Social Cognitive Factors of Science, Technology, Engineering, And Mathematics Career Interests

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Abstract

Guided by the Social-Cognitive Career Theory (SCCT), this study examined factors influencing Science, Technology, Engineering, and Mathematics (STEM) career interests and career goals of college students in Taiwan (N = 320). A two-step modeling approach was used. First, the measurement part of the model was examined followed by a test of the full structural equation model. Both the measurement models and the path models were confirmed suggesting a good fit of SCCT with Taiwanese college students. The correlations among SCCT constructs were in the expected direction. Implications for professional counseling and research were discussed.

Introduction

There is increasing attention and competition both nationally and internationally regarding recruitment of the science, technology, engineering, and mathematics (STEM) workforce (National Science Board, 2016). Strong STEM workforce development is viewed as essential to economic growth in the United States and many developing countries, yet researchers and policymakers are concerned that the current workforce will not meet the growing demands of the STEM labor market (Babarović, Dević, & Burušić, 2019). It is important that governments work together to address this global issue in recruiting more students in STEM disciplines (Hill & Kahin, 2012). As we build our 21st Century workforce, it is of increasing importance to understand the development pipeline of the STEM workforce (National Science Board, 2016).

Understanding how students become interested in a STEM career is the first step in addressing the development of the STEM workforce. Interest is a motivational construct that refers to the state of being engaged with a particular object, event, or idea (Hidi & Renninger, 2006). Most researchers would agree that the career interests of school-aged students are one of the most significant predictors of subsequent educational and vocational attainment (Mau, 2003; Wang & Dagol, 2013). Because of the importance of students' career interests, many researchers have investigated the relative significance of factors that may be influential in shaping specific career aspirations and interest in STEM fields (e.g., Mau & Li, 2018; Navarro, Flores, Lee, & Gonzalez, 2014; Shin, Rachmatullah, Roshayanti, Ha, & Lee, 2018).

Counseling and educational inquiry on STEM career interests had been focused largely on the labor force in the United States (Lent & Brown, 2017). There is a growing interest in building cumulative knowledge through sharing research findings and inferences from a global perspective. Around the world, research within the context of career development addresses similar issues and aims to be relevant to policy and practice. A variety of theories or theoretical frameworks have been utilized to understand STEM career development. Over the last few decades, the Social-Cognitive Career Theory (SCCT) (Lent, Brown, & Hackett, 1994, 2000) has become one of the most utilized vocational theories to understand career interests and behaviors of individuals worldwide; we used SCCT as the conceptual framework for this study.

The SCCT Interest and Choice Models

The SCCT interest and choice models comprise a variety of constructs such as vocational self-efficacy, outcome expectations, career interests and goals, as well as contextual factors that influence individual's career choices (Lent, Brown, & Hackett, 1994). When applied to the STEM fields, the SCCT models predict that enhancing self-efficacy and fostering positive and realistic outcome expectations lead to STEM career interests. This in turn leads to STEM career goals and eventually preparation for entering into a STEM occupation (Fouad & Santana, 2017). The key constructs of SCCT are described as follows:

Self-efficacy. Self-efficacy is an individual's belief in their ability to achieve goals (Bandura, 1986). It serves as an organizing mechanism through which individuals employ their existing cognitive, behavioral, and social skills to a task. SCCT postulates that self-efficacy affects individuals' decisions to engage in a task, determine effort required, and to endure in case of an undesirable outcome (Lent, Brown, & Hackett, 1994, 2000). Self-efficacy therefore functions both as an antecedent of outcome expectations and interest, and as a direct contributor to goals (Sheu, Lent, Brown, Miller, Hennessy, & Duffy, 2010). When localizing SCCT to STEM disciplines, it has been shown that one’s backgrounds and learning experiences shape the development of STEM self-efficacy, outcome expectation, STEM career interests, and goals, in turn influencing one’s educational and vocational choices (Wang & Degol, 2013). Prior studies have demonstrated that self-efficacy is a key variable in predicting STEM vocational interests and choices (e.g., Kim & Seo, 2014; Mau & Li, 2018; Navarro, Flores, Lee, & Gonzalez, 2014; Wang, 2013).

