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Self-Efficacy for Cross-Disciplinary Learning in Project-Based Teams

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BACKGROUND
While research indicates that self-efficacy is related to learning on discrete tasks, less is known about self-efficacy for learning in complex, ill-structured learning environments. A measure of self-efficacy for design teams provides grounding for the design of learning support.

PURPOSE (HYPOTHESIS)
This study aims to determine the usefulness of a measure of self-efficacy for cross-disciplinary team learning (CDTL) within a multi-disciplinary, project based setting. Research questions include: (1) Does student efficacy for CDTL change over the course of the semester? (2) What is the effect of (a) task complexity; (b) prior learner experience; (c) team composition; and (d) personal factors on efficacy for CDTL?

DESIGN/METHOD
Efficacy for CDTL while working on multi-disciplinary team projects was assessed using a 16-item Self-efficacy for CDTL scale. A total of 112 undergraduates from 34 teams in a service learning program completed both pre and post project questionnaires.

RESULTS
A statistically significant increase in pre-post semester self-efficacy was found across three team learning factors: identification, recognition, and integration. Individual GPA and year in college were related to higher levels of improvement in the identification factor, while the completion of multiple design phases in team tasks was related to lower levels of improvement in the identification factor.

CONCLUSIONS
This study contributes to our knowledge of individual self-efficacy and the design of learning environments involving multi-disciplinary teams. It is an important step toward the development of theory and evidence that can help higher educational institutions to better understand if and how students learn to collaborate while working on team design projects.

KEYWORDS
cross-disciplinary learning, self-efficacy, project-based teams

INTRODUCTION

The ability to work as an engaged member of a project team is an important competency for undergraduate engineering students (Felder & Brent, 2003; Hilborn, 1994; Mills & Treagust, 2003). Many higher education institutions arrange students in teams consisting of students from different disciplines (Borrego & Newswander, 2008; Tsang, Van Haneghan, Johnson, Newman & Van Eck, 2001). Participants on such teams are expected to learn to transcend their own disciplinary boundaries, appreciate different frameworks, and eventually broaden their perspectives to include those of other disciplines (Borrego & Newswander, 2008; Fruchter & Emery, 1999; O'Brien, Soibelman, & Elvin, 2003).

Many engineering programs in higher education have shifted toward a student-centered rather than teacher-centered approach to learning. This shift has spurred the adoption of pedagogical advances such as project-based learning as a method to prepare engineering students for the profession, as well as more innovative research in the areas of multi-disciplinary team learning. For example, Fruchter and Emery (1999) examined how student project teams practiced "cross-disciplinary" learning. They suggested that a major component of teamwork is learning to work with others from different disciplines. Another major finding from this study was the notion that cross-disciplinary learning involves an evolution from individual to collaborative thinking by team members.This research also highlights the importance of employing metacognitive strategies within project based learning environments. In the current study, undergraduates working on project-based multi-disciplinary teams in a service learning program assessed their efficacy for cross-disciplinary team learning (CDTL). An overarching goal was to validate the assessment measure relative to the CDTL construct, and to understand how characteristics of the team context and task influence self-efficacy for CDTL.

THEORETICAL FRAMEWORK

Cross-disciplinary team learning is highly interrelated with team structure, dynamics, and collaborative learning processes that are expected to occur as any team or group attempts to solve a problem (Schaffer & Chen, 2009). According to Borrego and Newswander (2008), team member efforts to understand and appreciate the contributions and various disciplinary frameworks of other team members are essential for interdisciplinary and cross-disciplinary collaborations. For instance, Ritcher and Parattie (2009) explored cross-disciplinary learning by conducting a case study of students from different disciplines in a university course. Two major learning barriers related to cross-disciplinary learning were identified: "(1) students fail to recognize the relationship between their own discipline and an interdisciplinary subject; (2) students fail to recognize and value the contributions of multiple technical and non-technical fields to a given interdisciplinary problem" (p. 39). An example of one of the many challenges students face in a team environment is applying and sharing technical or disciplinary knowledge with others while solving design problems. Validation of a theoretical framework for understanding cross-disciplinary team learning (CDTL) developed by Schaffer, Lei, and Reyes (2008) was based on a review of collaborative learning and cross-disciplinary learning literature, and interviews and analysis with several undergraduate teams. A follow-up study by Schaffer and Chen (2009) identified four overall cross-disciplinary team learning goals for individuals on multi-disciplinary teams including the ability to: (1) self-identify skills, knowledge, and potential project contributions; (2) recognize the potential contributions of others to the project; (3) interact with team members during design discussion to draw out and clarify disciplinary perspectives; and (4) synthesize awareness and appreciation of other disciplines and reflect this understanding in design products. Efforts to validate these theoretical goals or factors suggest that three factors rather than four may be used as the basis for assessment of cross-disciplinary learning (Schaffer, Chen, and Oakes, 2010). These factors are briefly reviewed in the Results section of the current study.

