Using Social Cognitive Career Theory to Assess Student Outcomes of Group Design Projects in Statics

Rebecca A. Atadero,[a] Karen E. Rambo-Hernandez,[b] and Meena M. Balgopal[a]

[a]Colorado State University, [b]West Virginia University

Abstract

Background Engineering programs strive to retain students and prepare them for engineering careers. Introducing group design projects into courses may help keep students interested while also improving their learning outcomes.

Purpose/Hypothesis This study measures differences in student content knowledge and intention to persist in engineering between an intervention section with group design projects and a comparison section without. We hypothesized that students in the intervention section would show an increase in both outcomes that could be demonstrated with structural equation models based on social cognitive career theory (SCCT).

Design/Method Intervention and comparison sections of a statics course were taught by the same instructor with predominately lectures. Students in the intervention section participated in three group design projects that supplemented the course content. All students took pre-tests and post-tests that assessed statics content knowledge and variables in SCCT. Data were analyzed using structural equation modeling.

Results The use of projects did not result in higher self-efficacy, outcome expectations, content knowledge, or intention to persist for students in the intervention. However, for students in the intervention section, there were strong positive relationships between self-efficacy and outcome expectations and between intention to persist and content knowledge that were not demonstrated in the comparison section.

Conclusions By using SCCT to model how students develop into engineers, we could detect the effect of introducing projects into a statics course. Connections formed by students in the intervention section between their own abilities, goals, and success in engineering demonstrate that group design projects do benefit students.

Keywords project-based learning; social cognitive career theory; student outcomes

Introduction

The need for reform of engineering education in the United States has been well established over the past two decades (e.g., National Research Council [NRC], 1995; National Academy of Engineering [NAE], 2005). Reform is needed to ensure a workforce that possesses the

Journal of Engineering Education http://wileyonlinelibrary.com/journal/jee
January 2015, Vol. 104, No. 1, pp. 00–00 DOI 10.1002/jee.20063

requisite skills and is large and diverse enough to meet the challenges of the twenty-first century while preserving the global competitiveness of the U.S. economy (NRC, 2007, 2010). The need for more well-trained engineers is reflected in current efforts to produce more science, technology, engineering, and math (STEM) graduates from U.S. institutions. President Obama's initiative, Educate to Innovate, provides guidance and resources to connect the private sector to education, improve STEM teacher education programs, increase federal investment in STEM, and broaden the participation of citizens who pursue STEM studies and jobs (The White House, 2013). For university STEM disciplines to respond, we need to identify what types of improvement actually benefit student learning outcomes and their plans to remain in STEM careers (Henderson, Beach, & Finkelstein, 2011).

The National Science Board (National Science Board [NSB], 2007) identified three key challenges facing engineering education in particular: the need to respond to the changing global context of engineering by producing graduates who have knowledge and abilities in areas such as communication, systems thinking, and business practices in addition to the analytic skills that are the emphasis of the current system; the need to change the perception of engineering as a career path for socially inept males and to emphasize the societal contributions of engineering; and the need to retain engineering students. Changes in course content and activities are one way to improve engineering education.

The skills and qualities that engineering graduates need are identified in *The Engineer of 2020: Visions of Engineering in the New Century* (NAE, 2004). Attributes of successful engineering graduates include: strong analytical skills; practical ingenuity; creativity; communication; business and management; leadership; high ethical standards and professionalism; dynamism, agility, resilience, and flexibility; and the ability to be lifelong learners. Engineering education in the United States places great emphasis on analytical skills (NSB, 2007) but is not effectively preparing students in many of the other areas. The companion report, *Educating the Engineer of 2020* (NAE, 2005), gives fourteen recommendations to improve the current model of engineering education in the United States, which include the integration of design projects early in the engineering curriculum.

The need to improve retention of engineering students is critical (NSB, 2007). Students are most likely to drop out within the first two years of an engineering program (Litzler & Young, 2012) for varied reasons. The National Science Board (2007) noted that the heavy emphasis on fundamental math and science courses at the beginning of engineering programs prevents students from understanding the nature of engineering and identifying themselves as future engineers; this emphasis leads to student attrition from engineering. Incorporating design into the early stages of engineering programs may help students to recognize the relevance of their early math and science courses and develop a better understanding of engineering. The introduction of design can be accomplished by integrating group design projects into the course content of early engineering science courses.

Projects in Engineering Courses

Projects, and design projects in particular, can help engineering programs teach the necessary content in just four years, promote creativity and innovation in students, promote lifelong learning, encourage knowledge flexibility, relate students to the profession, develop practical ingenuity, motivate students, provide interaction with peers, and teach nontechnical content and skills (NSB, 2007; NAE, 2004, 2005; Crismond, 2001; Schachterle & Vinther, 1996). Projects are often used to introduce design into the curriculum and are commonly used in first-year "cornerstone" and final-year "capstone" courses (Dym, Agogino, Eris, Frey, & Leifer, 2005) but are less common in other engineering courses (Mills & Treagust, 2003).

De Graaff and Kolmos (2003) asserted that "project work is problem-based by definition" (p. 659). Two key features of projects are that they center on a driving question or problem and require students to produce a final product (Blumenfeld et al., 1991). Projects require the initiative of a student or group, involve different kinds of learning activities, are relatively long in duration, and integrate instructors as advisers. The application of projects to engineering courses can vary in scope from a small project initiated by a single instructor in a single class to an entire program of study oriented around project and problem-based learning (for example, at Aalborg University, as described by de Graaff and Kolmos, 2003). Helle, Tynjälä, and Olkinuora (2006) identified four common instructor motivations for using projects in courses: professional – projects reflect professional practice; democratic and humanitarian – service learning projects benefit others; developmental – projects encourage student critical thinking; and pedagogic – projects help students learn and understand concepts better. This benefit to student learning may be partially derived from increased motivation to learn (Blumenfeld et al., 1991; Prince & Felder, 2006; Thomas, 2000).

The use of projects in classrooms is often studied under the label of project-based learning, which is one of several student-centered strategies called "inductive learning" by Prince and Felder (2006). A precise definition of project-based learning is difficult to achieve, as aspects of project-based learning overlap with other student-centered techniques (Prince & Felder, 2006), and the characterization of what constitutes project-based learning can vary depending on the study (Thomas, 2000). Project-based learning is perhaps most commonly associated with problem-based learning. Some sources consider problem-based and project-based learning to be variations on a single approach (Kolmos & de Graaff, 2014). Other sources draw distinctions between problem- and project-based learning (Prince, 2004; Smith, Sheppard, Johnson, & Johnson, 2005). Problem-based learning requires groups to work independently to find solutions or solve problems, whereas project-based learning requires groups to work independently to produce "a deliverable in the form of a report or presentation" (Smith et al., 2005, p. 89). Moreover, project-based learning is often associated with the application of knowledge (gained through previous or accompanying instruction), while problem-based learning is often associated with the acquisition of knowledge (Acar & Newman, 2003; Blumenfeld et al., 1991; Helle et al., 2006; Mills & Treagust, 2003).

