AC 2012-5013: THE USE OF THE SOCIAL COGNITIVE CAREER THEORY TO PREDICT ENGINEERING STUDENTS' MOTIVATION IN THE PRODUCED PROGRAM

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The Use of the Social Cognitive Career Theory to Predict Engineering Students' Motivation in the PRODUCED Program

Abstract

Within the state of Virginia, an initiative to increase the number of engineering students exists via a program called PRODUCED. PRODUCED is an outreach from the University of Virginia (UVA) School of Engineering and Applied Science (SEAS). PRODUCED was initially established to help fill an engineering gap being realized in the Lynchburg, Virginia area, with program roots dating back to 2007; the first graduates are expected in the spring of 2012. To measure the expectations of the students, a portion of Lent and Brown's Social Cognitive Career Theory (SCCT) model was used. A quantitative survey was developed and sent to students at five community colleges in the state of Virginia. The purpose of the study was to test the predictive relationship among four variables (self-efficacy, outcome expectations, interests, and goals) of the SCCT model and to measure participants' motivation to pursue engineering degrees and careers. The data from 68 responses were analyzed using internal consistency measures, descriptive statistics, correlations, factor analyses, and multiple regression. KMO and Barlett's Test yielded significant results to allow factor analyses. The mean of all four variables were above the mid-point of five-point Likert scale. Intercorrelation among the four variables is significant. Cronbach's alpha of four variables ranged from .75 to .91. Three regression models were used to measure the predictive relationship among the four variables, and all the models yielded significant results. All of the assumptions of regression were reasonably met. However, outcome expectations were not a good predictor of goals. The success of students in 2+2 programs is important; knowing the extent to which students are motivated toward a career goal and then understanding what motivates them is critical to this success. This work provides valuable information as a first step in knowing how to measure student motivation to persist and to determine further research necessary to understand that motivation.

Introduction

There is a concern that the number of American students pursuing engineering careers is insufficient for future demand. The Science and Engineering indicators published by the National Science Foundation[1] revealed that the number of United States students pursuing a science or engineering degree is relatively stable, yet the number of United States jobs for science and engineering is increasing. In addition, the Science and Engineering indicators revealed there is still a gap between minority (or underrepresented) groups and majority groups with respect to the number of students pursuing engineering[1]. As part of the Center for the Advancement of Engineering Education (CAEE) final report, it was recommended that future research on the experiences of engineering students include studies of community college students and a consideration of these students as an underrepresented group[2]. Within the state of Virginia, an initiative to increase the number of engineering students exists via a program called PRODUCED. PRODUCED is an outreach from the University of Virginia (UVA) School of Engineering and Applied Science (SEAS) that was initially established to help fill an engineering gap being realized in the Lynchburg, Virginia area, with program roots dating back to 2007; the first graduates are expected in the spring of 2012[3]. Based on research by the UVA SEAS team,

several other areas of Virginia were identified as locations for the PRODUCED program resulting in the current program having cohorts at five community colleges[3].

The purposes of this study are threefold: (1) to determine the predictive relationship among four select variables of the SCCT model, specifically, self-efficacy, outcome expectations, interests, and goals as the theory postulates, (2) to measure participants' motivation to pursue degrees and careers in engineering fields by administering an instrument to assess their level of the four components of the SCCT model, and (3) measure gender differences in terms of their possession of the characteristics of the four components of the SCCT model. Our resulting research questions are:

1) *Does the SCCT model represent an accurately predictive model for the PRODUCED program?*
2) *To what extent do students within the PRODUCED program want to achieve the goal of an engineering degree?*
3) *Are the expectations and goals biased by gender?*