Self-Efficacy in Project-Based Learning

The classic theoretical framework for self-efficacy developed by Bandura (1977, 1982, 1986) highlights the role of self-referent thought in guiding human action and change. Students' self-reported confidence levels in working and learning with team members from different disciplines theoretically reflect a belief in their abilities to engage on such teams. According to Bandura, behavior changes achieved through methods such as guided exposure, modeling, persuasion, and anxiety reduction, are in part the result of creating or strengthening one's efficacy expectations. Self-efficacy has been hypothesized to influence choice of behavioral activities, effort expenditure, persistence in the face of obstacles, and task performance (Brown & Lent, 1991). It has been measured in many contexts and is typically related to skills and abilities related to specific task performance (Eccles & Wigfield, 2002; Schunk, 1994; Stone & Bailey, 2007).

Researchers in many disciplines have investigated efficacy change in project-based learning environments. For example, project-based learning influences student efficacy for academic knowledge in medical education (Papinczak, Young, Groves, and Heynes, 2008), communication and cultural knowledge in foreign language learning (Mills, 2009), and collaboration in software design engineering (Dunlap, 2005). However, researchers have reported mixed results of the direction of the self-efficacy change. Prior research on self-efficacy in a project-based learning environment suggests that the quality of project-based learning experiences impacts students' self-efficacy (Dunlap, 2005). Mills (2009) investigated students' efficacy in a language learning course and found significant increases in student self-efficacy in the areas of "communication, cultures, connections, comparisons, and communities" after participation in a project-based learning curriculum. This research concluded that positive experiences will lead to an increase of self-efficacy, while stressful or fearful experiences will lead to a reduction of self-efficacy.

On the other hand, some studies have shown that student efficacy has decreased by the end of a learning experience. Papinczak, et al. (2008) reported that in the beginning of a study, students exhibited high levels of self-efficacy in terms of academic efficacy because of their undergraduate performance and self-confidence regarding their use of learning strategies. However, over a year-long course of study in a school of medicine designed around project/problem based learning it was shown that "students lose self-efficacy and move away from deep-strategic learning approaches to more surface approaches" (Papinczak et al., 2008, p. 213). Several potential causes for this unexpected change were identified with a major one being low student estimates of time required by project based learning projects.

In the engineering education realm, Richardson (2008) reported on the use of self-report to improve self-efficacy of students working on design projects. In another study conducted in a team environment, researchers developed a measure of self-efficacy for performing design tasks (Carberry & Lee, 2010) in which a validated framework for design was the basis for assessing self-efficacy. The current study is similar to the Carberry and Lee study in that a framework for cross-disciplinary team learning was the basis for developing assessment items. The need to assess self-efficacy for team learning is warranted since it is not clear from the literature how project based learning environments impact learners' confidence to learn with and from others in the undergraduate education context.

The current study explores the potential impact of team context, task complexity, and individual characteristics on learner efficacy beliefs related to working with others from different disciplines. Two research questions were explored: (1) Does student efficacy for CDTL change over the course of the semester? (2) What is the effect of (a) task complexity; (b) team composition; and (c) individual characteristics on efficacy for CDTL?

It is clear that both individual and team level factors influence the extent to which individuals acquire professional skills such as cross-disciplinary teamwork. The factors examined in research question two are aligned with the core principles of learning system design (Smith & Ragan, 2004).