Outcome expectation. Outcome expectation refers to beliefs about the consequences of given actions. Career-related outcome expectations can be described as a person’s view of whether he or she will be able to satisfy his/her key values in choosing a particular educational or vocational path (Lent, Brown, & Hackett, 1994). According to SCCT, outcome expectation is posited to function as a subsequent of both learning experience and self-efficacy, and as a direct contributor of interests, goals, and actions. In other words, engagement in particular STEM activities leads to positive affective experiences, which influence self-efficacy and outcome expectation, in turn influencing subsequent choices of STEM activities (Eccles, 2009). Using a meta-analytic path analysis, Sheu et al. (2010) found that outcome expectation significantly predicted career interests as measured by Holland’s interest types.

Contextual factors. Contextual factors are external variables that either facilitate or impede an individual's self-efficacy beliefs and outcome expectations, and hence, their vocational interests and goals. According to SCCT, these external variables influence career development whether they are objective or perceived (Lent, Brown, & Hackett, 2000). Contextual factors also affect educational and vocational interests and goals. Throughout childhood and adolescence, individuals spend substantial time in school. The school environment affects students' social interactions with peers and teachers, and provides students with opportunities to take ownership of their learning process and encouragement to think positively about their academic abilities. This, in turn, affects how they approach their schoolwork (Urdan & Schoenfelder, 2006). Research has shown the important role of contextual factors in predicting STEM interests (Kim & Seo, 2014; Li, Mau, Chen, Lin, & Lin, 2019).

Person inputs. Person inputs are variables accounting for an individual's uniqueness, capturing qualities such as disposition, socioeconomic status, ethnicity, gender, and other personal characteristics that influence self-efficacy (Lent et al., 1994). According to SCCT, person inputs interact with contextual factors to affect individuals' learning experiences and consequently influence their self-efficacy beliefs. Many studies (e.g., Fouad & Santana, 2017; Li, Mau, Chen, Lin, & Lin, 2019; Sheu & Bordon. 2017) have empirically demonstrated how person inputs play a role in career interests and decision-making through learning, experience, self-efficacy, and outcome expectations.

Research on SCCT has generated a wealth of empirical evidence supporting the validity of the theoretical model in the US. However, not enough attention has been paid to the applicability of the theory in understanding STEM career choices of individuals outside the US. Lent and Brown (2017) encourage researchers to extend the theory to include new cultures and populations that are underserved or understudied by vocational psychology.

Moreover, there are currently very few instruments that specifically focus on STEM (Kier, Blanchard, Osborne & Albert, 2014). Researchers have been using a variety of surveys that measure one or more aspects of SCCT to predict student interest in STEM fields (Rottinghaus, Falk, & Park, 2018). Guided by SCCT, Kier et al. (2014) developed the STEM Career Interest Survey (STEM-CIS), which tags on the six key constructs of the SCCT. They reported that STEM-CIS could be used to measure overall STEM interest as well as specific interests in science, technology, engineering, or mathematics separately. Mau, Chen, and Lin (2019) recently provided strong validity evidence for STEM-CIS in the context of high school students. To our knowledge, there are no studies that have utilized SCCT frameworks to develop a survey measuring STEM interests for Chinese/Taiwanese college students. Developing new instruments that effectively measure STEM interests and the decision-making process is crucial for advancing our understanding of factors influencing STEM interests and aspirations of individuals in this population (Tyler-Wood et al., 2010; Usher, 2009).

Purpose of Study

The purpose of this study is two-fold: to examine the validity of the Chinese version of the STEM Career Interest Survey (STEM-CCIS) in terms of its goodness of fit and its internal consistency, and to examine the relationships among constructs hypothesized in the SCCT model based on a sample of Taiwanese college students. We expect STEM-CCIS to replicate the 6-factor model as suggested by SCCT (Lent, Brown, & Hackett, 1994, 2000). We also hypothesize that person inputs and contextual factors are mediated through self-efficacy and outcome expectation to impact STEM career interests of college students in Taiwan.

Approximately 1.2 billion people speak a form of Chinese as their first language.

Counselors worldwide are looking for valid instruments to use with Chinese-speaking populations. It is important that Chinese-speaking individuals have access to career counseling services based on culturally relevant assessments and guidance tools. We believe the social-cognitive related factors identified in this study would extend STEM research and allow policymakers and counselors to implement developmentally appropriate and culturally sensitive career interventions for individuals who may be interested in STEM careers both domestically and internationally (Mau, 2016).

Method

Participants

College student participants (*N* = 363) were recruited from five universities, two from the northern region, two from the central region, and one from the southern region of Taiwan. Of the five universities, two were public and three were private. The choice of universities was primarily based on university type and geographical location. There were no statistical differences in the SCCT domain scales among the five universities examined in this study. Of the 363 participants, 32 did not complete the majority of the questions and 11 did not fill out the questionnaire correctly. The final sample of 320 participants comprised 159 males and 161 females, with 116 freshmen, 110 sophomores, 78 juniors, and 26 seniors. Participants majored in science (*n* = 102), engineering (*n* = 154), technology (*n* = 30), and mathematics (*n* = 34) related fields.