While the use of projects is not new to engineering classes, formal assessments of the effectiveness of projects are still needed. In a review of post-secondary implementation of projects, Helle et al. (2006) found that most articles on project-based learning were specific course descriptions that did not describe empirical research. Dym et al. (2005) reviewed project-based learning in engineering design courses and found that freshman courses containing projects, team work, and written and oral communication increased student retention. They also described students' enhanced abilities for collaborative work and for transferring knowledge to new contexts. At the University of Louvain, students in a project- or problem-based learning curriculum were compared with students in a standard curriculum and showed higher levels of knowledge, concept understanding, and application in 23 of 79 indicators, with just one indicator preferring the standard curriculum, and no difference in the remaining indicators (Prince & Felder, 2006). Graham (2010) summarized best practices in project-based learning in the United Kingdom, particularly with respect to transferability, and noted that current implementations include "very limited evaluations of the learning processes and outcomes" (Executive Summary) and that "a greater integration of program evaluations may help provide real evidence for the impact of PjBL [project-based learning], as compared to more traditional lecture based approaches" (p. 5). Therefore, formal evaluations of the effect of design projects and how they can improve engineering education are needed. Previous studies have focused primarily on the effectiveness of projects by measuring outcomes, such as changes in content knowledge, skill development, or retention. Missing from many of these studies is an exploration of the psychological processes of students that explained why these outcomes occurred.

Purpose

This study sought to examine the effect of group design projects on students' content knowledge and intention to persist in engineering. We also examined if the effect of group design projects on students' knowledge and intention to persist could be explained by changes in their social cognitive processes. A statics course was chosen because it is generally taken by students in the fall of their second year, a time when they are often taking many of the abstract mathematics and science courses that can obscure the nature of engineering. This course also falls within the first two years of the curriculum – a critical time for retention. Because statics has been traditionally taught with lecture and homework assignments from the textbook, we sought to evaluate the effect of integrating group design projects on student learning and on the psychological processes that contributed to these effects. Although not all of them are reported here, we used several assessment tools and techniques to more completely understand the effects the group design projects had on student content knowledge and other psychological processes (e.g., self-efficacy). Content knowledge was measured through the Concept Assessment Tool for Statics (CATS; Steif, 2010). Social cognitive career theory (SCCT) was the theoretical framework used to understand the career development of sophomore engineering students and, particularly at this stage, the interaction of variables affecting their intention to persist in engineering (Lent, Brown, & Hackett, 1994). Achievement goal theory was used to investigate changes in student motivation to learn. Student teams were videotaped during in-class group work sessions to allow us to study group dynamics and how students responded to the specific assignment prompts. This article focuses exclusively on the SCCT findings.

Theoretical Framework

Social cognitive career theory (SCCT) models the processes by which students choose and persist in a particular major and career (Lent et al., 1994). Lent and colleagues have shown that SCCT can be successfully applied to engineering students (Lent et al., 2003; Lent et al., 2005; Lent et al., 2008). SCCT is composed of three interlocking models that explain how people develop career and educational interests (interest model), make choices about careers (choice model), and perform and persist in their chosen career or major (performance model). It is derived from Bandura's (1986) social cognitive theory; and variables such as self-efficacy, outcome expectations, and personal goals are central to both theories. Self-efficacy refers to the beliefs people hold about their abilities to perform a certain behavior or complete a course of action in a particular performance domain (Lent et al., 1994; Bandura, 1977). Outcome expectations describe a person's beliefs or outlook on the results or consequences of particular actions (Bandura, 1986) and answer the question, "If I do this, what will happen?" (Lent et al., 1994). Personal goals are the decision to participate in a certain activity or to work toward a particular outcome at a future time. Lent et al. (1994) distinguish between choice goals (e.g., the decision to pick a particular major) and performance goals (e.g., the desire to earn a grade of A in a particular course). In SCCT the interaction of the social cognitive variables with other variables describing personal characteristics and the social environment are used to help explain the career paths people follow (Lent et al., 1994).

SCCT has been used to investigate the factors that affect persistence of students in an engineering major. Many studies have used the choice model and considered how students make and act on choices about their major. Lent et al. (2003) considered the effect of perceived contextual supports (e.g., encouragement from friends to stay in a major) and barriers (e.g., pressure from parents to change out of a major) on the choices and actions of engineering students, particularly to their intention to persist in an engineering major. A similar study (Lent et al., 2005) found that the SCCT model has predicative ability that spans gender and is applicable for students at very different types of campuses.

Much less research has been given to the third of the interlocking models, the SCCT performance model (Figure 1), for which performance goals (within the context of a major) are hypothesized to predict achievement levels (in that context). In the SCCT performance model, self-efficacy is hypothesized to have a direct effect on both student goals and on student academic performance. The relationship between self-efficacy and student goals is hypothesized to be mediated by the student's outcome expectations. Likewise, the relationship of self-efficacy to academic performance is hypothesized to be mediated by both student outcome expectations and goals. Thus, self-efficacy has both a direct and an indirect effect on goals and academic performance.

Focusing on the performance model, Brown et al. (2008) attempted to conduct a meta-analytic path analysis using the results of prior meta-analyses that relate the different variables of the SCCT performance model to one another in college students. However, they found no prior meta-analysis that include outcome expectations, and were unable to identify enough prior research that included outcome expectations to inform their own meta-analysis. While the relationship of self-efficacy to performance goals and attainment has been well studied, the effect of students' outcome expectations on their goals and attainment has been comparatively neglected.

Few intervention studies seek to specifically influence variables in the SCCT model. One study (Soldner, Rowan-Kenyon, Inkelas, Garvey, & Robbins, 2012) in engineering used SCCT to consider the effect of living-learning communities on student intent to persist in STEM. While STEM-focused living-learning environments had no direct effect on student intention to persist, the living-learning environment had a positive indirect effect on student

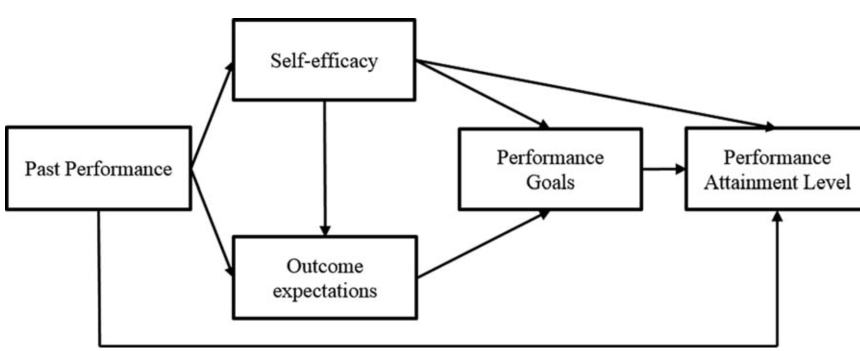

Figure 1 Adapted SCCT performance model.

intentions to persist through the social cognitive variables. Hence, studies that apply the SCCT model to understand the effect of pedagogical changes in engineering courses are valuable and timely.