Methods

Sample and Data

To explore the research questions, questionnaire data was collected from undergraduate students participating in a service learning program at a Midwestern university. The experiential instructional approach used in this setting provides an opportunity for all levels of students to apply knowledge and skills in authentic, real-world environments. Because projects were large and complex, it was an excellent context in which to study team learning. Purposive sampling (Patton, 1980) was used in this study. Participants were selected on the basis of their commonness (they were typical cases), and convenience (they were students registered in a project-based learning program). Students participated in this semester-long program for one or two academic credits, and selected teams based on their interests and the perceived goals of the team. Most teams consisted of a mix of freshmen, sophomores, juniors, and seniors, most were from one of the engineering areas of study, while approximately 30% majored in non-engineering fields such as education, liberal arts, science, and consumer and family sciences. Three hundred and three students enrolled in the program in the 2010 spring semester. Students' performance was assessed according to (1) their individual performances on the team, as reflected by their learning journal and peer reviews from other team members and (2) team performance as reflected by team design documents, expert review of design presentations, and client reviews.

An example of a service learning project team in this program is a multidisciplinary team that worked with a community partner to improve the quality of life of disabled students in local schools. The team worked with the partner to identify, design, and implement a wide variety of assistive technology applications. Three sub-teams worked on the following projects, namely, Interactive Programmable Alternative Augmentative Communication; Soccer Assistive Contact Rail; and Talking Embedded Arduino Portably Optimized. The three sub-teams had different goals and project scope, and members primarily worked within the sub-team to achieve project goals.

Questionnaire data were collected early and late in the semester. Instruments were administered via paper and pencil, and each took 10 to 15 minutes to complete. All students enrolled in the service learning program in the spring of 2010 were invited to complete the instrument. The pre-project questionnaire was administered at week 4 when project teams were early in formation (T1). It included questions about students' educational and demographic background (e.g. gender, age, year in school, major, and GPA), prior experience with teams, and efficacy ratings related to CDTL. The post-project questionnaire was administered at the end of the semester in week 15 (T2). The post-survey included the same set of questions that appeared on the pre-survey. In addition, the post-survey asked about characteristics of the task and intra-team learning behaviors. A total of 178 students filled out the pre-survey, while 191 responded to the post-survey. In total, 256 students from 60 teams responded to at least one survey, out of which, 112 from 34 teams responded to both. We also collected information on the college and major of the participants from archival records provided by the service learning program.

There were 25 female students and 87 male students in the total 112 responses, including 43 freshmen, 17 sophomores, 19 juniors, 31 seniors and 2 graduate students. The average cumulative GPA was 3.08.

Measures

Self-efficacy for CDTL. Questionnaire items were based on four elements of CDTL identified by Schaffer & Chen (2009). These elements include: (1) identification or the ability to self-identify skills, knowledge, and potential project contributions; (2) recognition or the ability to recognize the potential contributions of others to the project; (3) interaction or the ability to interact with team members during design discussion to draw out and clarify disciplinary perspectives; and (4) integration or the ability to synthesize awareness and appreciation of other disciplines and reflect this understanding in design products. A total of 16 items were developed to reflect these four elements. Participants were asked to rate their confidence in their abilities to carry out actions described in each item on a 0 to 100 scale, with larger numbers indicating greater confidence. As described in the results section, our analysis supports a three-factor structure, including identification, recognition, and integration. All three factors had acceptable internal consistency (see results in Table 1). Each individual's score on the four items for each factor was averaged to create an indicator for each factor.

TABLE 1
Revised Self-efficacy for CDTL Scale

Factor	Items (item loading)
Identification (Cronbach Alpha = 0.88)	• Clearly identify the type of knowledge and skills I have brought to this project (0.91).
	• Appropriately assess the relevance of my knowledge and skills to this project (0.95).
	• Accurately assess the extent to which my mastery of these knowledge and skills was adequate for the project (0.67).
	• Accurately evaluate how much my knowledge and skills contributed to the project (0.71).
Recognition (Cronbach Alpha = 0.87)	• Clearly identify the type of knowledge and skills possessed by team mates from other disciplines (0.75).
	• Accurately recognize goals that reflect the disciplinary backgrounds of other team members (0.89).
	• Discuss the contributions other disciplines have made to this project (0.64).
	• Think of ways other members have influenced the project in a way that represents their academic disciplines (0.63).
Integration (Cronbach Alpha = 0.82)	• Talk about the project design using other discipline language (0.84).
	• Provide input to others from different disciplines (0.82).
	• Be proactive in working on design problems with those from different disciplines (0.70).
	• Examine a design issue from my teammates perspective (0.61).