Theoretical Framework

The Social Cognitive Career Theory (SCCT)[4,5] provides the framework used in this research. Lent and Brown[6] demonstrated the SCCT model and provided information for developing an instrument to measure components of the SCCT model. Specific to our research questions are the personal motivation constructs (interest and self-efficacy) that, along with outcome expectations, affect the outcome of a career choice goal. The full model takes into consideration additional influencing factors of a person such as background, learning experiences, and proximal contextual affordances (supports and barriers). The model also considers how one's choice actions are influenced by their expectations, goals, and environmental influences, all of which then feed back into one's learning experiences. Figure 1 shows a modification to the full SCCT with expected relationship arrows. Definitions for the SCCT constructs for self-efficacy, interests, outcome expectations, and choice goals are necessary to ensure the questionnaire was designed to measure these constructs. Self-efficacy relates to a person's belief in their ability to accomplish actions required for a particular activity or performance domain. Self-efficacy can vary depending on the task (task-specific self-efficacy) under normative conditions. Self-efficacy can also be viewed as one's belief in their ability to overcome barriers to achieve a desired performance (coping efficacy). Within SCCT, task specific and coping efficacy are both studied as predictors of choice goals and persistence. Interests refer to people's likes and dislikes about an activity (engineering). An outcome expectation is the belief about the consequences of performing a behavior (e.g., earning money or helping others). Goals are the intention, plan, or aspiration to engage in an activity (e.g. engineering studies) or to obtain an outcome (become an engineer)[4,6].

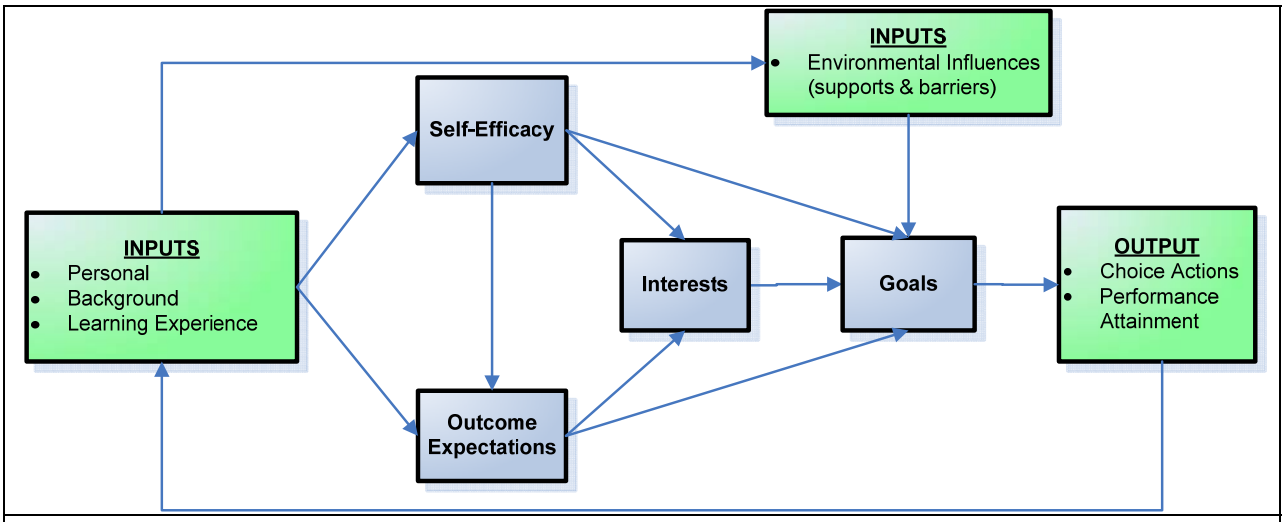

Figure 1. modified SCCT from Lent and Brown, used with Permission

The SCCT was derived mainly from Bandura's social cognitive theory[4]. An attempt was made to adapt, elaborate, and extend certain features of the theory to the career development process. Bandura's theory suggested that, "people act on their judgments of what they can do, as well as on their beliefs about the likely effects of various actions"[7]. Similarly, the focus of the SCCT is on understanding the processes during which individuals form interests, make choices, and attain varying degrees of achievements in occupational and academic pursuits[4].

An advantage of using the SCCT framework is the ability to link a student's interest and self-efficacy of their current curriculum choice to their outcome expectations and goals. In addition, there is commonality with relevant literature that allows comparison of results.