Research Design

In our study we asked the question, "How does participation in group design projects affect student content knowledge and intentions to persist in engineering?" We chose the SCCT performance model because students had already selected engineering as a major and were in their second year of college. We used a quasi-experimental design where two sections of a statics course were taught using the same content, but one section also included group design projects. Our research design allowed us to directly compare student outcomes when a course was taught with and without group design projects. To examine the relationships among variables in the SCCT model, we analyzed data using structural equation modeling.

Hypotheses Our first hypotheses were related to direct effects of the use of group design projects, namely that students in the intervention section would have higher self-efficacy scores than those in the comparison section (an outcome that would be consistent with results of a small-scale pilot study by Casper, Atadero, Balgopal, Rambo-Hernandez, and Fontane, 2013), and that students in the intervention section would have greater concept knowledge than students in the comparison section because the intervention section required students to apply the engineering concepts in their group design projects. Second, we hypothesized that the mediations in the SCCT performance model would be moderated by the intervention: specifically, outcome expectations would mediate the effect of self-efficacy on goals (intention to persist) and that this mediation would be stronger for the intervention section (subsequently referred to as the first moderated mediation hypothesis), and both outcome expectations and goals would mediate the effect of self-efficacy on concept knowledge and that this mediation would also be stronger for the intervention section (subsequently referred to as the second moderated mediation hypothesis). We expected that these mediations would be stronger for students in the intervention section than in the comparison section because these students engaged in engineering practices by applying their knowledge in the design projects.

Method

Participants

In this study, the effect of group design projects on social cognitive variables and content knowledge was assessed in the course Engineering Mechanics: Statics. This course covers the application of Newtonian mechanics to various bodies, systems, and machines in static equilibrium. At the experimental institution, a large land grant university in the western United States, it is a required course for civil, environmental, and mechanical engineering students, who usually take it during their second year. A few students from other engineering majors, such as electrical or chemical engineering, may take the course as a technical elective.

Students in two sections of a statics course participated in the study. Students were unaware of the study when they registered for the course; because the sections were both full at the start of the semester, the department prevented students from switching sections after learning about the study. In the intervention section, 101 of 112 students consented to allow data collection, and 108 of 115 students consented to allow data collection in the comparison section. The intervention section was 77% male and 7% ethnic minority students, while the comparison section was 86% male and 5% minority students. The students in the intervention section were mostly mechanical engineering majors (46%), followed by civil engineering majors (30%) and environmental engineering majors (16%). The students in the comparison section were also largely mechanical engineering majors (52%), followed by civil engineering majors (32%) and environmental engineering majors (11%). For those students with grade point average information available, an independent sample *t*-test indicated that upon entering the statics course the intervention and comparison sections did not have different grade point averages ($t(186) = 0.18$, $p = .86$). Chi-square tests revealed no statistically significant differences in the sections for ethnicity (χ^2 [$df = 7$] = 4.81, $p = .68$), sex (χ^2 [$df = 1$] = 2.57, $p = .11$), or major (χ^2 [$df = 7$] = 3.87, $p = .80$). Chi-square analyses indicated that the students with complete data and those with some missing data did not differ on ethnicity (χ^2 [$df = 7$] = 6.12, $p = .53$), sex (χ^2 [$df = 1$] = .99, $p = .32$), or major (χ^2 [$df = 7$] = 5.96, $p = .55$).

Procedure

This study was conducted during the fall semester of 2012, during which the same instructor taught both the intervention and comparison sections with the same lecture content. The two sections were taught back-to-back, three days a week. An audience response system (clickers) was used most days in both sections to engage and assess students and to promote attendance. The three midterm exams were administered during class. Student grades were based on homework assignments from the textbook (13% intervention section, 15% comparison section), class participation including audience response system use and participation in research activities or completion of alternative assignments (7% intervention section, 10% comparison section), midterm exams (30% intervention section, 45% comparison section), group design projects (30% intervention section, 0% comparison section), and a final exam (20% intervention section, 30% comparison section). The exam content was identical for both sections. The classrooms available at the midterm exam times did not allow students to spread out, and thus at least three variations of each exam were created for each midterm, and the same set of exams was used in both sections. The final exams for the two different sections were taken on different days as scheduled by the university, and thus different problems covering the same concepts were used in the two sections. Specific numerical values for quantities such as loads and dimensions were varied within each section on the final exams.

In addition to the traditional lecture format, the intervention section included three group design projects. Students completed these projects in teams of five. The instructor assigned teams in order to group students who had consented to videotaping. New student groups were assigned for each design project as part of another study. For each project, students were given approximately half a class meeting per project to work in their groups. The remainder of the group work occurred outside of class. The reserved evening exam time was used for students in the intervention section to present their projects to insure that the two lectures remained very similar.

In the intervention section, the course content was divided into three units; each group design project reflected the content of the course unit. For each project, student teams were required to design and construct an artifact, demonstrate its operation to the class, and prepare a report that included a description of their design and the analyses conducted. The first unit covered equilibrium, and the project task was to build a machine that would raise a team flag. These machines were designed with several individual components that are triggered in sequence to eventually achieve the objective through an indirect path. The second unit focused on applications of equilibrium with topics such as trusses, frames, machines, and beams. Student teams designed and built a bridge using only basswood sticks and string. The bridge was required to span a distance of 0.61 meters (2 feet) and was loaded by a point load at the midspan of the bridge until failure. The third unit covered miscellaneous topics in statics, including friction, moments of inertia, and virtual work. For the third project, teams were given dimensions of a ramp and asked to help a stuffed animal version of the school mascot climb the "mountain" using friction to the team's advantage. The series of group design projects was designed to promote creativity by placing minimal restraints on how students could achieve the design objective, facilitate lifelong learning skills by encouraging students to consider outside resources, promote knowledge flexibility by having students apply principles from class to real situations, develop practical ingenuity by asking students to construct their designs, motivate students through friendly competition, and help students identify with the profession by emphasizing design tasks.

