AC 2007-983: INTEGRATING THE DEVELOPMENT OF TEAMWORK, DIVERSITY, LEADERSHIP, AND COMMUNICATION SKILLS INTO A CAPSTONE DESIGN COURSE

Joseph Hanus, University of Wisconsin-Madison

Jeffrey S. Russell, University of Wisconsin-Madison

Integrating the Development of Teamwork, Diversity, Leadership, and Communication Skills into a Capstone Design Course

Abstract

The development of teamwork, diversity, leadership, and communications (TDLC) skills in our professional domain is critical to our engineering education program and profession. We solve problems in teams which are diverse, require leadership, and must communicate internally and externally to achieve their team goals. The challenge of developing these skills in the Civil and Environmental Engineering program at the University of Wisconsin at Madison, was addressed through the development of a series of workshops embedded within the senior capstone course. The development of these active learning workshops from traditional knowledge based lectures provided an insight into the student's cognitive knowledge level and appreciation for the TDLC skills. The students have a greater base of knowledge and experience in the TDLC skills than initially perceived, which resulted in the development of a Learn-Practice-Assess model. The intent of the model is to leverage the student's knowledge and experience, and develop life-long learning skills. A set of workshops based around the Learn-Practice-Assess model to develop TDLC skills is offered as an effective program to build upon the student's higher cognitive level, integrate across the TDLC skills, and provide a contextual application in the capstone design course and beyond.

Introduction

The development of individual skills in the technical and professional domains is paramount to preparing contemporary engineering students for success in the engineering field. The American Society of Civil Engineer's Body of Knowledge Committee has focused on identifying these skills, as well as how they should be taught and learned and who should teach and learn the skills[1]. The 15 outcomes in the BOK are categorized into the technical and professional domains [2]. It is the author's belief that our profession is comfortable and capable of teaching and developing the skills associated with the technical outcomes. However, the technical domain's skills are necessary, but not sufficient, for individual success in our profession; if not the overall success of our profession. The development of skills in the professional domain carries equal weight in the full development of a successful engineer and professional. Evidence of this position is substantiated by ASCE's efforts in development of Education for Professional Practice[3]. This paper will outline the evolution of a program in a senior civil engineering capstone course to develop a set of skills in the professional domain, specifically teamwork, diversity, leadership, and communications (TDLC).

The TDLC skills in the professional domain are directly related to BOK outcomes and associated ABET outcomes. Teamwork skills are clearly necessary to function on multidisciplinary teams (BOK 4, ABET d). The understanding of diversity opportunities and the skill to leverage diversity is associated with the knowledge of contemporary issues (BOK 10, ABET j). Leadership skills are indirectly related to teamwork skills and are defined as an understanding of the role of the leader and the leadership principles and attitudes (BOK 15). Effective communication skills are inherent to all the skills in the professional domain (BOK 7, ABET g). These skills are commonly addressed in engineering programs in separate courses and/or an end-of-program team project design course, i.e., capstone course. However, simply having a requisite capstone course with these skills included does not guarantee successful development of these skills, and potentially a negative experience could be detrimental in an individual's professional development. Many programs recognize this challenge and try to address the development of these skills through passive knowledge infusion within the capstone course. Several techniques commonly used to provide information to the students include lectures by the instructor, guest speakers, and outside the classroom reading assignments. Unfortunately, these techniques have suboptimal aspects that were realized by the authors in their capstone course development. It is the author's conclusion that the typical knowledge based instruction fails to integrate across the skills or place the information in the context of the current learning environment, and does not leverage the student's current knowledge base for further development. These conclusions will be discussed in the paper in context of the evolution of a capstone course.

The Evolution of TDLC Development in a Capstone Course

The senior capstone course in the Civil and Environmental Engineering Department at the University of University of Wisconsin at Madison (UW) is a typical end-of-program, 4-credit, team-based project design course. The two primary objectives of the course are to integrate prior coursework into an open-ended team-based real-world project and to prepare the students for transition into professional practice. Many programs have a similar course as the final opportunity to develop their students. The course is taught each spring and fall semesters with an enrollment of approximately 40 students each semester. The student groups are mentored by local professional engineers and their project products are judged by a panel of engineers. The students are expected to have sufficient fundamental technical knowledge to participate in the semester long project. Hence, the challenge is for the students to work effectively and efficiently together as a team in a realistic design project environment, i.e., critical skills needed in professional practice.

The TDLC skills are the specific focus in the development of the student's professional abilities. Historically these skills have been taught with a knowledge-based approached as previously discussed. Information was provided to the students via instructor presentations, guest lectures, and outside classroom reading assignments. The first author was a guest lecturer as part of a professional skills lesson in the Fall 2004 Semester to discuss his leadership experiences as a US Army Engineer Officer. A presentation was given and an author-lead discussion ensued on the topic of leadership. The presentation was well received as evident in the course-end surveys and the students made positive references to the discussion activity. Clearly the students advocated a more active learning environment. Based on this feedback, it was decided to expand this

presentation into a full-length lesson in the following semester that would expand the topic beyond leadership to the TDLC skills in general, i.e., leadership related to teamwork, diversity, and communications.