Relevant Literature

Use of the SCCT model allows for comparison to other literature and allows for identifying external factors unique to the population of interest. The SCCT has been used as a framework for studying career development and academics[8,9,10,11] as well as recent work with engineering students[9,12,13,14]. Because students pursuing an engineering degree via a community college pathway are considered nonconventional and underrepresented[2], the use of a framework considering a variety of factors is important so that assumptions about community college students, relative to "traditional" college students, are not overstated.

Research on engineering college students, using SCCT as a framework, includes work on persistence and underrepresented groups. Lent et al.[9] used the SCCT model to test its utilities on women and students at historically black universities. Their findings demonstrated that women do not differ significantly from men in possessing healthy levels of self-efficacy, outcome expectations, interests, and goals. This finding was consistent with other studies[15,16,17]. Trenor et al.[14] used an explanatory mixed methods approach with the SCCT framework to investigate female engineering students of an ethnically diverse background at an urban research university. Their findings showed significant differences by ethnicity on how students perceived engineering and its purpose and family backgrounds and influence. Furthermore, the Trenor et al.[14] study showed all students had a sense of belonging and social support. Therefore, gender

differences in terms of four components of the SCCT model in the case of students attending community colleges were tested to see if the results of research on this specific group of student were similar to other studies.

None of the referenced studies specifically measure community college engineering students, and not all test the same four constructs of interest for this study, though similar studies testing the validity of the SCCT model exist. For instance, Lent et al.[13] conducted a longitudinal study using the four variables used in this study on engineering students. Lent et al.[18] used the SCCT model on students in the computing discipline. However, in both those two studies, outcome expectations failed to be precursors of interests and goals contrary to what the theory postulates.

The numerous studies with Science, Technology, Engineering, and Math (STEM) majors have been conducted which lead to meaningful findings. However, because of specific differences in STEM fields in terms of disequilibrium—supply-demand—in the labor market, Lent et al.[9] suggested that specific fields within the STEM should be researched separately. In view of this suggestion, and Atman et al.[2] definition of community college engineering students as non-conventional and underrepresented, this study is unique in three different ways: (1) students in the PRODUCED program are studied for the first time, (2) participants belong to the E of the STEM field, and (3) the focus of the study was on non-conventional and underrepresented students.

Methods

Procedures

This study was an online survey with responses from 68 engineering students in the five community colleges that are part of the PRODUCED program initiated by the University of Virginia. The target population was students enrolled as engineering students in those five community colleges estimated to be 200. Everyone in the PRODUCED program was invited to complete the survey.

A professor at the University of Virginia, who oversees the PRODUCED program, helped recruit participants for the study. Specifically, he contacted people at the five community colleges who were in charge of the PRODUCED program in their respective colleges, introduced the survey, and requested support on the researchers' behalf as a known person of the PRODUCED program. The community college focal points—assigned to oversee the PRODUCED program—in turn, distributed the survey to students in their colleges by forwarding the link to the survey. The online questionnaire opened on March 25, 2011 and closed on April 6, 2011.

Interested students provided consent and agreement of being over 18 years of age by clicking 'continue' on the survey consent screen. The survey instrument was developed with skip logic causing anyone not consenting to automatically end the survey; the data indicated that everyone consented. Further, the online survey was designed to recognize the Internet Protocol (IP) address of the computer to prevent multiple responses from the same person.

Participants

Seventy students took part in the study, but the final analyses were conducted on 68 cases because of two incomplete surveys. All the participants were from five community colleges in the state of Virginia that were taking part in the engineering outreach program initiated by the Department of Engineering and Applied Science at the University of Virginia. Out of 68 participants, 88.2% were male (*n = 60*), and 11.8% were female (*n* = 8). Most of the participants were full time students (78.3%). Part time students accounted for 21.7% of the respondents. There were more first time college students (66.7%) than returning college students (21.7%) and transfer students (11.6%). In terms of their age, 85.7% of the participants were below the ages of 25; 2.8% of the participants were between the ages of 26 and 30; 7.1% of the participants were between the ages of 31 and 40, and 4.3% of the participants were between the ages of 41 and 45. The age range spanned 27 years (18 - 45). In the sample that was obtained, 46.4% of the participants represented Central Virginia Community College, 29.0% represented John Tyler Community College, 13.0% represented Danville Community College, 10.1% represented Germanna Community College, and 1.4% represented Virginia Highlands Community College.