Procedure

After receiving institutional review board approval, the researchers recruited the participants through STEM classes at the selected universities in spring 2016. Data were collected through a Qualtrics online survey created for this study. Following a brief description of the purpose of the study and an informed consent process, the questionnaire took about 30 minutes to complete. There was no remuneration or course credit for participation.

Instruments

The original STEM-CIS developed by Kier, Blanchard, Osborne & Albert (2014) was translated and adapted for this study using a back-translation procedure. The survey, which was developed in English, was first translated into Chinese by a doctoral level bilingual person who has knowledge of both Chinese and English cultures. For the back-translation, we followed the recommendation to make sure that the people performing the back translation have no previous knowledge of the instrument (Beaton, Bombardier, Guillemin, & Ferraz, 2000). A bilingual (English and Chinese) person with a Bachelor's degree in English and a Master's degree in translation and who had no background in counseling or psychology conducted the back translation.

Five university students were invited to fill out a pilot survey and provide feedback on the directions, question format, and wording. Additional revisions were made based on their feedback before the survey instruments were finalized and administered to the participants.

The STEM-CIS is a 44-item instrument that measures interest in the four subject areas of science, technology, engineering, and mathematics. The initial items were based on an extensive literature review guided by the SCCT theoretical framework, as well as other instruments that measure STEM career interests (e.g., Fouad, Smith, & Enoch., 1997; Tyler-Wood et al., 2010). Each discipline-specific subscale contains 11 items that address six social-cognitive constructs: self-efficacy (2 items; e.g., "I am able to get a good grade in science"), outcome expectation (2 items; e.g., "If I do well in my mathematics classes, it will help me in my future career"), goal (2 items; e.g., "I intend to enter a career that uses science"), interest (2 items; e.g., "I am interested in careers that use science”), contextual factors (2 items; e.g., “I have a role model in a science career”), and person inputs (1 item; e.g., “I would feel comfortable talking to people who work in mathematics careers”). Scoring was done with a five-point Likert scale, with response options ranging from “strongly disagree” (1) to “strongly agree” (5). Kier et al. (2014) reported that the Cronbach’s alpha of the STEM-CIS ranged from 0.77 to 0.89 for the subscales.

Statistical Analysis

Our statistical analysis of STEM-CCIS followed a two-step process: first, the measurement model was examined and fine-tuned, followed by a test of the full structural equation model (Anderson & Gerbing, 1988).

1. Measurement Model: Confirmatory factor analysis (CFA) was used to verify the psychometric properties of STEM-CCIS. We reorganized the 44-item STEM-CIS scale into 6 subscales to measure 6 latent variables: self-efficacy, outcome expectation, STEM interest, STEM goal, contextual factors, and person inputs. Using maximum likelihood estimation with AMOS (SPSS add on module version 21), we conducted analyses on the 6-factor scale.
2. Structural Model: After confirming the factor structure of the measure, the full structural equation model (SEM) was conducted. This procedure is similar to a path analysis with theoretical linkages among endogenous, exogenous, and mediating variables (Schreiber, Nora, Stage, Barlow, & King, 2006).

Multiple fit indices were used to determine if the model adequately reflected the observed data (Anderson & Gerbing, 1988; Weston & Gore, 2006). A χ^2 statistic was used to examine the differences between the observed and implied variance-covariance matrices. However, χ^2 statistics are greatly influenced by sample size and thus are rarely found to be nonsignificant in samples sufficiently large enough for CFA (Cangur & Ercan, 2015; Cudeck & Browne, 1983). Therefore, we also evaluated the model fit using the root mean square error (RMSEA), standardized root mean square residual (SRMR), the comparative fit index (CFI), and the Tucker-Lewis Index (TLI). The model fit was assessed using the following criteria: $\chi_2/df < 3$, TLI > 0.95, CFI > 0.95, RMSEA < 0.08, and SRMR < 0.08 (Schreiber, et al., 2006).

Results

Descriptive Statistics and Reliability

Table 1 presents the means, standard deviations and internal reliability coefficients for the factors of the STEM-CCIS. The results show very good internal reliability with an overall Cronbach’s alpha of .98. SCCT subscale internal consistency reliability coefficients ranged from .77 to .90. Discipline-specific subscale internal consistency reliabilities ranged from .90 to .93. This result compares favorably with the English scale originally developed by Kier, et al. (2014).