The full-length lesson in the Spring 2005 Semester included more student interactive exercises in an active learning environment. This was an effort to heighten the student's interest in the TDLC skills and address recommendations from the previous semester. Following the full-length lesson a group of students were interviewed to assess the effectiveness of the lesson. The students had three primary recommendations:

1. Continue to develop the TDLC skills in an active learning environment with interactive exercises and discussions versus passive lecture type formats;

2. Better integrate the four TDLC skills; and

3. Develop the TDLC skills as immediate help for the course project teams, i.e., they recognized that these skills were essential to their success in the immediate project requirements.

Based on these recommendations the course's overall approach to the TDLC skills were? reviewed. The students' desire to engage more in an active learning environment was expected; however, their desires to integrate the topics and provide a contextual application were unexpected. To meet this challenge, a set of three lessons was designed with interactive exercises and discussions, integrated across the TDLC skills, and scheduled early in the semester to provide an opportunity for use by the student teams in the course projects. The new TDLC lessons were included in the fall 2005 semester curriculum. A full course survey was administered following the third lesson. The students were asked four questions related to the TDLC lessons:

1. Were we effective in integrating the four skills: Teamwork, Communication, Diversity, and Leadership across the lessons? Yes/No – Why?

2. What are your recommendations to improve integrating the four skills: Teamwork, Communication, Diversity, and Leadership across the lessons?

3. Were the Teamwork, Communication, Diversity, and Leadership lessons, helpful to your project team in this course? Yes/No -> Why?

4. What are your recommendations to improve these lessons to help you in this course and beyond?

In response to the first question, the majority (84%) of the students felt we had effectively integrated the TDLC skills across the lessons. Their specific recommendations in the second question were limited, but useful in further refining the lessons. However, in response to the third question, only about a third (32%) felt the material was helpful to their project teams and their specific recommendations in question 4 were also limited. The responses indicated that much of the TDLC skills material was either common sense or they had sufficient experience in the skills that additional development was not significantly helpful. This prevalent attitude with the TDLC skills development was initially disconcerting yet identified a critical misunderstanding by course instructors. In an effort to zero in on this issue a two-part end-of-semester survey was initiated for this same group of students. The first part of the survey asked the students to assess their course project team's performance with respect to the TDLC skills with a rating of 1 to 5 as shown in Table 1.

Table 1. End-of-Semester Survey, Fall 2005 Semester

TDLC Skills	much below average	below average	average	above average	much above average
Teamwork: How well did your group work as a team to achieve the project objectives?	1	2	3	4	5
Diversity: How well did your team integrate and capitalize on your diversity, i.e., backgrounds, experiences, etc.	1	2	3	4	5
Leadership: How effective was your leadership plan and leadership efforts in achieving project objectives?	1	2	3	4	5
Communication: How effective was your team's internal and external communication skills?	1	2	3	4	5

The students' average response was 3.5 to 3.9 in all four TDLC skills. They felt they performed "above average" with respect to the TDLC skills. These responses correlated with the previous survey. The second part of the survey was an open-ended query question, "What advice with respect to teamwork, diversity, leadership, and communication skills can you offer to next semester's capstone design teams?" In response to this question, the students proved their point, i.e., they had extensive knowledge and/or experience with respect to the TDLC skills and understood their importance to the success of their project teams and their profession. Sample responses are shown to illustrate the student's level of understanding of the TDLC skills:

"These projects are very time consuming, you will need a good leader to facilitate meetings. This leader needs to realize teamwork and communication are going to be essential."

"Define roles in the group ASAP. Have a defined leader. Make sure everyone has input during meetings, don't just agree to agree."

"I believe that the most important advice that can be passed on, in not only becoming a successful in this class but just in general, is to become completely integrated with your team. Get to know one another on a personal level so that people are not afraid to step up and let each other know how you as well as others can contribute to the team."

"Get to know your team members and what they already know. Use this knowledge and learn from your team members. Establish a good communication base early. "

These results caused the course instructors to really step-back and reflect upon a better approach to the development of the TDLC skills in the capstone course. Bloom's Taxonomy in the Cognitive Domain[4] (Figure 1) was reviewed and it was concluded that students had a higher knowledge level than originally perceived by the course instructors. However, reflection upon the professional domain skills gave rise to the consideration that potentially Bloom's Taxonomy in the Affective Domain[5] (Figure 2) may be more applicable to developing these skills versus the common approach of the Cognitive Domain because of the personal emotional aspects of the TDLC skills. Potentially, the cognitive domain could describe the knowledge level of the TDLC skills and the affective domain could describe the student's ability to internalize the value of the TDLC skills and their ability to influence others with the TDLC skills.

Evaluation
Synthesis
Analysis
Application
Comprehension
Knowledge

Figure 1, Bloom's Taxonomy, Cognitive Domain[4]

Internalizing Values
Organization
Valuing
Responding Phenomena
Receiving Phenomena

Figure 2, Bloom's Taxonomy, Affective Domain[5]

As a result of this reflection of the two Bloom's domains, a simplified model was assembled. The model (Figure 3) reflects the instructor's understanding that the student's must achieve a high cognitive knowledge level of the TDLC skills, but must also develop the ability to apply the skills. The students must constantly assess their ability to apply the TDLC skills with respect to their knowledge level. Hence, a Learn-Practice-Assess model was proposed as a simple continuous approach to the development of the TDLC skills. The model requires a high level of cognitive understanding to assess the individual and team performances, and it requires developing a full appreciation of value of the TDLC skills. Through this approach the model addresses a fourth BOK outcome: recognize the need for, and an ability to engage in life long learning (BOK 9, ABET i).
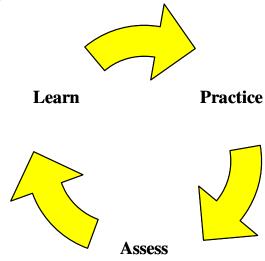
Learn   **Practice**