Instrument

To ensure construct validity, the process researchers followed in developing the instrument was two-fold. First, questions were adapted from similar literatures where the SCCT model was used (e.g., Concannon & Barrow[19]; Jones, Paretti, Hein, & Knott[20]; Lent et al.[9]) with modifications to account for specifics of study's participant group, where necessary. Second, we followed the measurement guidelines Lent and Brown[6] provided in developing instruments to assess social cognitive constructs in career research.

The questionnaire developed included items on interest, self-efficacy, outcome expectations, and choice goals. The questionnaire so developed was sent to students at five community colleges and the results were quantitatively analyzed in a manner similar to other studies that used the SCCT as a theoretical framework.

The instrument was intended to measure the four variables of the SCCT model, namely, self-efficacy, outcome expectations, interests, and goals as they relate to the pursuit of degrees and careers in engineering fields. The instrument contained 39 items. The construct of self-efficacy was measured by 10 items. Lent and Brown[6] defined self-efficacy as one's perceived ability to perform certain tasks. In measuring self-efficacy, items measuring coping, process, and self-regulatory efficacy were included. Coping self-efficacy is beliefs in one's ability to negotiate particular domain-specific obstacles. Process self-efficacy is concerned with one's perceived ability to manage general duties necessary for career preparation, entry, adjustment, or change across diverse occupational paths. Self-regulatory self-efficacy is perceived skills to direct and motivate one to perform self-enhancing behaviors.

Likewise, there were 10 items in the outcome expectation subscale. Outcome expectations are individual's beliefs about the result of performing specific behaviors. According to Lent and Brown[6], there are three different types of outcome expectations: (1) social outcome, which is related to benefit to one's family; (2) material outcome, which is related to financial gain; and (3)

self-evaluative outcome, which is related to self-approval. Therefore, items were included to measure social, material, and self-evaluative expectations in order to gain a clear understanding of the outcome expectations component of the SCCT model.

An interest is defined as people's likes, dislikes, and indifferences regarding diverse activities[6]. Interests play a significant role in career development research. We included eleven items in the scale to measure the interest component.

Goal is defined as the intention to engage in a particular activity or to produce a particular outcome[7]. The SCCT is concerned with two primary types of goals: choice content goals and performance goals. Choice content goal is the kind of activity one desires to pursue, and performance goal is the quality of performance one wishes to achieve. The instrument had eight items measuring the goals component of the SCCT model. The item number 8 (I intend to go to graduate school in a non-engineering discipline) of goals' subscale was reverse coded because it was negatively worded. When the inter-item correlation matrix was conducted before the item was reverse coded, it negatively correlated with all the other items in the subscale at a statistically significant level, $p < .001$. This shows that students in the PRODUCED program identify themselves highly with the engineering field.

Table 1. Scales used

Variable/Scale	1	2	3	4	5
Self-efficacy	Not confident	Little confidence	Moderate confidence	Very confident	Complete confident
Outcome Expectations	Highly unlikely	Unlikely	Somewhat likely	Likely	Highly likely
Interests	Very low interest	Low interest	Some interest	High interest	Very high interest
Goals	Strongly disagree	Disagree	Somewhat agree	Agree	Strongly agree

We used a five point Likert type scale to measure all the variables. Table 1shows the scales for each construct. Fourteen people reviewed the instrument before the administration of the survey to participants. The reviewers came from a measurement professor, a qualitative methodology professor, and two engineering education professors. In addition, two Ph.D. students in the Engineering Education Program and eight students pursuing undergraduate degrees in engineering (six mechanical engineering and two electrical engineering students) reviewed the questions. The reviewers did not complete the survey, but were asked to test the readability of the survey, appropriateness of items in terms of the research questions and target population, and their expert opinion on the questions measuring the intended constructs. We incorporated feedback from the expert reviewers into the final instrument to increase content validity.