Assessments

At the beginning and end of the course, all students in both sections completed the Engineering Affective Assessment (EAA) and Concept Assessment Tool for Statics (CATS; Steif, 2010) online outside of class time. The EAA comprised questions relating to SCCT, achievement goal theory, and student interest in engineering. The SCCT questions were adapted from Lent et al. (2008). These were pilot-tested in the same statics course the previous semester. In the pilot study, all of the subscales for the EAA and the post-test CATS scores demonstrated acceptable reliability, and the SCCT model fit the data extremely well (Casper et al., 2013).

EAA The EAA assessed self-efficacy, outcome expectations, and performance goals. The self-efficacy measure contained four items, such as, "How much confidence do you have in your ability to excel in your engineering major over this current semester?" Students responded on a scale from 1 (no confidence at all) to 5 (complete confidence). Students in our sample indicated high self-efficacy at pre-test and post-test (see Table 1). The outcome expectations measure contained 13 items, such as, "If I work harder in statics, I will do better in future engineering classes." Students responded on a scale from 1 (strongly disagree) to 5 (strongly agree). Students in our sample indicated high outcome expectations at both pre-test and post-test (Table 1). The performance goals (hereafter referred to as goals) measure consisted of seven items, such as, "I think earning a bachelor's degree in engineering is a

Table 1 Variables in the SCCT Model

	Intervention section		Comparison section			
	n	*M* (*SD*)	*n*	*M* (*SD*)	*t* (*df*)	*p*
Pre-test						
Self-efficacy	80	3.78 (0.68)	95	3.77 (0.63)	0.13 (173)	.90
Outcome expectations	80	4.26 (0.43)	95	4.22 (0.38)	0.53 (173)	.59
Goals	80	4.33 (0.54)	95	4.30 (0.49)	0.31 (173)	.76
CATS	85	24.53 (13.29)	101	22.15 (9.73)	1.37 (151.03[a])	.16
Post-test						
Self-efficacy	87	3.75 (0.85)	83	3.69 (0.76)	0.48 (168)	.63
Outcome expectations	87	4.02 (0.52)	83	3.95 (0.45)	0.95 (168)	.35
Goals	87	4.13 (0.69)	83	3.99 (0.68)	1.33 (168)	.19
CATS	94	33.18 (16.64)	90	32.76 (15.92)	0.17 (182)	.86

[a]Unequal variances were assumed for pre-test CATS t-test because the Levine's test for unequal variances was statistically significant ($p < .05$). All other t-tests assumed equal variances.

Table 2 Correlations between SCCT Variables

	1	2	3	4	5	6	7	8
1. Pre Self-efficacy	—	.26*	.39**	.27*	.67**	.23	.31**	.25*
2. Pre Outcome expectation	.31**	—	.44**	.05	.09	.50**	.35**	.09
3. Pre Goals	.33**	.39**	—	.07	.26*	.27*	.60**	.20
4. CATS pre-test	.07	.15	.15	—	.26*	.10	.00	.50**
5. Post Self-efficacy	.64**	.21	.16	.23*	—	.39**	.52**	.27*
6. Post Outcome expectation	.33**	.53**	.29*	.30**	.21	—	.48**	.13
7. Post Goals	.25*	.46**	.29*	.18	.47**	.47**	—	.26*
8. CATS post-test	.07	−.06	−.03	.41**	.23*	.10	.28*	—
n	175	175	175	186	170	170	170	185
Reliability	.84	.80	.79	.56	.88	.84	.86	.74

Note: Correlations for the intervention section are listed above the diagonal. Correlations for the comparison section are below the diagonal. Reported reliabilities are for all participants. *$p < .05$, **$p < .01$.

realistic goal for me." Students responded on a scale from 1 (strongly disagree) to 5 (strongly agree). Students in this sample indicated that they had high intentions to stay in engineering at both the pre-test and the post-test (Table 1). All EAA subscales exhibited acceptable reliability (Table 2).

CATS The CATS has been shown in previous studies to have adequate reliability and evidence of validity (Steif & Dantzler, 2005), and reliability was calculated for this study. The CATS reliability scores were low at the pre-test but much higher for the post-test (Table 2). Given that the CATS is a multiple-choice test and guessing might be high at pre-test, we anticipated that the reliability would be lower prior to instruction but higher after instruction (at post-test). The post CATS scores were moderately correlated with student total scores on the final exam ($r = .30$, $p < .001$)

Plan of analysis

The EAA and CATS results were analyzed to examine the relationships among the variables of interest in student career development for the intervention and the comparison sections. We conducted independent sample *t*- tests to test the first set of hypotheses that students in the intervention section would have higher post self-efficacy and post CATS scores.

Prior to testing the two moderated mediation hypotheses, we tested the model fit of the structural equation model (SEM) for the SCCT for the intervention and comparison sections. This multigroup SEM allowed for the simultaneous estimation of separate regression paths among the variables of interest for each group, allowed for the mediation hypotheses to be simultaneously tested, and provided estimates of model fit. We employed several a priori indications to determine acceptable fit. First, the most common indication of good model fit is a nonsignificant chi-square statistic. However, given that the chi-square statistic is sensitive to sampling fluctuation, comparative fit index (CFI) values above .95 and root-mean-square error of approximation (RMSEA) values below .06 or a confidence interval that contained .06, and the standardized root-mean-residual (SRMR < .08) were also used as indicators of acceptable model fit (Browne & Cudeck, 1993; Hu & Bentler, 1999).

Finally, we examined the effect of the design project intervention by conducting moderated mediation analyses. We used a multigroup SEM based on SCCT to model student career development and hypothesized mediations (i.e., self-efficacy → outcome expectations → goals, self-efficacy → goals → CATS, and self-efficacy → outcome expectations → goals → CATS) separately for the intervention and the comparison sections. The variables of interest were the post-test scores of self-efficacy, outcome expectations, goals, and the CATS score. (Not all variables were normally distributed; however, Curran, West, and Finch [1996] stated that problems with multivariate normality did not arise unless the univariate skewness and kurtosis exceeded 2.0 and 7.0, respectively. All univariate skewness and kurtoses were well below these thresholds.)

All analyses were conducted using full information maximum likelihood estimation in *Mplus* version 7.11 (Muthén & Muthén, 2014). Maximum likelihood estimation, which allowed incomplete cases to be retained for analysis, was preferable to other estimation techniques that delete cases with any missing data.

Results

Prior to testing our hypotheses, we compared students in the intervention and comparison sections at pre-test (Table 1). We applied a Holm-Bonferroni correction to the Type-I error threshold ($p < .05$) to account for the multiple comparisons (Abdi, 2010). A series of *t*-tests revealed that there were no statistically significant differences across groups at pre-test. Additionally, an examination of the correlation matrix revealed a similar pattern of associations across the two groups with one exception (Table 2). Specifically, the matrix revealed a moderately positive relationship between self-efficacy and outcome expectations (post-test) for the intervention section but a nonsignificant association between self-efficacy and outcome expectations in the comparison section.

