tax article; Bui, *Phoenix Water Rate Hike*; Kosik, *U.S. Water Infrastructure in Trouble*
17. Adler, *Restoring Colorado River Ecosystems*
18. IPCC, *Chapter 3 - Water Resources*; Dracup, *Water Sustainability: The Potential Impact of Climate Change*; Hooten, *Global Warming and Climate Change: Is Utah's Water Resources at Risk?*; Fahys, *Utah Outlook: Drier summers, wetter winters*
20. Funk, *Suggestions for Urban Water Conservation*
21. Ellin, Canalscape: *Practising Integral Urbanism in Metropolitan Phoenix*
22. Cech, *Chapter 15 – Emerging Water Issues*; Black, *Water Insecurity*
24. Page, *China Pushes Water Plan*; Foster, *China Redirects Water*; Watts, *Thirst of China Cities*
25. Position Paper #3 Klamath Dam Removal Resources