Instruction and Assessment of Multidisciplinary Teaming Skills in Senior Design

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Abstract

Although numerous articles in engineering disciplines focus on incorporating communication into courses and curricula, minimal scholarship exists that addresses the specific instruction and assessment issues involved with multidisciplinary teaming competence. As multidisciplinary teams are increasingly being implemented in engineering industry and academic courses (specifically in senior design courses), it is critical to explore the strategies for instruction and assessment of multidisciplinary teams. This study does just that by describing a tri-phased instructional and assessment protocol for multidisciplinary teaming instruction. Additionally, this study presents preliminary assessment results that contributed to iterative redesign of this tri-phased protocol. Ultimately, the protocols presented in this study can be tailored for other institutions and further tested for effectiveness in building multidisciplinary teaming competence.

Rationale

Industry uses multidisciplinary (MD) teams to enhance the success of new product development[1]. Multidisciplinary teams are also essential components of knowledge management practices in organizations. The combination of MD teams and optimizing emerging technologies enables organizations to manage the human side of learning and complex decision-making[2]. Because the needs of industry often influence the professional preparation of new entrants into the workforce, it is critical to attend to those educational issues involved with multidisciplinary teams. The current study provides insight into the under explored area of multidisciplinary teaming instruction and assessment within a senior capstone design course.

Numerous curricular changes in engineering disciplines nationwide have focused instruction on communication and teamwork skills[3]. While some programs have engaged in comprehensive curricular change, others have designed new stand-alone communication courses for engineering students[4]. Many of these communication-intensive courses target technical communication as a key critical skill to learn[5]. Other such communication courses for engineers focus on different communication skills such as listening, teamwork, visual aids, group creativity, and audience analysis[6].

Most often, the communication and teamwork instruction that occurs in engineering curricula is within the senior capstone course (such as a design course). In many of these cases, senior level courses include assignments that require communication and teamwork skills such as team design projects, team brainstorming sessions, or team portfolios[7]. Driving many senior capstone curricular models in engineering is the attempt to align communication instruction with industry's needs[8]. In light of recent industry needs, attention has recently been turned to issues of multidisciplinary teams. Yet minimal scholarship exists that explores the instruction and assessment of these multidisciplinary teams. The current study provides a starting point in exploring the instruction and assessment of multidisciplinary teams in the senior design curriculum.

At NC State University, one specific challenge emerging in one such chemical engineering senior design course revolves around the instruction and assessment of multidisciplinary teaming skills in the capstone design course. This effort is part of a larger NSF funded[9] project related to the integration of writing, teaming, and speaking instruction into engineering curricula. This paper describes the instructional strategies and assessment mechanisms that were used in that course to support students learning multidisciplinary teaming competence.

Multidisciplinary teaming in CHE 451

The initial focus of the NSF grant was a senior capstone chemical engineering design course, taught by engineering faculty on the NSF team. Although the course is listed in chemical engineering, each semester, many of the project teams involve students from other disciplines, such as Computer Science, Food Science, Industrial Engineering, Materials Science, and Economics. This paper describes multidisciplinary teaming instructional strategies and assessment tools for three offerings of this design course (one a year, over a three-year period).

Phase One: a generic model of teaming instruction and assessment

In the initial offerings of CHE 451, teaming instruction occurred during the Teaming, Writing, and Speaking (TWS) module—a weekly class during the regular time period of the design course. Teams that had multidisciplinary members who were unable to attend that module (members from other disciplines who had class at that time) were asked to relay information to their team members during the team's normal meeting times. Teaming instruction focused on four content areas: creating team ground rules, the stages of team development (forming, storming, norming, performing), establishing team roles, and writing team minutes. Throughout the course, multidisciplinary teams had to complete three team assignments: team minutes and logs, peer review sheets, and reflection assignments. Team minutes and logs detailed what happened at team meetings in terms of the design progress. Peer review sheets were assignments where students had to evaluate other team members so that the advisor and professor could get a sense of how the team was functioning. Finally, reflection assignments were weekly questions that asked students to reflect on their processes of preparing for and completing writing and speaking assignments as a team.