Assess

Figure 3, Learn-Practice-Assess
Continuous Development Model

The course's approach to the development of the TDLC skills was further refined based on the Learn-Practice-Assess model. The three TDLC lessons evolved into workshops with consideration for the Learn-Practice-Assess model and continued to integrate across the TDLC skills. Workshop was chosen to replace lesson in terminology as a subtle change to this material to set it apart from other lectures. The workshops were developed with the continuous Learn-Practice-Assess model driving the selection of interactive exercises and discussions with a more active learning environment. It was important to leverage the student's knowledge and experience, provide multiple opportunities to practice the TDLC skills, and develop their ability to assess their individual and team performance. This last mode, Assess, was believed to be key in closing the loop and establishing a life-long attitude towards the student's development of their TDLC skills. The three workshops were presented in the first half of the Spring 2006 Semester. Student survey data was again collected with two major improvements noted. First, 62% of the students felt the TDLC material was now helpful in the course project, up from 32% the previous semester. Second, the students' comments appeared to appreciate the effort to build upon their knowledge and experience in the TDLC skills. The workshops were further refined for the Fall 2006 Semester and the latest edition of the workshops follows in the paper with a summary of the student survey and assessment data.

Current TDLC Workshops

Three full workshops are currently used in the UW Capstone Course to develop the student's TDLC skills. Two additional activities supplement these three full workshops. Workshop 0 is included as primarily an out-of-class assignment at the start of the semester and the end-of-semester survey concludes the TDLC material in the course. The following sections describe each workshop and the associated exercises. The exercise details are included in the Appendices and form the core of the TDLC development program in the UW Capstone Course. The overall principle of the workshops is to use the Learn-Practice-Assess model as a continuous process of developing the TDLC skills. The success of the workshops is founded on interactive exercises, an active discussion environment, and supplemented with instructor experiences, advice, and assessments. Students are routinely reminded of the overall Learn-Practice-Assess model as the overall principle to the development of the TDLC skills for use in the course and beyond in their professional careers.

Workshop 0: *Can an Egg Fly?*

The first lesson in the UW Capstone course is primarily administrative in which the course details are outlined, course objectives reviewed, and students are formed into the project teams. At the end of the lesson the students are provided an out-of-class requirement which requires them to design and construct an item for a competition the next lesson, which is not specifically a TDLC workshop. The exercise currently used is the Egg Drop Exercise, see Appendix A. This well-know exercise was based upon one of course teaching assistant's graduate program at Stanford. The primary objective of this exercise is to immediately challenge the student's teamwork, leadership, diversity, and communication skills with a low-threat competition, i.e., no grade is assigned, just bragging rights. The Launch Masters from the Fall 2006 Semester are shown in Figure 4 and the winning egg delivery system is shown in Figure 5. The students appeared to enjoy the competition as a precursor to forming the project teams, as evident in their TDLC Workshop Assessments and end-of-semester interviews.

Figure 4, Launch Masters
Fall 2006 Semester

Figure 5, Best Egg Delivery System
Fall 2006 Semester

Workshop 1: *From the Egg to the Team*

The first full TDLC workshop is scheduled shortly after the Egg Drop Exercise and begins with a movie clip that highlights a successful team in a challenging situation. *Remember the Titans* is currently used in this workshop because it brings together all the TDLC skills. An informal discussion follows that focuses on successful teams, and more importantly why they were successful. Following this informal discussion the teams conduct an assessment of their Egg Drop Exercise, see Appendix B. The assessment process includes individual reflection and group discussion on the team's success and areas of improvement in terms of teamwork, design process, and communications. Given the necessity for group discussion within each team, they must sit together as a team. This is done in all the TDLC Workshops, i.e., students must sit together in their project teams. After the team assessment discussion the Learn-Practice-Assess model is introduced to the students and discussed as the overall philosophy for development of the TDLC skills.

In the discussion, the instructor highlights the value of learning from each other's experiences because the students have significant understanding and knowledge about the TDLC skills. This discussion provides a segway into the next exercise, which is an opportunity for the students to reflect upon their own personal experiences with successful teams, see Appendix C. Each team then discusses the common traits of their successful team experiences and the instructor lists the traits as part of the class discussion. As a result, it becomes evident that successful teams have common traits of teamwork, leveraged diversity, leadership and communications. Following this discussion, the instructor returns to the continuous development model: Learn – Practice – Assess. The instructor then transitions to the current course and reviews advice from previous students with respect to the TDLC skills, see Appendix D. The Appendix includes a sample of the advice provided by students from a previous semester. Again, the students individually review the advice provided and discuss in their groups what is most valuable to their project team. This exercise helps the students prepare for the course with respect to their TDLC skills.

The workshop concludes with each team developing a set of goals for the course, see Appendix E. This exercise is more effective now because the teams have completed and assessed the Egg Drop exercise, reflected upon their own successful team experiences, and considered past students advice. They are comfortable setting team goals for the course. The worksheets are collected from the teams for use in the third TDLC Workshop. The workshop is time intensive and transitions between exercises are carefully planned to ensure a smooth progression towards the most important exercise at the end, the Team Goals Exercise. Successful completion of this exercise is well received by the students and provides them with a positive start to their capstone course experience.