To test our first set of hypotheses, we examined the direct effects of the intervention on self-efficacy and content knowledge. The results of the independent samples *t*-test did not support the first set of hypotheses. No statistically significant difference existed between the intervention and comparison sections on post self-efficacy scores or post CATS scores. For the sake of completeness, we also examined the direct effect of the intervention on outcome expectations and goals. The results of the independent samples *t*-test did not indicate any statistically significant differences.

To test our second set of hypotheses, we conducted a multigroup analysis of the SCCT model for the intervention and comparison sections. Model fit indexes indicated that the SCCT model provided an acceptable fit to the data (χ^2 [$df = 26$] = 46.35, $p = .008$, CFI = 0.93, RMSEA = 0.087, 90% *CI* [0.044, 0.127], and SRMR = 0.063). An examination of the structural regression coefficients revealed several findings of note. First, the magnitude of the effect of self-efficacy and outcome expectations on goals was similar across the intervention and comparison sections as was the effect of self-efficacy on the CATS. However, for these two sections, self-efficacy influenced outcome expectations only for the intervention section (Figure 2), and goals were statistically significantly predictive of the CATS only for the intervention section. Thus, career development for students taught in the comparison section did not develop as expected according to SCCT.

Mediated effects In the SCCT model, two mediated effects are hypothesized. The first mediated effect is that self-efficacy influences goals directly and indirectly by activating student outcome expectations that in turn influence student goals. In other words, outcome expectations

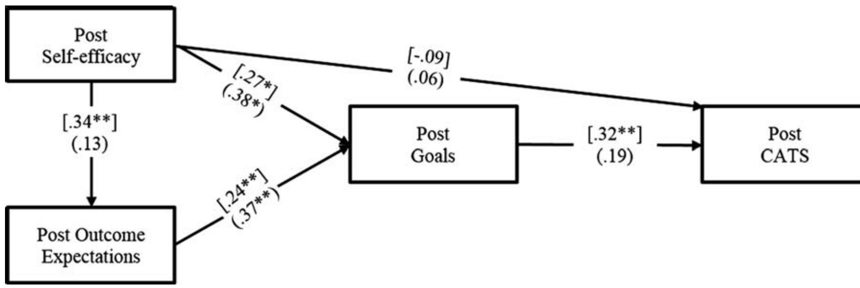

Figure 2 Multiple groups SCCT model for post-test data, controlling for pre-test data. Parameters in the figure are standardized regression coefficients. Values in brackets are for the intervention section; the values in parentheses are for the comparison section. Although the regression paths are not shown, pre-test variables were included as control variables for their post-test counterpart, and each of these regression paths was statistically significant. $^{*}p < .05$, $^{**}p < .01$.

mediate the effect of self-efficacy on goals. The second mediated effect is that self-efficacy influences performance attainment level directly and indirectly by activating both outcome expectations and student goals that then in turn influence performance (Figure 1). Specifically, outcome expectations and goals mediate the effect of self-efficacy on performance. In this study, goals represent student intention to persist, and performance is measured with the CATS score.

Mediation of self-efficacy on goals through outcome expectations To test the first moderated mediation hypothesis, we first examined the relationship among the first three variables shown in Figure 2: self-efficacy (independent variable), outcome expectations (mediator), and goals (dependent variable). For the intervention section, post self-efficacy scores were positively related to post outcome expectations ($\beta = 0.34$, $b = 0.21$, $SE = .067$, $p = .002$), controlling for pre self-efficacy and pre outcome expectation scores. Post self-efficacy also had a positive effect on post student goals ($\beta = 0.27$, $b = 0.22$, $SE = .101$, $p = .03$) after controlling for pre self-efficacy and pre goal scores. Post outcome expectations was also positively related to post student goals ($\beta = 0.24$, $b = 0.32$, $SE = 0.114$, $p = .006$) after controlling for pre outcome expectations and pre goal scores. Because the relationships between self-efficacy and outcome expectations and between outcome expectations and goals were statistically significant, we proceeded to test the indirect effect of self-efficacy on goals through outcome expectations. Because this indirect effect is a product term and thus not normally distributed, we used a bootstrapping procedure that repeatedly resamples the data and makes no distributional assumptions to create a 95% confidence interval around the indirect effect (MacKinnon, Fairchild, & Fritz, 2007; Shrout & Bolger, 2002). The bootstrapping procedure with 10,000 repetitions revealed that the indirect effect of self-efficacy on goals through outcome expectations was statistically significant ($\beta = 0.08$, $b = 0.066$, 95% CI [0.017, 0.155]); this statistically significant indirect effect indicates that outcome expectations partially mediated the relationship between self-efficacy and goals.

When we examined the same hypothesized mediation for the comparison section, there was not a statistically significant relationship between self-efficacy and outcome expectations ($\beta = 0.13$, $b = 0.08$, $SE = 0.058$, $p = .18$). The other two remaining paths were statistically significant (i.e., post self-efficacy on goals: $\beta = 0.38$, $b = 0.33$, $SE = 0.140$, $p = .017$; post outcome expectations on post goals: $\beta = 0.37$, $b = 0.54$, $SE = 0.163$, $p = .001$). Because the path from post self-efficacy to post outcome expectations was not statistically significant, post outcome expectations could not mediate the effect of post self-efficacy on post goals for the comparison section.

To summarize the results on the first moderated mediation hypothesis: post self-efficacy was positively related to post outcome expectations for students in the intervention section and unrelated for students in the comparison section. In the intervention section, outcome expectations partially mediated the effect of self-efficacy on goals or the intention to persist in engineering. Thus, the mediation proposed by the SCCT model held for the intervention section but not for the comparison section, and students in the comparison section did not develop according to the SCCT model. These results support the hypothesis that the mediation of self-efficacy on goals through outcome expectations would be stronger for the intervention section than the comparison section.

Mediation of self-efficacy on post-test (CATS) through outcome expectations and goals To test the second moderated mediation hypothesis, post CATS scores were added to the first mediation model (Figure 2). According to the complete SCCT model, post self-efficacy and post goals directly predict post CATS score, post self-efficacy indirectly predicts post CATS through post goals, and post self-efficacy also indirectly predicts post CATS through outcome expectations on goals (double mediation). We examined the relationship among all of the variables shown in Figure 2 by course section, namely self-efficacy (the independent variable) on academic outcomes (dependent variable) through two mediators: goals and outcome expectations followed by goals.

In the intervention section, post goals but not post self-efficacy directly statistically significantly predicted post CATS scores, controlling for all other variables in the model. We tested the statistical significance of the mediated, or indirect, effects of self-efficacy on the post CATS through post outcome expectations and post goals.