Task complexity. Task complexity was based on the design stages identified by this specific service learning program, namely, Identification, Specification, Conceptual Design, Detailed Design, Delivery, Service/Maintenance, Redesign, and Retirement. Students reported on the percentage of time their team devoted to each design stage during the semester. We first computed the number of design stages on which the team worked during the semester as reported by each individual on the team. The number of design stages identified by individuals displayed significant between-group variation (ICC1 = 0.26, $p < .01$), suggesting that the design tasks had significant variation across teams. Significant within-group agreement (ICC2 = 0.57, $p < .01$) indicated that members within the same team had a high level of agreement in their perception of team task. Significant between-group variation and within-group agreement validated group level analysis and group level aggregation of individual responses. We therefore computed the mean number of design stages across individual members to form a team level measure.

Team composition. We considerd three aspects of team composition, namely, team size, team gender diversity, and disciplinary diversity. Team size was measured by the number of members on the team. Gender diversity was measured by the proportion of males on the team. Disciplinary diversity referred to the extent to which team members came from different disciplines. Students participating in the service program came from 18 colleges and schools (e.g. School of Electric & Computer Engineering, College of Science, College of Liberal Arts, and so on). We counted the number of different colleges/schools team members came from to form a measure of disciplinary diversity.

Individual characteristics. Participants reported their gender, cumulative GPA, year in college, and prior experience with teams. Year in college was determined using a 4 point ordinal scale (1- Freshmen, 2- Sophomore, 3- Junior, 4- Senior or Super Senior). Prior experience with team was determined using a 3-point scale (0 = No experience, 1 = Some experience, 2 = A lot of experience).

Results

Factor Analysis

Factorial analysis helped to determine how well questionnaire items loaded onto the theoretical CDTL factors they were intended to measure. Exploratory factor analysis was conducted in data collected at T1 to empirically determine the factor structure in the items we used to assess self-efficacy for CDTL. A major finding was the identification of three distinct factors rather than four. The four questionnaire items for identification (factor 1) and the four for recognition (factor2) all loaded as expected. The items for appreciation and interaction, however, did not load on a single factor. Two of the items for interaction loaded together with the items for integration (factor3), and the other two items cross-loaded on two factors. All items for interaction as well as other items that cross-loaded were dropped from the model to obtain a more clear factor structure. In the revised structure, all factor loadings were greater than 0.4 with 3 factors emerging for the validated CDTL scale. Confirmatory factor analysis conducted on data collected at T2 statistically validated the three-factor structure that emerged from the exploratory factor analysis. See Table 1 for the revised scale and items. All three factors had acceptable internal consistency, as indicated by high Cronbach alpha coefficent's (see Table 1) for the scale items within each factor (Cronbach, 1951; Nunnally, 1978). High Cronbach alpha coefficients are one indicator that an instrument is measuring the latent construct it is intending to measure.

Research Question One

Our first research question examined the degree to which self-efficacy changed from the beginning (T1) to the end (T2) of the semester. A repeated measures *t*-test on the 112 participants who filled out the survey at both T1 and T2 was conducted to determine if there was significant change in the students' pre and post semester ratings. Results are presented in Table 2. The mean score for all three factors at T2 were significantly higher than the mean score at T1, suggesting significant overall increases in levels of efficacy for CDTL. We then computed the differences between the score at T1 and T2 (T2 > T1, $p < .01$) for all three factors. The frequency table for each change score reveals substantial variation in the nature and degree of change across individual participants. For identification, the change scores ranged from -30 to 67.5, with 33.04% of the participants reporting no change or a decrease in their efficacy level. The change scores for recognition ranged from −42.50 to 72.50, with 30.04% of the participants reporting no change or a decrease. Finally, the change score for integration ranged from to -52.5 to 60, with 41.96% reporting no change or a decrease. Over 60% of the participants had never taken part in a service learning team project before, therefore lacked knowledge about the project tasks and how teams in the program operate. The decrease of efficacy for CDTL for some participants more likely reflected an over-estimation of one's ability at the beginning of the semester than an actual decrease in one's ability. Another possible explanation may have been initially high expectations related to the project experience.