Workshop 2: *Building Teams and Bridges*

The second TDLC workshop is scheduled several weeks after the first workshop and begins in the Learn mode with an instructor-lead Diversity Opportunity Discussion. The instructor focuses on four questions and builds upon the student's experiences and knowledge:
1. How do you define diversity?
2. How diverse is our civil engineering profession?
3. Why do you think diversity is important to our profession?
4. How can we improve the diversity of our profession?

Each question is used to stimulate discussion followed by making a few factual statements about each question. For example, we define diversity as "all our human differences refers to the cumulative characteristics that a person or group of persons unique, and implies a fullness of ideas, perceptions, traditions and ways of living that over the human spectrum." This is followed by a discussion on context (individual, group, and organization affiliation) and three principles, with examples given by the instructor:
1. Intent versus impact,
2. Values, beliefs, and actions/behaviors, and
3. What you know, what you do not know, and what you do not know you do not know.

The transition from this discussion to the next exercise is abrupt as a second instructor, first author, bursts into the classroom unannounced declaring that the project teams have an emergency mission, see Appendix F. The sudden transition is effective in grabbing the student's attention and immediately engaging them in an exercise that requires them to pick members of an emergency field engineering team. A variety of scenarios has been used and typically follows a current natural disaster. Appendix F includes the current scenario and a sample of the candidates for selection to the field engineering team. The candidate information is routinely adjusted to ensure conflict in member selection and challenge the diversity issue in team selection. The ensuing discussion is lively as each team defends their choices and various diversity issues are highlighted. The instructor promotes discussion by playing devil's advocate in challenging the student's choices and leading this discussion. The discussion provides the indirect assessment tool for this exercise.

Upon completing the fictional team selection exercise the students are challenged to build a model bridge in the classroom with K'nexs ©, see Appendix G. This exercise is an entertaining extension of the previous exercise. The students are fully engaged at this point in the workshop and eagerly dig into building their bridge models. However, to-date the only known solution to the exercise requires the teams to think outside the specified rules. A successful bridge can be built if two separate teams combine their given materials, which is not explicitly prohibited in the rules. The student teams from the Fall 2006 Semester are shown building their bridges in Figure 6, and a successful bridge from the Spring 2006 Semester, built with materials from two teams, is shown in Figure 7.

Figure 6, Build a Bridge Exercise
Fall 2006 Semester

Figure 7, Successful Bridge Model
Spring 2006 Semester

Workshop 3: *Closing the Loop with Assessments*

The final TDLC workshop is scheduled mid-semester and after a major assignment in the course. The timing is critical because it provides an opportunity for the teams to assess their performance and adjust if needed while there is still time in the course. The workshop begins again in the Learn mode with an instructor lead discussion on Assessment and Feedback Techniques. This information is deemed critical in the development of the TDLC skills, because the student's limited experience with such techniques

The instructor begins the discussion by posing the question, "What comes to your mind when the word feedback is used?" The discussion sets the stage for presenting two models and some practical tools. The first model is built around a *situation*, *behavior*, and *impact of behavior*. Behavior is a complex area impacted by individual values, beliefs, thoughts and feelings. The second model focuses on providing feedback for a specific situation and highlights the relationship between the giver and their assumptions, tact, and intent; and the receiver and their willingness to be open minded. The instructor highlights in the discussion that *feedback* and *assessment*, when practiced effectively, is an information exchange and a learning experience. The key tools include your own ears to listen and using questions to solicit information in the exchange. The discussion is again typically well received as students begin to see the value of the overall development model again: Learn – Practice – Assess.

Following the discussion, the teams are provided their Team Goals from the first TDLC Workshop and given an opportunity to assess their performance and develop recommendations for the remainder of the semester, see Appendix H. This timely assessment is carefully directed by the instructors as the teams may not have been as successful as they have hoped. The instructors focus on common problems and solutions for the entire class. The student's next exercise is the assessment of the TDLC workshops themselves, see Appendix I. The instructor highlights that the TDLC development program in this capstone course evolves based upon their feedback, e.g. more interactive exercises, recognizing student knowledge and experience in the TDLC skills, etc. This assessment concludes the TDLC skill development in the UW Capstone Course until the end-of-semester survey.

End-of-Semester Survey

The final activity is the end-of-semester survey which provides an opportunity for the teams to assess their performance with respect to the TDLC skills, and provide advice for the future students in the UW Capstone Course with respect to the TDLC skills, see Appendix J.