First, we tested the single mediated effect of post self-efficacy on the post CATS through post goals (i.e., self-efficacy → goals → CATS) for the intervention section. Having already established that self-efficacy predicted goals, we established that goals predicted CATS score ($\beta = 0.32$, $b = 0.08$, $SE = 0.029$, $p = .007$). Then using the same bootstrapping procedure previously described, we examined the mediated effect of self-efficacy on post CATS through post goals and found that this indirect effect was positive and statistically significant ($\beta = 0.09$, $b = 0.023$, 95% CI [0.003, 0.042]).

Second, we tested the double mediated effect of post self-efficacy on post CATS through post outcome expectations then post goals (i.e., self-efficacy → outcome expectations → goals → CATS) for the intervention section. Having already established that self-efficacy predicted outcome expectations and outcome expectations predicted goals, we then examined the double mediated effect of post self-efficacy on post CATS through post outcome expectations and post goals and found that this effect was also positive and statistically significant ($\beta = 0.03$, $b = 0.005$, 95% CI [0.001, 0.016]).

Next, we examined the relationships among post self-efficacy, outcome expectations, and CATS in the comparison section. Like the intervention section, the direct effect of post self-efficacy scores on post CATS was not statistically significant ($\beta = 0.06$, $b = 0.01$ $SE = 0.025$, $p = .63$); however, post goals did not predict post CATS scores for the comparison section ($\beta = 0.19$, $b = 0.04$, $SE = 0.026$, $p = .11$). All indirect paths of post self-efficacy must pass through the path of post goals to post CATS (i.e., self-efficacy → goals → CATS, and self-efficacy → outcome expectations → goals → CATS). As the path from post goals to post CATS is a necessary path in the mediation model, and this path did not exist, there could be no statistically significant indirect path from self-efficacy to post CATS, precluding a mediation of self-efficacy on CATS scores.

To summarize the results on the second moderated mediation hypothesis: self-efficacy was not directly related to the post CATS scores for students in the intervention section or the comparison section over and above the other variables in the model, contrary to what the SCCT model predicts. For the intervention section only, self-efficacy was indirectly related to the CATS scores through both outcome expectations and goals. However, for students in the comparison section, self-efficacy was not directly or indirectly related to the CATS scores, and therefore these students did not develop according to the SCCT model. Our finding supports the second moderated mediation hypothesis that the relationship of self-efficacy on post CATS scores would be mediated by outcome expectations and performance goals and would be stronger for the intervention section than the comparison section.

Discussion

This study is part of a larger project to determine the effect of integrating group design projects into the course content of a second-year engineering statics course. The goal was to examine the effect of introducing group design projects on students' content knowledge and intentions to persist in engineering within the framework of SCCT. There are three notable findings: self-efficacy and content knowledge of students does not differ between the intervention and comparison sections; post self-efficacy and outcome expectations are uncorrelated for students in the comparison section; and changing the course content by adding group design projects affects the relationship among the variables of interest in the SCCT model and content knowledge.

The first finding, that the self-efficacy and content knowledge of students in the two different sections is not different, is contrary to our pilot data (Casper et al., 2013). The intervention does not have a statistically significant direct effect on self-efficacy after controlling for initial self-efficacy. Both the intervention and the comparison sections demonstrated drops in their outcome expectations and goals during the semester but not self-efficacy. We suspect that students are generally more optimistic at the beginning of the semester than at the end, a trend observed by Guillaume and Khachikian (2011). That student self-efficacy was the same in both sections was somewhat unexpected and may be partially the effect of students' not receiving individualized feedback on their projects. While self-efficacy is a personal belief, students were provided grades and feedback at the group level. This grading scheme did not give students direct feedback regarding their individual contributions. Haynes and Heilman (2013) found that women in mixed gender groups gave themselves less credit for team accomplishments than their male teammates when working on a male-typed task. Furthermore, Bandura (1977) stated that persons develop their levels of self-efficacy in part by experiencing personal performance accomplishments and responding to verbal persuasion (feedback). With group grading, students might not receive the full benefit to self-efficacy of successful performance because there are other possible explanations for that performance than their own personal effort. Hence, future studies should examine self-efficacy when students are provided more individualized feedback on their personal contributions to the group.

In some ways, the fact that students in both sections had the same content knowledge could be encouraging to engineering instructors who are hesitant about introducing group design projects into their course content. Classes were shortened for students in the intervention section to allow time to work in groups; therefore, these students had less exposure to instructor explanation of content than did those in the comparison section. Instructors may be concerned that students will learn less with group design projects integrated into courses than in lecture-only courses. However, in our study, integrating group design projects did not limit students' content knowledge.

The second finding was that for students in the comparison section the relationships between self-efficacy and outcome expectations, and between goals and content knowledge, were not strengthened over the semester. In fact, self-efficacy and outcome expectations were not even correlated at post-test. Students who believed that they had the ability to be successful in engineering courses failed to connect that belief with desirable outcomes as an engineering student and future engineer. However, for students in the intervention section, the relationships between self-efficacy and outcome expectations, and between goals and content knowledge, strengthened by the end of the semester. Our findings are consistent with other reports that students need early design experiences to help form an engineering identity (NSB, 2007). The results suggest that including group design projects helped students to strengthen the relationships between what they believe they can do and what they expect will happen in engineering, and between their content knowledge and intention to persist in engineering. By using lectures exclusively, engineering faculty may be unintentionally preventing students from forming these connections, making it more difficult for engineering students to persist in an engineering career.

The third important finding is that the introduction of group design projects affected the relationships among the variables of interest in the SCCT model. For students in the intervention section, self-efficacy ultimately influenced intention to persist indirectly through outcome expectations, but for students in the comparison section, self-efficacy failed to indirectly influence intentions to persist. Our intervention affected the relationship of self-efficacy and outcome expectations on intentions to persist, which is related to actual persistence (Eris et al., 2010). Considering the full model, self-efficacy influenced content knowledge indirectly through outcome expectations and intentions to persist, but only for students in the intervention section and not the comparison section.

Many studies have demonstrated that factors outside the engineering curriculum, such as barriers and support (for example, financial concerns about paying for school or the existence of tutoring programs), influence student career development through self-efficacy (Lent et al., 2003, 2005). We were able to demonstrate that changing factors within the engineering curriculum (for example, incorporating group design projects) can also influence student career development through self-efficacy. This finding is relevant to engineering programs because engineering students spend a great deal of their time doing required coursework, such as the group design projects required by this intervention, whereas support programs, such as those intended to aid students from underrepresented groups, are often extra-curricular: students are not required to participate in the support programs, and the support might be offered at times or places inconvenient to students. Engineering programs that want to reach and retain as many students as possible, might be well served by introducing group design projects into more undergraduate courses. By allocating resources to course enhancements in required courses, engineering programs can reach a much broader audience and improve the retention and content knowledge of all students, not just the students who avail themselves of support programs.