Research Question Two

The second research question focused on identifying factors that influenced changes in efficacy. The dependent variable was change in self-efficacy from T1 to T2 (T2-T1). Because of the nested data structure, we employed a multi-level modeling technique that can account for interdependence among data reported by individuals within the same team (Nezlek, 2008; Kozlowski, & Klein, 2000). The analysis sample consisted of 109 participants (out of the 112 that filled in surveys at both T1 and T2) from 31 teams (out of 34), after dropping participants with missing values on the analyses variables and dropping teams with less than two responses. Table 3 presents the results.

We started with a random intercept model (Table 3). Model 1 contains the control variable, namely, individual identification at T1. It has a significant negative relationship with change in identification. This result suggested that individuals with a high identification

TABLE 2
Repeated Measure t-test for Differences in Self-efficacy for CDTL at T1 and T2 ($N = 112$)

	Mean at T1	Mean at T2	T2-T1	*t* value	*p* value
Identification	71.45	80.15	8.61	5.59	0.00
Recognition	70.67	79.13	8.46	5.21	0.00
Integration	73.53	78.58	5.04	3.20	0.01

TABLE 3
Multi-level Models of Changes in Identification from T1 to T2 (Indiviudal = 109, Team = 31)

	Random Intercept Models					
Individual level	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
T1 identification	−0.80**	−0.83**	−0.83**	−0.83**	−0.83**	−0.83**
Male		−4.13#	−5.07*	−3.25	−2.47	−3.08
GPA		0.06#	0.07*	0.06#	0.07*	0.06*
Year in college		1.03	1.17	1.55**	1.07	1.56*
Prior team experience		1.47	0.94	0.52	1.26	0.30
Team level						
Team size			−1.23*			−0.76
Task complexity				−2.41**		−1.79#
Proportion of males					−9.94#	−5.34
Number of disciplines					−1.17#	−0.41
Constant	66.18**	62.36**	67.65**	73.32**	72.01**	79.75**
Log likelihood	−405.16	−400.20	−398.04	−393.98	−397.83	−392.40
Likelihood ratio test		2−1	3−2	4−2	5−2	6−2
		$p < .05$	$p < .05$	$p < .05$	$p < .05$	$p = .11$

Note. ** $p < .01$. * $p < .05$. #$p < .1$

score at T1 tended to report a smaller increase in their identification score at T2, probably for two reasons: They had less room for improvement, and greater likelihood of over estimating their abilities at T1. Model 2 tested the effects of four individual characteristics, gender (male = 1), cumulative GPA, year in college, and prior experience on teams. Both gender and cumulative GPA are significant at .1. Compared to females, males reported a smaller increase in their identification score over the semester. Individuals with higher GPA tended to report a slightly greater increase in their identification score from T1 to T2.

Model 3 to Model 6 tested the effects of team level variables on self-efficacy, including team size, task characteristics (number of design stages involved in the task), proportion of males on the team, and number of different disciplines within a team. Model 3 showed that team size had a significant negative impact on changes from T1 to T2. Teams with more members tended to report a smaller increase in the team's average identification score. Model 4 showed that projects that involve more design stages were also associated with a smaller positive change in a team's average identification score from T1 to T2. Both of these findings were important to team learning environment design but were not unexpected. Model 5 incorporated two indicators of team composition. Both proportion of males and the number of disciplines on the team were significant at 0.1, and both were negatively associated with increases in the team's average identification score from T1 to T2. Finally, in Model 6 which included all team level variables, only the number of design stages involved in team tasks is significant at .1. Additionally, Model 4 and Model 6 together suggested that once task characteristics were controlled, year in college became significant with a positive association with team average change in identification from T1 to T2. In other words, students that were more senior tended to report a larger increase in their identification score from T1 to T2. In contrast, Models 4, 5, and 6 suggested that gender becomes insignificant when team level variables were controlled.

We also estimated random intercept and random coefficient models to assess if the effects of gender on changes in self-efficacy, and the slope of GPA in predicting changes in self-efficacy varied across teams. Analysis yielded insignificant standard deviation for the coefficients for gender and GPA[1]. Likelihood ratio tests suggested that the intercept and random coefficient models did not improve the model fit in comparison to the corresponding random coefficient model (i.e., Model 2). Therefore, our results do not support the idea that the relationship of changes in self-efficacy in identification with gender and GPA may vary across teams.

We conducted the same set of analyses with changes in recognition and integration as the dependent variables. However, none of the above individual characteristics or team level variables had a significant effect. We therefore did not include detailed results of those analyses.