Learn-Practice-Assess Model

The TDLC workshops follow the Learn-Practice-Assess model with a continuous development loop. The exercises provide opportunities in each mode of the model. The workshops are shown within the context of the model in Figure 8. The model begins with Workshops 0 to 1 and continues clockwise around the model for Workshop 1. Workshop 2 enters the model in the Learn mode with the Diversity Opportunities Discussion and continues clockwise. Similarly, Workshop 3 enters the model in the Learn mode with the Leaders Assessment Techniques Discussion and finishes with the end-of-semester survey. The associated appendices are included for the workshop exercises. The TDLC development program flows effectively around the continuous Learn-Practice-Assess model. Throughout the TDLC workshops the model is highlighted and students are reminded that it is continuous development process in the course and beyond in their profession.
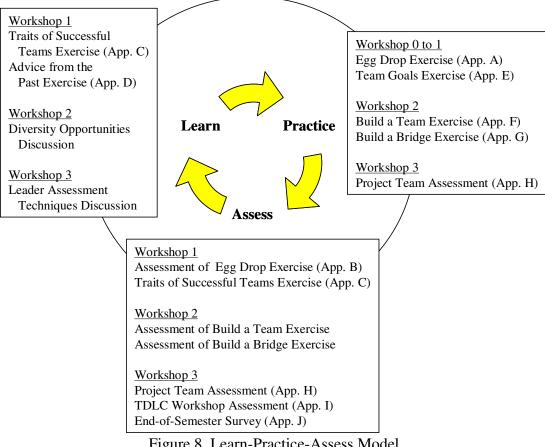
Workshop 1
Traits of Successful
  Teams Exercise (App. C)
Advice from the
  Past Exercise (App. D)

Workshop 2
Diversity Opportunities
  Discussion

Workshop 3
Leader Assessment
  Techniques Discussion

Learn   **Practice**

Assess

Workshop 0 to 1
Egg Drop Exercise (App. A)
Team Goals Exercise (App. E)

Workshop 2
Build a Team Exercise (App. F)
Build a Bridge Exercise (App. G)

Workshop 3
Project Team Assessment (App. H)

Workshop 1
Assessment of Egg Drop Exercise (App. B)
Traits of Successful Teams Exercise (App. C)

Workshop 2
Assessment of Build a Team Exercise
Assessment of Build a Bridge Exercise

Workshop 3
Project Team Assessment (App. H)
TDLC Workshop Assessment (App. I)
End-of-Semester Survey (App. J)

Figure 8, Learn-Practice-Assess Model
for TDLC Workshops

Integration of TDLC skills

The TDLC Workshops are matrixed against the four skills to ensure adequate coverage of each. Relationships were considered for each activity versus each skill and classified as strong, moderate, or none. Teamwork is strongly related to success in those exercises with team products, i.e., Egg Drop, Team Goals, Build a Team, and Build a Bridge; and with the Project Team Assessment. However, teamwork is only moderately related to assessments because the assessments are inherently for self-improvement versus class competition The skill in maximizing diversity opportunities is moderately related to most of the activities with teams rewarded for leveraging their diversity to complete tasks. However, the Diversity Opportunities Discussion provides a focused opportunity for this skill. Leadership is similarly related, i.e., moderately to all team activities and is the focus of the Leader Assessment Techniques Discussion. The communications skill spans all activities and is strongly related to the discussion and assessment activities. The results of this integration review are shown graphically in Table 2 with strong relationships as filled boxes and moderate relationships as partially filled boxes. The TDLC skills appear to be integrated across the TDLC Workshops. This conclusion is verified with the students TDLC Workshop Assessments.

Table 2, Activities versus TDLC skills

	Activity	Teamwork	Diversity	Leadership	Communications
	Egg Drop Exercise	■	◪	◪	◪
Workshop 1	Assessment of Egg Drop Exercise	◪	◪	◪	◪
Workshop 1	Traits of Successful Teams Exercise	◪	◪	◪	◪
Workshop 1	Advice from the Past Exercise	◪	◪	◪	◪
Workshop 1	Team Goals Exercise	■	◪	◪	◪
Workshop 2	Diversity Opportunities Discussion		■		■
Workshop 2	Build a Team Exercise	■	◪	◪	◪
Workshop 2	Assessment of Build a Team Exercise	◪	◪	◪	◪
Workshop 2	Build a Bridge Exercise	■	◪	◪	◪
Workshop 2	Assessment of Build a Bridge Exercise	◪	◪	◪	◪
Workshop 3	Leader Assessment Techniques Discussion			■	■
Workshop 3	Project Team Assessment	■	◪	◪	■
Workshop 3	TDLC Workshop Assessment				■
	End-of-Semester Survey				■

TDLC Workshop Assessment

The TDLC Workshop Assessment's (Appendix I) numerical results are provided for Questions 1 and 3, with student "Yes" responses shown in Figures 9 and 10, respectively. The results indicate success integrating the TDLC skills and an opportunity to continue to improve the in-course benefits of the TDLC workshops.

1. Were we effective in <u>integrating</u> the four skills: Teamwork, Communication, Diversity, and Leadership across the lessons? Yes/No – Why?
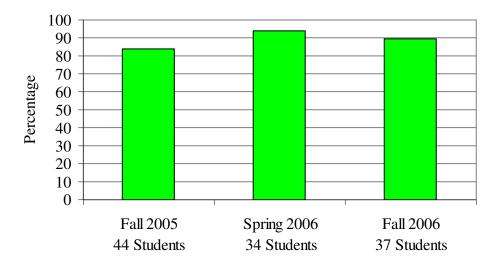
Figure 9, Student "Yes" Responses to Question 1

3. Were the Teamwork, Communication, Diversity, and Leadership workshops, helpful to your project team in this course? Yes/No -> Why?
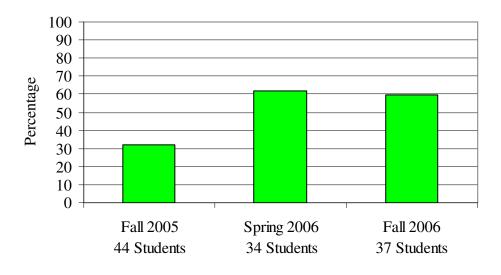
Figure 10, Student "Yes" Responses to Question 3

End-of-Semester Surveys

The End-of-Semester Survey's (Appendix J) numerical results are provided for Question 1 in Table 3, with numerical scores ranging from 1 (much below average) to 2 (below average) to 3 (average) to 4 (above average) and to 5 (much above average).