Limitations

Students registered for one of the two sections as it fit with their schedules. For this reason, we conducted a quasi-experiment rather than a randomized controlled trial. The two groups were not significantly different from each other on collected variables such as sex, ethnicity, and GPA.

The CATS instrument had somewhat limited utility for this study. In particular, the reliability of the scores at pre-test was low. The results from our study suggest that the CATS may not be the best pre-test measure for statics knowledge. In fact, Paul Steif, the developer of the CATS, has recently recommended the Force Concept Inventory as an alternative pre-test for statics (personal communication, January 14, 2013). Future researchers may want to consider alternative measures to assess student knowledge prior to instruction to avoid complications due to low reliability.

We did not collect data related to how much time students in the two sections spent on their coursework. Some effects observed here may be attributable to increased time spent studying statics by students in the intervention section. Although time-on-task has been hypothesized as an important variable affecting student academic performance, the relationship between time spent outside of class and academic performance in college students has consistently been found to be weak (Guillaume & Khachikian, 2011; Nonis & Hudson, 2006; Plant, Ericsson, Hill, & Asberg, 2005).

Implications

Although the engineering education community has been slow in adopting change (Graham, 2012), the integration of group design projects into the curriculum described in this study was feasible and produced student benefits related to retention. Simple project interventions, such as the one described here, can be relatively inexpensive, scalable for large classes, and easily integrated into the existing curricula. Supplementary projects are more likely to be accepted by other engineering faculty and may lead to more systemic changes in an engineering department.

Furthermore, the SCCT performance model accurately describes how engineering students choose to persist toward engineering careers and how that intention to persist affects achievement. The studies by Lent and colleagues also demonstrated that the SCCT model accurately described student career development, but those studies did not examine how changes in course content affected students' intentions to persist in engineering or performance on academic measures. SCCT in this study provided insight into the processes through which the group design projects affected student knowledge and intention to persist. The fact that the SCCT performance model was able to capture student intentions to persist in engineering is important because future researchers can use the SCCT model to illustrate how other changes in their classroom have affected student content knowledge and intentions.

In conclusion, group design projects can benefit engineering students' career development. Our findings should be of interest to the engineering education community because they provide evidence that instructional innovations can increase the intention to persist of students in engineering studies and professions. While we have shown that SCCT can be used to measure the effect that integrating group design projects into a traditional lecture course can have on student career development, further studies are needed to identify the particular aspects of the project experience that can explain these outcomes.

Acknowledgments

This material is based upon work supported by the National Science Foundation Research Initiation Grant in Engineering Education 1137023 awarded to Rebecca Atadero, Meena Balgopal, Darrell Fontane, and Karen Rambo-Hernandez. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors are grateful to the editors and anonymous reviewers whose comments greatly improved this paper.

References

Abdi, H. (2010). Holm's sequential Bonferroni procedure. In N. Salkind (Ed.), *Encyclopedia of research design* (pp. 1–8). Thousand Oaks, CA: Sage.

Acar, B. S., & Newman, I. A. (2003). Students as tutors: Learning problem-solving skills by tutoring PBL. *International Journal of Engineering Education, 19*(5), 712–716. Retrieved from http://www.ijee.ie/articles/Vol19-5/IJEE1449.pdf

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. doi: 10.1037/0033-295X.84.2.191

Bandura, A. (1986). *Social foundations of thought and action: A Social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Sustaining project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, *26*(3 & 4), 369–398. doi: 10.1080/00461520.1991.9653139

Brown, S. D., Tramayne, S., Hoxha, D., Telander, K., Fan, X., & Lent, R. W. (2008). Social cognitive predictors of college students' academic performance and persistence: A meta-analytic path analysis. *Journal of Vocational Behavior*, *72*(3), 298–308. doi: 10.1016/j.jvb.2007.09.003

Browne, M., & Cudeck, R. (1993). Alternative ways of testing model fit. In K. Bollenand & S. Long (Eds.), *Testing structural equation models*. Newbury Park, CA: Sage.

Casper, A. M., Atadero, R., Balgopal, M. M., Rambo-Hernandez, K. E, & Fontane, D. (2013). *The impact of project-based group work on engineering college students' content knowledge and affect*. Paper presented at the annual conference of the National Association of Researchers in Science Teaching, Rio Grande, Puerto Rico.

Crismond, D. (2001). Learning and using science ideas when doing investigate-and-redesign tasks: A study of naïve, novice, and expert designers doing constrained and scaffolded design work. *Journal of Research in Science Teaching*, *38*(7), 791–820. doi: 10.1002/tea.1032

Curran, P. J., West, S. G., & Finch, J. F. (1996). The robustness of test statistics to nonnormality and specification error in confirmatory factor analysis. *Psychological Methods*, *1*(1), 16–29. doi: 10.1037/1082-989X.1.1.16

de Graaff, E., & Kolmos, A. (2003). Characteristics of problem-based learning. *International Journal of Engineering Education*, *19*(5), 657–662. Retrieved from http://www.ijee.ie/articles/Vol19-5/IJEE1450.pdf

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering design thinking, teaching and learning. *Journal of Engineering Education*, *94*(1), 103–120. doi: 10.1002/j.2168-9830.2005.tb00832.x

Eris, O., Chachra, D., Chen, H. L., Sheppard, S., Ludlow, L., Rosca, C., . . . & Toye, G. (2010). Outcomes of a longitudinal administration of the persistence in engineering survey. *Journal of Engineering Education*, *99*(4), 371–395. doi: 10.1002/j.2168-9830.2010.tb01069.x

Graham, R. (2010). UK approaches to engineering project based learning. Retrieved from http://www.rhgraham.org/RHG/Recent_publications_files/MIT%20White%20Paper%20-%20UK%20PjBL%20April%202010.pdf

Graham, R. (2012). The one less traveled by: The road to lasting systemic change in engineering education. *Journal of Engineering Education*, *101*(4), 596–600. doi: 10.1002/j.2168-9830.2012.tb01120.x

Guillaume, D. W., & Khachikian, C. S. (2011). The effect of time-on-task on student grades and grade expectations. *Assessment & Evaluation in Higher Education*, *36*(3), 251–261. doi: 10.1080/02602930903311708

Haynes, M. C., & Heilman, M. E. (2013). It had to be you (not me)! Women's attributional rationalization of their contribution to successful joint work outcomes. *Personality and Social Psychology Bulletin*, *39*(7), 956–969. doi: 10.1177/0146167213486358

Helle, L., Tynjälä, P., & Olkinuora, E. (2006). Project-based learning in post-secondary education – Theory, practice and rubber sling shots. *Higher Education*, *51*, 287–314. doi: 10.1007/s10734-004-6386-5

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching*, *48*(8), 952–984. doi: 10.1002/tea.20439

