AC 2010-834: WHAT MAKES A TEAM "CROSS-DISCIPLINARY"? DEVELOPMENT AND VALIDATION OF CROSS-DISCIPLINARY LEARNING MEASURES

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Abstract

This a progress report on a research project funded by the National Science Foundation to identify or develop, and validate measures of cross-disciplinary team functioning, in order to assess the best practices for developing such competencies. The project is a collaboration of undergraduate, multidisciplinary, service learning, and project based learning programs at four institutions. While a great deal of literature exists related to assessment of team functioning, there is relatively little research on the assessment of cross-disciplinary team learning (CDTL), where team members are presumed to learn to transcend their own disciplinary boundaries, appreciate different frameworks, and (eventually) broaden their perspectives to include those of other disciplines. A basic framework of CDTL was developed based on review of collaborative learning and cross-disciplinary learning literature and interviews and analysis of team member reflections. Best practices related to general competencies were identified, and four major cross-disciplinary learning objectives were derived from this framework. These include: the learner's ability to self-identify their own skills, knowledge, and potential project contributions; the ability to recognize the potential contributions of others; team members' collective ability to infuse project design goals and processes with contributions of diverse team members; and team members' collective understanding of how other disciplines have influenced project outcomes. Initial survey measures of pre-post project confidence levels across these dimensions have been developed and piloted in Fall '09 semester and all partner programs have been invited to pilot these measures in the Spring '10 semester. Furthermore, the research team is building upon this framework to validate previous measures and to develop other measures of cross-disciplinary team functioning. Job analysis is being used to identify common themes perceived by current and past participants in a multidisciplinary team project, and by faculty "coaches" and the program supervisors. When themes are identified from the interviews, a survey is created to assess those dimensions. This survey will be piloted and psychometric analyses will be performed to revise the survey before it is offered to the partner university programs. The results provide an additional data point indicating student competency in the skills identified for successful cross-disciplinary team functioning. Finally, the measurement of cross-disciplinary team learning is complex thus a single measure is not sufficient. Since team project learning goals and scope varies widely across institutions there are a great many challenges when conducting this type of assessment. A tool to compile and describe means and methods each partner university is using to assess the defined cross-disciplinary learning objectives has been created. Ideally, this tool can help understand how the context of each program influences how cross-disciplinary teamwork is represented, understood, and assessed. Case study data will be used to describe cross-disciplinary learning within context.

Introduction

Two independently developed measures of cross-disciplinary team learning are described in this paper. Section I describes an evolutionary research process beginning with validation of a cross-disciplinary team learning (CDTL) theory and framework with CDTL factors embedded within phases of project development. Confirmatory factor analysis served to narrow items of interest and more importantly, help to align these items with goals, competencies and best practices of the service learning program for which they were designed. The current stage in this evolution is a focus on identification of specific cross-disciplinary learning objectives and related behaviors, attitudes, and understandings. Specified CDTL objectives form the basis identifying measurement of these objectives across the four partner institutions. Section II represents a partial replication of research validating the CDTL framework. The emphasis in this study is on identifying and measuring broad competencies as a function of doing cross-disciplinary team work. Thus, "cross-disciplinary" is defined in terms of team composition as in teams comprised of multiple disciplines. The logic is then that measurement of such teams is a reflection of the team's cross-disciplinarity.

I. Development of cross-disciplinary team learning objectives and related self-efficacy measures

Multiple theoretical perspectives are required to better understand how cross-disciplinary teams learn and what interventions will support their learning. The following questions helped drive the selection of theories: 1. How do individuals become effective team members? 2. How do project teams become high performing teams (and what does a high performing team look like)? 3. How do such teams effectively adapt to project and situational demands? Some of the disciplines/fields and theories that inform the evaluation framework include: experiential learning and project-based learning in education[1]; design theory and cross-disciplinary learning in engineering[2,3,4]; teamwork and diverse teams in psychology [5,6]; design theory in management [7,8]; socio-cultural systems and organizational learning in system theory [9,10].

Evidence from team research studies indicates that design task complexity, overall team member time on task, and team member expertise levels are related to the evolution of shared mental models among team members [11,12]. Cross-disciplinary team learning (CDTL) is highly interrelated with team dynamics and collaborative learning processes that are expected to occur as any team or group attempts to solve a problem. Assessment of CDTL is thus a unique component of the assessment of individual and team functioning.

An effort to create a unified framework was completed by this research team in 2007. This effort included the validation of the cross-disciplinary team learning or CDTL framework with the same service learning program targeted in the current study. A major thrust of this validation effort was to identify the strongest CDTL sub-factors associated with the theory underlying the framework. The method for validation was to administer construct valid assessment items to cross-disciplinary service learning teams. Confirmatory factor analyses helped to tease the sub-factors out of the original CDTL framework that appear to most strongly represent the underlying theoretical constructs. More specifically, analysis suggested that elements of cross-disciplinary learning must be assessed at both the individual and unit-level.