[Table 1 inserted here]

Measurement Models of SCCT STEM Career Interests

Two measurement models were examined and summarized in Table 2. Model 1 is an initial model with all 44 items defining the 6-factor scale of STEM-CCIS. Model 2 is a modified model of model 1. To improve the fit of model 1, we deleted 4 items (i.e., I know someone in my family who uses mathematics/science/engineering/technology in their career) from the contextual factors scale due to their low factor loadings. We then parceled the remaining 40 items into 24 items by aggregating items that share a similar discipline and factor scale (e.g., “I am able to get a good grade in science” and “I am able to complete my science homework”). Item parceling has been often used in empirical SEM analyses to reduce model complexity

(Bandalos, 2002; Little, Cunningham, Shahar, & Widaman, 2002). Consequently, a 24-item STEM-CCIS scale was confirmed. As seen in Table 2, Model 2 shows an adequate fit of the SCCT factor structure [χ^2 (185) = 800.41, χ^2/df = 4.33, TLI = 0.89, CFI = 0.93, *RMSEA* = 0.10, SRMR= 0.07]. The χ^2 difference between the original model and the modified model far exceeded the suggested value of 3.84, indicating the adequacy of the modification (Anderson & Gerbing, 1988).

[Table 2 inserted here]

Structural Equation Model of SCCT STEM Career Interests

After confirmation of the measurement scale, the variables were computed based on the confirmed 24-item scale. We then conducted the path analysis on the SCCT model. Results of SEM, as seen in Table 2, showed improvement in fit indices [χ^2 (3) = 14.28, χ^2/df = 4.76, TLI = 0.96, CFI = 0.99, *RMSEA* = 0.10, SRMR = 0.02]. Seventy eight percent of variance on STEM interest was accounted for by the model and 79% of variance on STEM goal was accounted for by the model. All paths in the model are significantly related.

[Figure 1 inserted here]

SCCT posits that person inputs and contextual factors are mediated through self-efficacy and outcome expectation to impact career interest and goal. As can be seen in the Table 3, results of path analyses, in general, do correspond to this expectation. Personal inputs directly affect contextual factors (β = 0.66, $p < .001$), self-efficacy (β = 0.36, $p < .001$), and STEM interest (β = 0.14, $p < .001$), and indirectly affect self-efficacy (β = 0.25 $p < 0.001$), outcome expectation (β = 0.40, $p < .001$), STEM interest (β = 0.54, $p < .001$), and STEM goal (β = 0.59, $p < .001$). Whereas contextual factors directly affect self-efficacy (β = 0.37, $p < .001$), and STEM interest (β = 0.30, p < .001), and indirectly affect outcome expectation (β = 0.18, p < .01), STEM interest (β = 0.22, p < .001), and STEM goal (β = 0.44, p < .001). Self-efficacy directly affects outcome expectation (β = 0.49, p < .001), STEM interest (β = 0.42, p < .001), and STEM goal (β = 0.28, p < .001), and indirectly affects STEM interest (β = 0.09, p < .001) and STEM goal (β = 0.36, p < .001). Outcome expectation directly affects STEM interest (β = 0.19) and STEM goal (β = 0.17, p < .001), and indirectly affects STEM goal (β = 0.10, p < .001). STEM interest directly affects STEM goal (β = 0.53, p < 0.001). The total effect of self-efficacy on STEM interest is 0.51 and the total effect of self-efficacy on STEM goal is 0.64. The path diagram with standardized coefficients and standardized errors are summarized in Figure 1.

[Table 3 inserted here]

Discussion

The aim of this study was to adapt the STEM Career Interest Survey (Kier, et al., 2014) for use with Taiwanese students and to examine factors influencing Taiwanese college students' STEM career interests and plans using SCCT theoretical framework. Our findings help address several important issues in understanding how students become interested in a STEM career and whether or not the STEM interest instrument developed in the US can be adapted for use in Taiwan.

To accomplish this goal, we developed STEM-CCIS, an adaptation of the STEM-CIS for Taiwanese college students. Correlations between the six SCCT factors represented in STEM-CCIS ranged from r = .49 to .89. These findings support using a combined scale score as well as individual subscales to assess the career interest identity of Taiwanese college students (Mau, et al., 2019).