1. Assess your Capstone Project Team's performance in the TDLC skills on a scale of 1 to 5.

Table 3, End-of-Semester Survey Results of Team Performance in TDLC Skills

TDLC Skills	Fall 2005	Spring 2006	Fall 2006
Teamwork: How well did your group work as a team to achieve the project objectives?	3.8	4.0	4.3
Diversity: How well did your team integrate and capitalize on your diversity, i.e., backgrounds, experiences, etc.	3.9	4.0	3.9
Leadership: How effective was your leadership plan and leadership efforts in achieving project objectives?	3.5	4.0	3.9
Communication: How effective was your team's internal and external communication skills?	3.8	3.8	4.1

These results indicate that the students rated their team's performance above average in the TDLC skills in their capstone course experience. This assessment is further supported with the results of the second question, "What advice with respect to teamwork, diversity, leadership, and communication skills can you offer to next semester's capstone design teams?" The responses to this question indicate that the students have high cognitive level of understanding of the TDLC skills and their importance to team success and our profession. Hence, their assessments are validated.

The TDLC workshops continue to be developed in the UW Capstone Course. The course website is included in the Bibliography for reference. Specifically, the Diversity Opportunities and Leader Assessment Technique Discussions are targeted for development into more active learning activities. The challenge is ensuring the student's knowledge level (cognitive domain) is sufficient for greater application (affective domain). Additionally, the entire course is under review with respect to the Learn-Practice-Assess model to determine how the expected skills in the technical domain are practice and assessed. Finally, the entire program that culminates in the capstone course is under review with respect to the findings reported herein, specifically how are skills effectively and efficiently developed in the technical and professional domains. Potentially, the development of these domains must be integrated across a program, not focused only in the capstone course.

Conclusions

Several conclusions can be drawn from reflecting upon the evolution of the TDLC skills development program and the current TDLC Workshops in the Civil and Environmental Engineering Capstone Course at the University of Wisconsin at Madison.

1. Evolution of a course program can provide a unique insight into the student's knowledge base of course topics. Deliberate reflection upon this insight may be the basis for altering a course to the betterment of the student's educational experience.

2. Students have a higher cognitive level in the TDLC skills than may be perceived by instructors. Hence, leveraging this higher level is critical to further developing the student's TDLC skills.

3. The development of the skills in the professional domain may require consideration beyond the traditional Bloom's Taxonomy in the Cognitive Domain. Potentially, the Cognitive Domain provides a knowledge base assessment and Bloom's Taxonomy in the Affective Domain may provide an effective application assessment.

4. A continuous model of Learn-Practice-Assess may be appropriate for those development programs which students exhibit the higher cognitive level but require further development in the application, as demonstrated in the TDLC skills development program in this paper.

5. The development of TDLC skills across a program, versus one capstone course, would ideally be the most effective means to ensuring students are prepared for their profession. Additionally, such development in their education experience would transcend to further development in their professional careers.

Capstone courses typically provide the last opportunity for a program to positively affect the student's development of the skills in the professional domain, which are critical to the student's success in their professional career. The success of our profession hinges on the education of our future engineers and their ability to continue life-long learning. The TDLC skill development program in the Civil and Environmental Engineering capstone course at the University of Wisconsin at Madison addresses the challenge of skill development in the professional domain with a series of interactive workshops based around a continuous Learn-Practice-Assess model. Programs are welcome to apply any or all of the elements presented in this paper to the betterment of our professional education system and society.

Bibliography

1. ASCE (2004). *Civil Engineering Body of Knowledge for the 21st Century – Preparing the Civil Engineer for the Future.* Reston, Virginia: American Society of Civil Engineers.

2. ASCE (2005). *Key Points About Policy Statement 465: Academic Prerequisites for Licensure & Professional Practice.* Downloaded on December 15, 2006. http://www.asce.org/pdf/KeyPoints-PS465-V19-100305.pdf.

3. ASCE. *Education for Professional Practice.* Accessed on December 15, 2006. *http://www.asce.org/raisethebar/.*

4. Bloom B. S. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. New York: David McKay Co Inc.

5. Krathwohl, D. R., Bloom, B. S., & Bertram, B. M. (1973). *Taxonomy of Educational Objectives, the Classification of Educational Goals. Handbook II: Affective Domain*. New York: David McKay Co., Inc.

6. University of Wisconsin at Madision,Civil and Environmental Engineering Capstone Course Webpage http://www.engr.wisc.edu/cee/courses/cee578.html.