Data Analysis

For statistical analyses of the data, descriptive statistics were analyzed, measured Cronbach's alpha of each construct, tested intercorrelation among the four variables, conducted factor

analyses, and finally analyzed three models of multiple regression to answer the three research questions.

Descriptive analyses included mean and standard deviation of each variable. We used Cronbach's alpha of each variable as an internal consistency measure. Factor analyses were conducted to check if all the items in each subscale loaded together to ensure that each construct is distinct. Based on the results of the factor analyses, decisions to delete a few items from the instrument were made. KMO and Barlett's Test were conducted and their statistical significance allowed factor analyses to be conducted. Factor analyses in turn made it possible to conduct multiple regressions to answer key research questions. In order to derive meaningful interpretations from the outputs of multiple regressions, all the four assumptions of the regression were checked and these assumptions were reasonably met. For instance, there were linear relationships between the predictors and outcome variables in all the three models. Normality of errors assumption was also met as indicated by Normal P-P plot and histograms of residuals from each model.

Homogeneity of variance assumption was met with the residuals distribution being roughly rectangular in all three models. There was no evidence to suggest that the observations were dependent in this dataset. Finally, we detected no problem with multicollinearity. It is not desirable to have a very high correlation between the independent variables (for instance, r equal to greater than .9) because such high correlations could negatively affect the regression model. A correlation between variables in this study is demonstrated in Table 2. Both the Tolerance and VIF values are within the range in all the three models.

Table 2. Statistical results (N = 68)

Variables	1	2	3	4	M	SD	α
1.Self efficacy	_				4.008	.676	.906
2.Outcome	.614**	_			4.061	.657	.886
3.Interests	.573**	.624**	_		3.970	.694	.874
4. Goals	.659**	.421**	.640**	_	4.095	.846	.883

Results

The overall reliability of the 39 items scale used to test the four variables of the SCCT model resulted in a Cronbach's alpha (α) of .93. However, some items were deleted from some of the variables to ensure construct validity as a result of factor analyses. Appendix 1 shows the entire instrument with deleted questions having a strikethrough. The revised scale contained 29 items and the Cronbach's alpha of the revised scale increased to .94. Each item in the revised scale correlated strongly with the total score as demonstrated by Item-Total Statistic. Table 2 presents the mean, standard deviation, and Cronbach's alpha of each variable. Table 2 also presents the intercorrelation among four variables. It was possible to do factor analyses for each variable

because KMO and Barlett's Tests were significant. The KMO for the four variables are: self-efficacy—.88, outcome expectations—.81, interests—.88, and goals—.87. Barlett's test were significant for all four variables ($p<.001$). Factor analyses resulted in deletion of a few items as enumerated below.

It was important to test if items in each variable loaded together to ensure construct validity of the variables. Preferably, all the items should measure as intended, which is checked to verify they load together when a factor analysis is conducted. If the construct was not valid, interpretation of the results, using such constructs in the regression models, were not meaningful. Therefore, factor analyses were conducted. All the original 10 items of the self-efficacy were retained because they loaded together. Out of 10 items in the case of outcome expectations, only six items could be used (#5, 6, 7, 8, 9, and 10) for data analyses. Likewise, out of 11 of interests' items, only six items (# 1, 2, 3, 5, 6, and 7) were usable for data analyses. In the case of goals, the original scale had eight items to measure the construct. Only one item (# 7) did not load with the others. After deleting all the unacceptable items from each variable, the component matrix showed that items in each subscale loaded together.