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*, 1–55. doi: 10.1080/10705519909540118

Kolmos, A., & de Graaff, E. (2014) Problem-based and project-based learning in engineering education – Merging models. In A. M. Johri & B. M. Olds (Eds.), *Cambridge handbook of engineering education research* (pp. 141–160). New York, NY: Cambridge University Press.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, *45*, 79–122. doi: 10.1006/jvbe.1994.1027

Lent, R. W., Brown, S. D., Schmidt, J., Brenner, B., Lyons, H., & Treistman, D. (2003). Relation of contextual supports and barriers to choice behavior in engineering majors: Test of alternative social cognitive models. *Journal of Counseling Psychology*, *50*(4), 458–465. doi: 10.1037/0022-0167.50.4.458

Lent, R. W., Brown, S. D., Sheu, H.-B., Schmidt, J., Brenner, B. R., Gloster, C. S., . . . & Treistman, D. (2005). Social cognitive predictors of academic interested and goals in engineering: Utility for women and students and historically black universities. *Journal of Counseling Psychology*, *52*(1), 84–92. doi: 10.1037/0022-0167.52.1.84

Lent, R. W., Sheu, H. B., Singley, D., Schmidt, J. A., Schmidt, L. C., & Gloster, C. S. (2008). Longitudinal relations of self-efficacy to outcome expectations, interests, and major choice goals in engineering students. *Journal of Vocational Behavior*, *73*(2), 328–335. doi: 10.1016/j.jvb.2008.07.005

Litzler, E., & Young, J. (2012). Understanding the risk of attrition in undergraduate engineering: Results from the project to assess climate in engineering. *Journal of Engineering Education*, *101*(2), 319–345. doi: 10.1002/j.2168-9830.2012.tb00052.x

MacKinnon, D. P., Fairchild, A. J., & Fritz, M. S. (2007). Mediation analysis. *Annual Review of Psychology*, *58*, 593–614. doi: 10.1146/annurev.psych.58.110405.085542

Mills, J. E., & Treagust, D. F. (2003). Engineering education – Is problem-based or project-based learning the answer? *Australasian Journal of Engineering Education*, *11*, 2–16. Retrieved from: http://www.aaee.com.au/journal/2003/mills_treagust03.pdf

Muthén, L. K., & Muthén, B. O. (2014). *Mplus user's guide* (6th edn.) Los Angeles, CA: Author.

National Academy of Engineering (NAE). (2004). *The engineer of 2020: Visions of engineering in the new century*. Washington, DC: National Academies Press. Retrieved from: http://www.nap.edu/openbook.php?record_id=10999

National Academy of Engineering (NAE). (2005). *Educating the engineer of 2020: Adapting engineering education to the new century*. Washington, DC: National Academies Press. Retrieved fromhttp://www.nap.edu/openbook.php?isbn=0309096499

National Research Council (NRC). (1995). *Engineering education: Designing an adaptive system*. Washington, DC: National Academies Press. Retrieved from: http://www.nap.edu/openbook.php?record_id=4907

National Research Council (NRC). (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: National Academies Press. Retrieved from: http://www.nap.edu/openbook.php?record_id=11463

National Research Council (NRC). (2010). *Rising above the gathering storm, revisited: Rapidly approaching Category 5*. Washington, DC: National Academies Press. Retrieved from http://www.nap.edu/openbook.php?record_id=12999

National Science Board (NSB). (2007). *Moving forward to improve engineering education*. Arlington, VA.: National Science Foundations. Retreived from http://www.nsf.gov/pubs/2007/nsb07122/nsb07122.pdf

Nonis, S. A., & Hudson, G. I. (2006). Academic performance of college students: Influence of time spent studying and working. *Journal of Education for Business*, *81*(3), 151–159. doi: 10.3200/JOEB.81.3.151-159

Plant, E. A., Ericsson, K. A., Hill, L., & Asberg, K. (2005). Why study time does not predict grade point average across college students: Implications of deliberate practice for academic performance. *Contemporary Educational Psychology*, *30*(1), 96–106. doi: 10.1016/j.cedpsych.2004.06.001

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*(3), 223–231. doi: 10.1002/j.2168-9830.2004.tb00809.x

Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learing methods: Definitions, comparisons and research bases. *Journal of Engineering Education*, *95*(2), 123–138. doi: 10.1002/j.2168-9830.2006.tb00884.x

Schachterle, L., & Vinther, O. (1996). Introduction: The role of projects in engineering education. *European Journal of Engineering Education*, *21*(2), 115–120. doi: 10.1080/03043799608923394

Shrout, P. E., & Bolger, N. (2002). Mediation in experimental and nonexperimental studies: New procedures and recommendations. *Psychological Methods*, *7*(4), 422–445. doi: 10.1037/1082-989X.7.4.422

Smith, K. A., Sheppard, S. D., Johnson, D. W., & Johnson, R. T. (2005). Pedagogies of engagement: Classroom-based practices. *Journal of Engineering Education*, *94*(1) 87–101. doi: 10.1002/j.2168-9830.2005.tb00831.x

Soldner, M., Rowan-Kenyon, H., Inkelas, K. K., Garvey, J., & Robbins, C. (2012). Supporting students' intentions to persist in STEM disciplines: The role of living-learning programs among other social-cognitive factors. *Journal of Higher Education*, *83*(3), 311–336. doi: 10.1353/jhe.2012.0017

Steif, P. (2010). Concept Assessment Tool for Statics (CATS). Retrieved from https://cihub.org/resources/3

Steif, P. S., & Dantzler, J. A. (2005). A statics concept inventory: Development and psychometric analysis. *Journal of Engineering Education*, *94*(4), 363–371. doi: 10.1002/j.2168-9830.2005.tb00864.x

Thomas, J. W. (2000). *A review of research on project-based learning*, San Rafael, CA: Autodesk Foundation.

The White House. (2013). *Education: Knowledge and skills for the jobs of the future*. Retrieved from http://www.whitehouse.gov/issues/education/k-12/educate-innovate

Authors

Rebecca A. Atadero is an assistant professor in the Department of Civil and Environmental Engineering at Colorado State University, 1372 Campus Delivery, Fort Collins, CO, 80523-1372; rebecca.atadero@colostate.edu.

Karen E. Rambo-Hernandez is an assistant professor at West Virginia University in the College of Education and Human Services in the Department of Learning Sciences and Human Development, P.O. Box 6122, Morgantown, WV 26506-6122; kerambohernandez@mail.wvu.edu.

Meena M. Balgopal is an associate professor at Colorado State University in the School of Education and the Graduate Degree Program in Ecology. School of Education, Colorado State University, 1588 Campus Delivery, Fort Collins, CO 80523-1588; meena.balgopal@colostate.edu.