In the current study, the strongest CDTL factors were aligned with the service learning program outcomes and goals related to cross disciplinary team learning. Major service learning program competency areas include: project accomplishments, project progress, reflective/critical thinking, teamwork/leadership, and communication. Specific cross-disciplinary learning goals that students are to be assessed on include the ability to: 1) Identify their own level of knowledge and potential contribution to team goals; 2) Recognize others' knowledge and potential contribution to team goals; 3) Appreciate the collective team knowledge contribution to idea generation, solution selection, and other design processes; and 4) Share understanding of the design solution and how it is instantiated in terms of team product quality.

The purpose of this study was to 1) validate identified cross-disciplinary learning goals by investigating students' understanding of cross-disciplinary; 2) examine how students' self-efficacy for cross-disciplinary goals was impacted by participation on cross-disciplinary project design teams. This study seeks to address two major research questions: what is students' understanding of cross-disciplinary team learning, and how do students' levels self-efficacy change through participation on cross-disciplinary design teams.

Method

Researchers conducted a mix-method approach in this study to assessing students' cross disciplinary team learning. Research team developed two instruments for this study: self-efficacy scale reflection and mid-semester reflection. Instruments include a pre and post self-efficacy reflection survey and a mid-term semester reflection. Students are asked to rate their own self-efficacy according to cross-disciplinary learning objectives. Mid-term reflection is also collected to understand better students' perceptions and understanding of themselves as well as other team members, in terms of the knowledge and skills that different discipline might bring into the project. Two cross-disciplinary teams with 14 participants were recruited for this pilot study.

Data Collection

Three data collection points were set in this study: the fourth week, the eighth week and the fifteenth week. The pre-project self-efficacy survey was distributed to students in four teams on the forth week of the project. In the eighth week, students reflected on their experience of cross-disciplinary team learning. Table 1 shows the procedure of data collection.

Week 4	Week 8	Week 15
Pre project self-efficacy reflection survey	Mid semester reflection	Post project self-efficacy reflection survey

Table 1. Data collection procedure

The pre and post self-efficacy instruments contain the same items. A sample question is " Rate your degree of confidence or belief in your ability to engage in discussions with team members who are from different disciplines." Students were asked to rate their confidence or belief level from 0 to 100. They were asked to provide both a rationale for the pre survey and to reflect on differences between pre and post semester ratings.

In addition, during the semester, students reflected on their cross-disciplinary team learning experience based on these guiding questions:
1. Think about these questions: How well do you know your teammates? Can you think of ways each has contributed to the project in a way that represents their academic discipline area?

Reflect upon your experience during the first half of the semester and list a few examples of these contributions. If some have not contributed why do you think this is so?
2. Think about these questions: Do you feel engaged in the discussions your team has about design? Are you comfortable asking technical questions or discussing design issues with teammates? Reflect upon your experience during the first half of the semester and describe your engagement in and comfort level with design discussions.

Data Analysis

The quantitative data was analyzed by paired t-test to find out whether the changes in the pre and post self-efficacy survey were statistically significant. Researchers also used one-way ANOVA to test the correlation between prior cross-disciplinary team experience and the confidence differences between pre and post semester ratings. The qualitative data served as a triangulation to support the findings from the quantitative data. The written reflection in the pre and post self-efficacy reflection helps to understand the reason of certain changes in students' self-efficacy.

Results and discussion

Table 2 summarizes results comparing students' pre and post self-efficacy survey data.
In this small, preliminary study, researchers found no correlation between team members' confidence (self-efficacy) levels and year in school (freshman, sophomore, junior, senior, grad). However, all students' confidence in their knowledge and ability to contribute to the project increased as a result of participation on a semester-long design team. More specifically, students who had no prior experience in cross-disciplinary teams saw a statistically significant increase in confidence levels relative to their ability to contribute to the project as well as their understanding of how different disciplines contribute to the project, with a r square= 0.36.

There were two students, whose confidence level decreased at the end of the semester, when being asked to reflect on their current ability what knowledge/skills that they bring to the project. One student wrote: "I learned that I may know about something but not in enough depth." Another student more specifically identified a content knowledge area that would be benefit to the project by stating he "needed more engineering experience preferably".

For the two students had lower self-efficacy point in identifying the goals and constraints of other disciplines, students might have over-rated themselves in the beginning of the semester. One student wrote down in his reflection: “As I look back at the semester, I assumed what my team members were capable of. However, that assumption was very much in error.”

A major theme emerged among students who stated no change in self-efficacy levels for cross-disciplinary team learning. It was found that this type of student was good at self-identifying skills and knowledge. For example, one student reflected that: "I knew my skills and was able to use them throughout the semester."