Three regression models were run to determine the relationships between the SCCT constructs, and the regression slopes are shown in Figure 2. In the first regression model, self-efficacy was an independent variable and an outcome expectation was a dependent variable. This model was statistically significant, $F(1, 66) = 42.874$, $p < .001$. Self-efficacy explained 39.4% of the variability of the outcome expectations. In the second regression model, self-efficacy and outcome expectations were the predictor variables of interest. The model was statistically significant, $F(2, 65) = 25.31$, $p < .001$. The two predictor variables (self-efficacy and outcome expectations) accounted for 44.7% variance of the dependent variable, interests. In the third regression model, self-efficacy, outcome expectations, and interests were the independent variables and goals were the dependent variable. This model was also statistically significant, $F(3, 64) = 26.902$, $p < .001$. It is important, however, to note that while the overall model was significant, t statistics of the outcome expectations was insignificant t (-1.298), $p = .199$ in the case of the third model. It had a negative regression slope—a one-unit increase in outcome expectation will decrease goals by.191—contradicting the SCCT model. Its 95% confidence interval is from -.486 to .103.

Gender was used to test if it predicts four variables differently. We ran four separate multiple regressions; gender was the independent variable in all the cases and each variable in the instrument – self-efficacy, outcome expectations, interests, and goals – was held as the dependent variable in each model. We created a dummy variable for gender so we could use it as a continuous independent variable, which is an important prerequisite to run regressions. In all the four cases, the results were not statistically significant.