During Phase One, the teaming assignments—logs, minutes, peer reviews (see Appendix A), and reflection assignments—provided the primary mechanisms for assessing teaming competence. Additionally, several questions on a pre- and post-course survey asked students to evaluate their competence and confidence in teaming abilities.

Content analysis of Phase One assessment materials led to the following three conclusions: students in multidisciplinary teams needed a scheduled common time for teaming instruction (where the entire team could attend), students receiving instruction were challenged by the need to integrate multidisciplinary information into a coherent team voice in their reports and presentations, and students found it difficult to address interpersonal team issues—specifically with members from other disciplines. These conclusions implied the need for additional instruction on the issues particular to the multidisciplinary team setting. Therefore, for Phase Two, we redesigned the teaming instruction to focus specifically on issues of multidisciplinary teaming.

Phase Two: A multidisciplinary focus for teaming instruction and assessment

In the course offering for Spring 2002, Phase Two teaming instruction was changed to a consultation format so that the TWS consultant could meet with teams at a time when all members could attend. Phase Two instruction focused on the following content areas: creating team ground rules, facilitating team roles, establishing team cohesiveness and productivity, and addressing feedback as a multidisciplinary team. Phase Two multidisciplinary teams were required to complete team logs and minutes and to perform peer reviews of team members. Reflection assignments were eliminated from Phase Two to encourage teams to reflect in a face-to-face, collaborative setting where solutions could be generated (thus dealing openly with interpersonal team issues) instead of in the more individualized setting of having reflection assignments where there were minimal opportunities to actually discuss reflections in a team setting. Phase Two assessment mechanisms were very similar to those used in Phase One: peer review sheets, team logs and minutes, and pre- and post-course surveys.

Phase Two assessment revealed that teams receiving teaming instruction faced specific challenges that were different from teams not receiving instruction (this was true for both multidisciplinary and single-disciplinary teams). Multidisciplinary teams receiving instruction found it difficult to manage the demands of the design project in a way that facilitated team project management (e.g., they saw the project management assignments—minutes and logs—as busy work that did not actually support their design project). Specifically, the multidisciplinary nature of the team added enough complexity that project management became increasingly challenging for the students in this project. Additionally, analyses revealed that multidisciplinary teams receiving instruction needed the basic multidisciplinary teaming instruction supplemented with a more tailored approach that addressed particular team issues. As a result of these conclusions, the NSF team redesigned the teaming instruction again for Phase Three of the project.

Phase Three: A project-management, outcomes-based model for teaming instruction and assessment

Phase Three teaming instruction maintained the consultant format for two reasons: to ensure that all members of each team could participate in the training, and to provide teamwork training tailored to the specific needs and experiences of the individual teams. Content covered in Phase Three instruction included much of the material covered in Phase Two (setting ground rules, negotiating in a team, and addressing feedback as a team). In addition, though, two content areas were added to the consultations: facilitating team project management issues (developing a schedule and identifying the critical tasks), and managing team-specific issues related to particular projects and to the written and oral deliverables required by each project. Phase Three multidisciplinary teams were required either to complete consultation reflections (brief in-progress reflections at the end of the consultation period) or to engage in team problem solving when they had matters of concern to discuss (in a face-to-face, collaborative manner); they were also to complete team minutes, logs, and team peer reviews.

Assessment tools for Phase Three included those used in Phase Two plus one additional assessment tool – a teaming rubric. Prior to Phase Three, it was recognized that assessments emerging from Phases One and Two provided only indirect statements about team performance. For example, team reflection and logs provided valuable information about in-progress team development, but they did not speak to whether the teams learned teaming skills, specifically those required of them in multidisciplinary teams. Therefore, a teaming rubric was created that outlines specific behavioral outcomes expected for an effective multidisciplinary team (see Appendix B). General rubric categories include project management, team productivity, and team cohesiveness, with several operational definitions (outcomes-statements) beneath each category. This rubric will be completed twice during the semester by faculty advisors, the TWS consultant, and industry representatives—as a primary indicator of team competence. Phase Three data are being collected in Spring 2003 and will be analyzed in Summer 2003.