In summary, our factor analyses suggested a three factor structure for self-efficacy for CDTL. The three factors included identification, recognition, and integration. These three factors had acceptable reliability, convergent validity, and discriminant validity. Repeated measure *t*-tests suggest overall improvements in all three aspects of self-efficacy for CDTL from T1 to T2. However, multi-level modeling was only able to provide some suggestive evidence for the influence of individual and team level factors on changes in identification, but was not able to find significant predictors for changes in recognition and integration. Individual GPA emerged as a significant predictor of changes in identification, and team task characteristics (number of design stages involved in team tasks) also seemed to be a relatively consistent predictor of changes in efficacy for identification.

Discussion

This study contributes to the burgeoning area of inquiry into multi-disciplinary team learning by exploring two main questions: (1) Do levels of self-efficacy for CDTL change over the course of a semester while working on a team project? (2) What factors influence the change?

To answer the above questions, we first developed a scale for self-efficacy in CDTL. The three-factor structure that emerged from the analysis was theoretically derived, then empirically revised and verified through EFA and CFA on two different sets of data. The three factors have reasonable reliability and convergent and discriminant validity. Future studies should further validate the scale and link self-efficacy for CDTL to other important individual and team outcomes, such as individual learning and task performance, as well as team effectiveness.

Results from this study on a sample of undergraduates working on multidisciplinary project teams suggested that overall changes in self-efficacy for CDTL occurred during projects. This echoed the findings by Mills' (2009) study that students' self-efficacy would increase in the areas of communication, cultures, connections, comparisons, and communities after participating in project-based learning environment. This may be a credit to the

[1]Details on the results of the random intercept and random coefficient models are available from the authors.

opportunities that students had in design discussions, design presentations, and client meetings throughout the multidisciplinary project process. There was considerable variation across individuals in terms of the direction and magnitude of the change. Notably, 30% of the participants reported no change or a decrease in their CDTL self-efficacy from T1 to T2. This finding was expected in a group of diverse learners working on diverse projects. One interpretation is that at T1, students may be more vulnerable to over-confidence and thus over-estimate their abilities in CDTL, due to the lack of knowledge about the task and the team (Papanczak & Young, 2008). Another interpretion is that students often fail to estimate the difficulties or "hold a naïve view of possible difficulties" (p. 395) at the beginning of the learning process in a collaborative learning environment (McNair ,Paretti, & Kakar, 2008). Since data was collected at two points in time, one at the beginning and one at the end of the semester, additional data on changes in individual self-efficacy for CDTL could be collected. It is recommended that future research designs allow collection of data at three or more points in time so as to understand how students' self-efficacy changes over time. In addition, qualitative data would also provide richer insights on why students report decreases in their efficacy for CDTL.

Multi-level modeling of changes in self-efficacy did not identify a significant predictor for changes in recognition, and cross-disciplinary understanding and integration, but did provide some evidence that individual GPA, year in college (Schaffer & Chen, 2009), and team task characteristics (Dunlap, 2005; Edmondson, 1999) may exert influence on changes in self-efficacy. Evidence for the influence of other team level variables such as team size and team composition was less compelling, but still encouraging. The noisy CDTL efficacy data at T1 may have reduced our ability to detect meaningful relationships. The small team size (mean = 3.5) may also have limited the ability to detect a significant relationship at the individual level, and prevented detection of random coefficients. Future studies with improved design and data structure are necessary to further investigate how individual characteristics and team context influence individual self- efficacy.

Implications/Conclusion

In short, this study contributes to our knowledge of individual self-efficacy and learning in multi-disciplinary team settings. Overall self-efficacy for CDTL was found to increase across all respondents. However, a large number of individual students displayed a self-efficacy change that suggests a decrease in confidence and learning during the experience. Advisors of teams in project-based learning programs should understand that students' learning in a project-based environment is influenced by many factors, such as team composition, task complexity, and a host of individual factors. Scaffolding strategies and coaching should encourage students to be more involved and engaged in team learning behaviors that accentuate identification, recognition, and integration.

This study contributes to our knowledge of individual self-efficacy and the design of learning environments that include multi-disciplinary teams. It is an important step toward the development of theory and evidence that can help higher educational institutions to better understand if and how students learn to collaborate while working on multi-disciplinary project design teams.

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