	Confidence to identify what knowledge/skills you bring to the project.	Confidence to recognize the project goals and constraints of team members from other disciplines.	Confidence in your current ability to contribute to the project.	Confidence in your ability to engage in discussions with team members who are from different disciplines.	Confidence in your ability to understand how different disciplines contribute to the project.
Mean difference (100 pt scale)	10.71	9.29	15.71	9.29	7.14
α= .90 is sig.	0.**978**	0.**916**	0.**995**	0.**934**	0.**981**
# students with an increase in self-efficacy	9	8	11	8	7
# students with a decrease in self-efficacy	2	2	1	1	1
# students with no change in self-efficacy	3	4	2	5	6

Table 2. Preliminary data analysis summary

Preliminary data from this pilot study shows that students' self-efficacy for specific cross-disciplinary team learning objectives was influenced by participation on team projects with others from different disciplines. Further data collection will help better understand how team composition, stage of project design, and individual factors such as year in school and prior experience with similar projects impacts confidence levels.

II. Development of cross-disciplinary team functioning measures

The team also attempts to develop and measure teamwork in cross-disciplinary project teams. Such teams consist of members with different functional experiences and abilities, and will likely come from different departments within the organization [13]. Many believe that in order for organizations to maintain a competitive advantage, cross-disciplinary teams are essential[14]. Several researchers support the idea that by broadening the range of experience and expertise available to a team as their effectiveness increases [15,16].

Understanding the competencies of cross-disciplinary team functioning is an important outcome to prepare students for the contemporary world of work, but it has proven difficult to assess how well students are prepared when they graduate. Therefore, the first objective of this part of the research study was to develop a measure; the second objective was to measure the dimensionality of the survey.

Method

Students were sampled from a medium-sized Midwestern undergraduate institution that requires student participation in cross-disciplinary, team projects. The projects are real-world problems that would benefit from perspectives provided by diverse disciplines. Students and faculty involved in the Interprofessional Projects Program (IPRO) participated in the development of the Cross-Disciplinary Functioning Survey (CDFS) and additional measures. For the job analysis conducted before the development of the measure 10 students volunteered for interviews and 25 students submitted essay questions regarding their experiences as members of cross-disciplinary teams. After the development of the survey 54 students volunteered to participate in the survey's administration anonymously.

Data collection and analysis

Job Analysis

A job analysis of current IPRO students was conducted. There were no descriptions available to the researchers of what all students did in common in the program. Students had to have completed one IPRO course and currently enrolled in another to be considered a subject matter expert (SME) for this study. A memo was sent through the professors of IPRO to recruit students for interviews; 11 responded and 10 completed the interview. The students were asked 34 questions regarding the specific requirements of their project teams. The interview included several questions soliciting critical incidents. An example critical incident question is "Think about a time when you/your students had to rely on others to finish a task successfully. What led up to that situation? What actions were taken? Who performed which actions? What were the results?" Questions were also provided as a requirement for students in which they discussed their experience as a member of a cross-functional team member.
After soliciting participants to contribute their essay, 25 students allowed us to use their answers. A sample question is "What knowledge, skills, and abilities did you bring with you that have been valuable to you in your project work?"

CDFS

Based on the results from the job analysis the researchers created the 37-item CDFS measuring 7 dimensions. Seven items were removed before distribution during the item writing process. The 30-item measure was distributed to participants answering on a seven-point Likert scale. The complete measure had a reliability estimate of α =.970 with subscales team skills (α= .862), communication (α= .866), accountability (α= .892), technical skills (α= .835), research (α= .780), project management (α= .836), and project vision (α= .782).

Results and discussion

The dimensionality of the 30 items from the Cross Disciplinary Functioning Survey was analyzed using principle axis factor analysis. Three criteria were used to determine the number of factors to rotate: the a priori hypothesis that there are seven unique dimensions, the scree test, and the interpretability of the factor solution. The scree plot and factor solution indicated that there are 4 components. The factor correlations were low to moderate, -.301 to .633. Because there were several moderate correlations, Oblique rotation was appropriate. Oblique rotation assumes that the factors are correlated. Based on this reasoning, four components were rotated using a Direct Oblimin rotation procedure. The rotated solution, as shown in Table 2, yielded four interpretable factors: research competency, interpersonal management, trust, and project planning. Four items did not load highly on any factors. One item loaded on more than one factor. Our model accounts for a total 66.7% of the variance.

The initial reliability analysis made the researchers skeptical of the dimensionality of the CDFS. Using factor analysis we were able to interpret that there were four interpretable and unique factors that represent different dimensions of cross-disciplinary teamwork. There were four items that did not have clear loadings; as they did not have high item-total correlations, the researchers decided to remove the items.

III. Implication and Limitations

Together, these validation and development efforts represent an attempt to employ a multifaceted approach to the assessment of a highly specific kind of team learning.

The findings of the second study serve as a kind of validation of the original CDTL framework. Limitations include the moderate number of interviews that were conducted during the job analysis and the sample size for the measure. The researchers intend to collect more data for the next revision of the measure. We encourage future researchers to validate the CDFS for similar cross-disciplinary teams use.

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