Appendix A

Egg Drop Exercise

Instructions:

a. Each team is required to design and construct an egg delivery container for a shipping company. The company specializes in egg deliveries dropped from airplanes and they need a new delivery container. They require consistently safe delivery of their product. The customers they serve are not only price conscious, but are also swayed by style and aesthetics.

b. The requirements are as follows;
   (1) A container for a single egg that can be dropped from a height of approximately 30 feet onto a 4-foot x 4-foot square target without breaking the egg.
   (2) After release the container must fall free, without further guidance or restraint,
   (3) Simple and efficient designs are preferred. Parachute styles and bubbled wrapped designs are not permitted.
   (4) Eggs for practice and final designs are provided and can not be altered, i.e., boiled.
   (5) Teams must procure their own materials from the approved materials list. The final cost will be determined by listed unit costs.
   (6) Teams may use an unlimited amount of materials in their practice designs, but must provide a detailed cost account of their final design at the final design test.
   (7) The final design test will be at (time), at (location), on (date). At this final design test each team will designate a launch master for testing their design.
   (8) Teams are permitted to test their practice designs at the final design test location.
   (9) Teams will be assessed on delivery success, final cost, and aesthetics. Success requires egg delivery in the target without breaking. Final cost will be based on the submitted detailed cost account. Aesthetics will be a subjective score by a panel of judges prior to launching.

c. Approved materials and price list.

Item	Unit	Maximum for Final Design	Unit Cost ($)	Number Used in Final Design	Total Item Cost
paper	sht	10	0.001		
pipe cleaners	ea	40	0.030		
wood dowels (1/8 in.)	ea	22	0.072		
plastic straws	ea	25	0.011		
toothpicks	ea	50	0.005		
rubber bands	ea	150	0.005		
super glue	tube	1	0.900		
binder clips	ea	6	0.183		
ice cream sticks	ea	20	0.024		
styrofoam balls	ea	12	0.216		
transparent tape	in	1,000	0.001		
poster board	sht	1	0.490		
index cards (4x6)	sht	20	0.001		
eggs	ea	1	No Charge	1	$0.00
				Total Cost	

Appendix B

Assessment of Egg Drop Exercise

Instructions:
a. Each team member completes the discussion areas below. Please answer the two questions for each of the three areas: Teamwork, Design Process, and Communications.
b. Each team will discuss their responses and present their results to the class in the discussion.
c. These handouts will be turned in at the end of the workshop.

Teamwork	
In terms of teamwork… Name one thing your team did well –	Name one thing your team could improve -

Design Process	
In terms of your team's design process… Name one thing your team did well –	Name one thing your team could improve -

Communications	
In terms of team's communications… Name one thing your team did well –	Name one thing your team could improve -

Appendix C

Traits of Successful Teams

Instructions:
a. Each team member completes questions 1 and 2 individually.
b. Each team discusses the individual responses and identifies the common traits with their successful team experiences and answers question 3.
c. Each team will present their results to the class in the discussion.
d. These handouts will be turned in at the end of the workshop.

Individual Questions:
1. Name a successful team <u>you have been on or are on now.</u>

2. Why was or is this team successful?

Team Question:
3. What are the common traits with everyone's experience on successful teams?

Appendix D

Advice from the Past

Instructions:
a. Each team member reads through their selection of advice from the past and identifies what they think is the best advice for their team this semester.
b. Each team will discuss their responses and present their results to the class in the discussion.
c. These handouts will be turned in at the end of the workshop.

Last semester the students were surveyed for "advice" to you this semester with the question, What advice with respect to teamwork, diversity, leadership, and communication skills can you offer to next semester's capstone design teams? Sample comments are included:

(1)	When defining objectives throughout the project, spend time cooperatively determining the quality/level of work expected from each person for each assignment
(2)	These projects are very time consuming, you will need to find a good leader to facilitate meetings. This leader needs to realize teamwork and communication are going to be essential. This semester I had a leader that liked to have everyone working on separate parts of the project which some of us believed did not work best for the members we had
(3)	Define roles in the group ASAP. Have a defined leader. Make sure everyone has input during meetings, don't just agree to agree.
(4)	I believe that the most important advice that can be passed on, in not only becoming a successful in this class but just in general, is to become completely integrated with your team. Get to know one another on a personal level so that people are not afraid to step up and let each other know how you as well as others can contribute to the team. This will also make communication among the group more open.
(5)	Regardless if you are working on a submittal or assignment. Have frequent communication with your group members to ensure everyone is working towards a common goal and is on the same page.
(6)	Additional advice comments are provided to each student.

Individual Question:
1. What advice do you recommend for your team this semester to follow?

Appendix E

Team Goals Exercise

Instructions:
a. Each team member completes the questions individually.
b. Each group discusses their responses and completes a "group" sheet.
c. Each team will discuss their responses and present their results to the class in the discussion.
d. These handouts will be turned in at the end of the workshop.

Team Name: _____

1. What is your team goal and what are three sub-goals to achieving this goal?

Goal:
Sub Goal 1:
Sub Goal 2:
Sub Goal 3:

2. What is the role of each person on the team?

Name	Role

3. Name three expected challenges to your team's goals – how will the team plan to overcome those challenges?

Challenge	Plan to Overcome

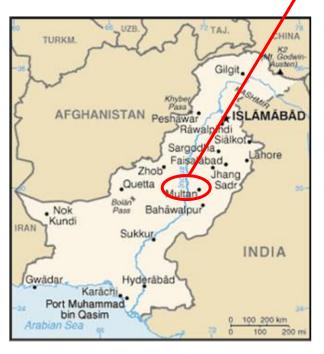**Appendix F**

Build a Team Exercise

Instructions:
a. Read the Project Summary.
b. Each team completes a Build a Team worksheet.
c. Each team will discuss their responses and present their results to the class in the discussion.
d. These handouts will be turned in at the end of the workshop.