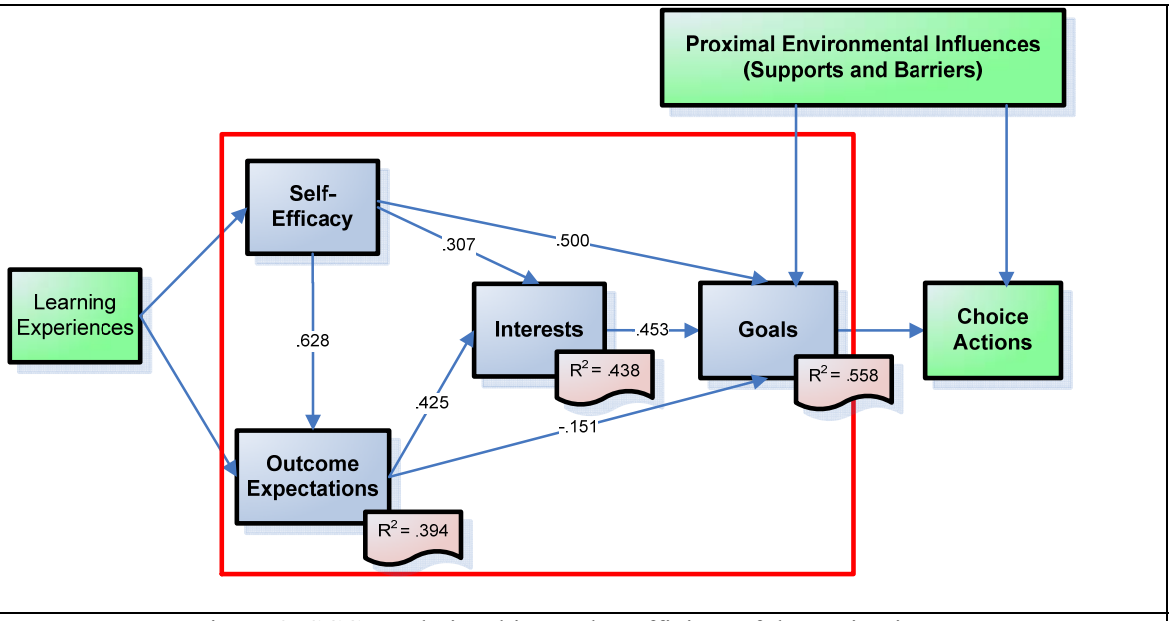

Figure 2. SCCT Relationships and coefficient of determination

Discussions

As noted earlier, this study strove to address three research questions. All the three regression models supported the predictive relationship among variables. The first model, where self-efficacy was the independent variable and the outcome expectations were the dependent variable, had an r^2 of .38. It means that the predictor variable, self-efficacy was able to account for 38% of the explanatory variable's variance, outcome expectation's variance. In the second model, where self-efficacy and outcome expectations were the independent variables and the interests were the dependent variable, had an r^2 of .45. An increase in a number of independent variable tends to increase the value of r^2 as this model demonstrated and the third model will demonstrate the same. The second model had two independent variables and they were able to capture 45% of the variance in the dependent variable. Finally, the third model, where self-efficacy, outcome expectations, and interests were the predictor variables and goals were the explanatory variable, had an r^2 of .55. The third model with the highest number of independent variables, it accounted for 55% of variance in the dependent variable.

Based on the results of the statistical analyses, the PRODUCED program is likely to achieve its goals because all the three regression models were statistically significant and all the four assumptions of regression were reasonably met. However, outcome expectations were not a good antecedent of goals in this study, contradicting what the SCCT model postulates. The third regression model produced a statistically significant result where outcome expectations were one of the predictor variables. However, *t* statistics of the outcome expectations were not statistically significant, *t* (-1.298), p = .199. This finding is consistent with numerous other studies[9,13,18].

Table 2 contains the means, standard deviations, intercorrelation, and Cronbach's alpha of each variable. Positive correlations among the variables are consistent with what the SCCT choice model studies[4] predicts, and are also consistent with past studies[9,13,18].

Gender is not statistically significant in predicting the four variables. Therefore, it is clear that both males and females who are in pursuit of engineering degrees and who are looking for careers directly pertaining to engineering fields have similar levels of self-efficacy, outcome expectations, interests, and goals. This finding is consistent with previous studies where the gap between males and females demonstrated similar levels of academic self-efficacy studies[16,17], and similar levels of technical interests and outcome expectations[21].

It is possible that students in the PRODUCED program were highly motivated to identify themselves with a degree and career in engineering. However, because of numerous difficulties, they may not have been able to pursue an engineering degree from four-year institutions from the beginning. Therefore, it may not be wholly correct to attribute the success of the program to the innovativeness of the PRODUCED program. However, if the students continue, as they believe they will, the PRODUCED program will result in fulfilling the career interests of its participants and in reducing the gap of needed engineers versus available engineers. With mean scores of four—above the mid-point of the rating scale—in the case of all four variables, it is indicative of the fact that most of the participants had high levels of self-efficacy, interests, and goals in pursuing engineering degrees and careers in engineering fields. Therefore, we say that the PRODUCED initiative is likely to meet its objectives.

Limitations

There are a few limitations to this study. First, the researchers purposefully chose which elements of the SCCT model to research so information on previous learning experiences, supports and barriers, and certain personal inputs (e.g. economic, ethnicity, family) were not included. Though a limitation, other authors[13] also restricted their study to the same constructs and Lent et al.[9] added social supports and barriers. A second limitation is not knowing the effect of the self-reporting bias or the makeup of students opting to not participate. Third, this is a cross-sectional study. Therefore, it will be meaningful to conduct a longitudinal study to measure students' change in their levels of self-efficacy, outcome expectations, interests, and goals over time. Fourth, the number of participants is not as great as is desired. Fifth, in future work, asking for a GPA, specifically to see if they earn GPA of 3.4 or higher will be helpful because it takes the above mentioned GPA for students to gain automatic admission into engineering programs at the University of Virginia, if they choose to go there.

Conclusion

As delineated above, PRODUCED program is likely to be successful based on the SCCT model. We recommend follow-on research to determine if students actually persist as well as research on why (or why not) they persist. All the three regression models fitted the data well. However, with consistent failures to show predictive relationship between outcome expectations and goals—in studies after studies—it is worth reconsidering the role of outcome expectations in the SCCT choice model, specifically the consideration of removing the arrow going from outcome expectations to goals. It is interesting that high outcome expectations do not necessarily lead to pursuit of goals in that area, which may indicate that the outcome should be valuable in the first place for it to translate into goals.

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