Multidisciplinary teaming instruction and assessment

Over a three-year period, our NSF team developed three models for multidisciplinary teaming instruction and assessment. Each model was designed and redesigned in an iterative process based on data from the prior semester. Ultimately, a tailored, competence-oriented model for teaming instruction and assessment seemed to fit best given our institutional needs, the nature of student challenges, and that particular ways in which projects and teams were designed in this setting. As models for multidisciplinary teaming instruction and assessment are explored for particular institutions, it is critical to develop a process that includes phased assessments so that students and faculty involved have an opportunity to provide feedback that allows for iterative redesign and leads to increased competence of multidisciplinary teams. These findings provide a much-needed starting point in providing clear models for multidisciplinary teaming instruction and assessment models. Additional studies that test the effectiveness of these models can now be completed. Eventually, current findings and future research could not only impact the ways in which multidisciplinary teaming is taught and assessed, but also the ways in which students transition into industry and work within organizations that demand multidisciplinary teaming skills.

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[9] This study emerged from a larger NSF funded project (Grant No. EEC-0080484) "Establishing New Multidisciplinary Curricular Paradigms: Biotechnology and Chemical Engineering." Specific acknowledgments should be given to all members of the NSF team who have contributed to this project over the past three years: Dr. Steven Peretti, Department of Chemical Engineering; Dr. Chris Anson, Campus Writing and Speaking Program; Dr. Richard Spontak, Department of Chemical Engineering; Dr. Christopher Daubert, Department of Food Science; Dr. Lisa Bullard, Department of Chemical Engineering, Ms. Margaret Heil, Department of Computer Science, Dr. Paula Berardinelli, Assessment Coordinator, Mr. David Kmiec, Writing and Speaking Consultant, Dr. Naomi Kleid, Writing and Speaking Consultant, and Ms. Amanda Granrud, Coordinator of Undergraduate Tutorial Services in Writing and Speaking. As a team, we have worked in a truly collaborative way and each of our research interests and endeavors have benefited from this collaboration.

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Appendix A
Peer Rating of Team Members

Name____ Group #_______________

Please write the names of all of your team members, INCLUDING YOURSELF, and rate the degree to which each member fulfilled his/her responsibilities in completing the team assignments. The possible ratings are as follows:

Excellent	Consistently went above and beyond—tutored teammates, carried more than his/her fair share of the load
Very good	Consistently did what he/she was supposed to do, very well prepared and cooperative
Satisfactory	Usually did what he/she was supposed to do, acceptably prepared and cooperative
Ordinary	Often did what he/she was supposed to do, minimally prepared and cooperative
Marginal	Sometimes failed to show up or complete assignments, rarely prepared
Deficient	Often failed to show up or complete assignments, rarely prepared
Unsatisfactory	Consistently failed to show up or complete assignments, unprepared
Superficial	Practically no participation
No show	No participation at all

These ratings should reflect each individual's level of participation and effort and sense of responsibility, not his or her academic ability.

Name of team member	Rating
____________________	_________________
____________________	_________________
____________________	_________________
____________________	_________________

Your signature: ______________________________________

Comments (optional):

Appendix B
Teaming Rubric

Teamwork—Grading Checklist		
Team:		
Date:		
Evaluator:		
	Possible Points	**Score**
Team Project Management (30%)		
Team set and followed collaborative goals and ground rules	**10**	
Team set timelines for project completion and managed their work to met critical path requirements	**10**	
Entire team kept and participated in meetings with__________________ (Pick appropriate one: faculty advisors, TWS consultant, industry sponsors)	**10**	
Productivity of Team (40%)		
Team delegated work among members responsibly and appropriately	**10**	
Individual team members contributed an appropriate amount of effort and time toward team	**10**	
Team coordinated effective information exchange between all members	**10**	
Team collaboratively addressed feedback from multiple sources and successfully incorporated it into subsequent deliverables	**10**	
Cohesiveness of Team (30%)		
Team members made efforts to understand, include, and respect other team member's perspectives and ideas	**10**	
Team addressed personality problems and conflicts as a constructive whole—not as separate individual members	**10**	
Team oral presentations and written reports reflected integration of different members' content into a coherent team voice	**10**	
Total Score (100%)	**100**	
Comments:		