Project Summary

A major highway bridge over the river Indus in eastern central Pakistan was damaged by a recent earthquake. It is a critical transportation link through the rugged mountain ranges of Pakistan AND it carries pipelines for petroleum, natural gas, and fresh water. It is believed that a natural gas line broke first and exploded. This explosion destroyed the span shown above and ignited the other petroleum pipes causing severe damage to all spans in the bridge. It is critical to the recovery operations to restore this highway bridge, reconnect the pipelines, and clean-up the environmental hazards from the broken pipelines.

Appendix F

Build a Team Exercise

Build A Team Worksheet

A field engineering team is being assembled to leave immediately for the site. This field engineering team will be required to rapidly assess the damage, propose an expedient and temporary repair to the bridge and pipeline system, and propose environmental remediation to the site. A list of candidates has been assembly. The field engineering team will be living and working in an extreme austere environment with limited resources and support.

Assuming your team accompanies the selected group, who else would your team recommend taking?

Who do recommend for the team from the list of 12 candidates attached?

(1) _____

(2) _____

(3) _____

You team can add two more persons. Who would you add – it must be someone that is "known", e.g. family, friends, etc.

(4) _____

(5) _____

Appendix F

Build a Team Exercise

Sample of Candidates
(photos have been excluded for copyright reasons)

(insert photo here)	Ashmid Muhamid Associates Degree, Civil Engineering Technology from Houston Technical College BA, Physicians Assistant from Houston University 22 years old Not married Speaks English, Punjahi (language in 48% Pakistan pop) Ashmid has spent the last two years working as a contractor in northern Afghanistan as a Physicians Assistant and Safety Officer.
(insert photo here)	Angelina Vilkomak BS in Civil Engineering from University of South Africa MS in Chemical Engineering from University of Netherlands 36 years old Not married Speaks English, Punjahi (language in 48% Pakistan pop) Angelina has spent 6 years in the Peace Corps working to improve waste water treatment in India and Pakistan. Her family owns a large construction company in South Africa.
(insert photo here)	John Craig BS in Civil Engineering from US Military Academy, NY MS in Project Management from the University of Missouri, Rolla 52 years old Married, four children Speaks English and German John recently retired from 20 years in the US Army. His last assignment was the Deputy Commander US Army Corps of Engineers, Afghanistan Office. He retired as a Colonel.

Appendix G

Build a Bridge Exercise

Instructions:

a. Each team is provided a bag of K'nexs© to build a bridge between two tables, spaced 30 inches apart, to support a dead load road deck (index cards), and live load vehicles (5 toy cars shown below).

b. Use only K'nexs© provided to the class.
c. You have 15 minutes to build the bridge.
d. Good Luck!

Appendix G

Build a Bridge Exercise

Instructor Notes:
a. Each group is given a bag of K'nexs© with the following components

Connectors	Rods
White = 5	Green = 8
Blue = 2	Grey = 4
Green = 2	Yellow = 17/18
Purple = 9	Red = 5
Yellow =7	

b. Dead load is a deck of 8 index cards taped together.
c. Live load is 5 small toy cars.
d. A known solution is shown below. This solution requires two separate teams to work together, which is <u>not</u> explicitly forbidden in the rules.

Appendix H

Project Team Assessment

Instructions:
a. Each team member completes the questions individually.
b. Each group discusses their responses and completes a "group" sheet.
c. Each team will discuss their responses and present their results to the class in the discussion.
d. These handouts will be turned in at the end of the workshop.

Individual Questions:
Given a copy of your team goals from Workshop I,
1. How well has your team done to meet these goals?

2. What can you do as an individual team member to better help the team?

3. What do you think the team needs to do to better meet the team goals?

Appendix I

TDLC Workshop Assessment

Instructions:
a. Each team member completes the questions individually.
b. Please turn-in your assessment of the TDLC Workshops prior to leaving class.

Individual Questions:
1. Were we effective in <u>integrating</u> the four skills: Teamwork, Communication, Diversity, and Leadership across the workshops? Yes/No – Why?

2. What are your recommendations to improve <u>integrating</u> the four skills: Teamwork, Communication, Diversity, and Leadership across the workhops?

3. Were the Teamwork, Communication, Diversity, and Leadership workshops, helpful to your project team in this course? Yes/No -> Why?

4. What are your recommendations to improve these workshops to help you in this course and beyond?

Appendix J

Advice for Next Semester Survey

Instructions:
a. We would like to gather your "advice" for next semester's Capstone Course students. Recall that we used last semester's student advice in the first TDLC Workshop at the start of this semester and I believe you found this helpful. Please "play it forward!"
b. Please answer the questions below individually.
c. Please turn-in your survey prior to leaving class.

Individual Questions:
1. Assess your Capstone Project Team's performance in the TDLC skills on a scale of 1 to 5. Circle a score for each domain:

TDLC Skills	much below average	below average	average	above average	much above average
Teamwork: How well did your group work as a team to achieve the project objectives?	1	2	3	4	5
Diversity: How well did your team integrate and capitalize on your diversity, i.e., backgrounds, experiences, etc.	1	2	3	4	5
Leadership: How effective was your leadership plan and leadership efforts in achieving project objectives?	1	2	3	4	5
Communication: How effective was your team's internal and external communication skills?	1	2	3	4	5

2. What advice with respect to teamwork, diversity, leadership, and communication skills can you offer to next semester's capstone design teams?