Consequently, we examined the relationships among constructs hypothesized in the SCCT model based on a sample of Taiwanese college students. We hypothesized that person inputs and contextual factors are mediated through self-efficacy and outcome expectation to impact STEM career interest and STEM career goals (Lent et al., 1994). As seen in Figure 1, results of path analyses do generally agree with this theoretical expectation, with 79% of the variance accounted for by the measurement model. Previous studies (e.g., Betz, 2008; Lent, 2005) using meta-analysis reported correlation coefficients of self-efficacy to interests in the .50s and self-efficacy to choice goals in the .40s. Our results were comparable with previous studies in that self-efficacy was more potent than outcome expectation in predicting STEM career interest and STEM career goals.

Our findings demonstrate that person inputs and contextual factors lead to an increase in self-efficacy of Taiwanese college students, in turn developing their positive attitudes toward STEM careers. It is interesting to note that in the original choice model (Lent et al., 1994; Lent et al., 2000) person inputs and contextual factors are not directly correlated with career interest. Our study, however, shows that both person inputs and contextual factors have a significant direct effect on STEM career interest, albeit smaller than their impacts on self-efficacy. Further research is needed to clarify if this discrepancy is sample specific (Taiwanese college samples vs non-Taiwanese samples) or discipline specific (e.g., STEM vs. non-STEM).

Our results also confirmed the mediation effect of outcome expectation on STEM career interest and STEM career goals. The magnitude of the effect, however, was smaller than self-efficacy's; self-efficacy had a direct effect on STEM interests $\beta = 0.43$ and STEM goals $\beta = 0.27$, whereas outcome expectation had a direct effect on STEM interests $\beta = 0.20$ and on STEM goals $\beta = 0.17$. Research on the differential impacts of self-efficacy and outcome expectation on career interest and goals have had varying results. It is likely that the discrepancies in the results of these studies are due to the differing samples and contexts. For example, when predicting math/science goals in a general college sample, Lent and colleagues (Lent et al., 2001) found outcome expectations exceeded the direct effects of self-efficacy, and the opposite pattern to occur in samples composed of students majoring in math/science-intensive fields. Whereas, when Sheu et al. (2017) examined 37 studies conducted outside of the US, they concluded that evidence for the mediating role of outcome expectations was less consistent than self-efficacy in relating proximal contextual factors to career interests or career goals. It may be helpful if further research investigating the differential effect of the SCCT constructs could address sample and context specific issues. Regardless, our findings show that self-efficacy and outcome expectations positively correlate to STEM interests and STEM career goals of Taiwanese college students.

Implications for Counseling Practices

Our findings suggest that the adapted Chinese version of STEM-CCIS has sound psychometric quality comparable to the English version of STEM-CIS. Thus, we believe the STEM-CCIS may be used as an assessment for identifying STEM career interests of Taiwanese college students. Counselors may also consider using the STEM-CCIS to screen students who may be interested in STEM career for further counseling interventions. The original scale developed by Kier et al. (2014) was discipline-specific. The present study provides validity evidence for Taiwanese college students that can be used without specifying the discipline. We believe it is important to avoid focusing on specific STEM disciplines prematurely when helping students who are in the early stage of STEM career exploration. Different approaches can be used to measure STEM-CIS, separately as well as combined scale approaches. One may use the combined scale to indicate an overall interest in STEM fields, followed by examining a discipline-specific scale to gain further insight on the nature of an individual's interests.

The findings of this study also highlight the importance of self-efficacy as a mediating variable for STEM interest and choice. One of the most useful aspects of SCCT is that the theory depicts relationships among the key constructs in such way that it can be readily used to guide the development and implementation of counseling interventions. For example, if students do not have strong self-efficacy for a specific STEM subject, they are less likely to value STEM education or pursue STEM careers (Betz, 2007). Thus, enhancing self-efficacy is crucial in career interventions designed to increase STEM career interests of college students. Counseling interventions designed to enhance self-efficacy beliefs have received empirical support based on data gathered in the United States (Sheu & Lent, 2015). To increase students' self-efficacy, counselors could focus on the four sources of self-efficacy described by Bandura (1977): mastery experiences, vicarious experiences, social persuasion, and physiological reaction, in their counseling interventions (Sheu & Bordon, 2017).

Implications for Future Research

Counselors and academic advisors worldwide are looking for valid instruments available for working with Chinese-speaking populations. Further research will likely be needed to validate this instrument for use with Chinese speaking populations in China, Hong-Kong, Singapore and other countries, or even with the nearly 3 million Chinese speakers in the United States. One cannot assume Chinese speakers of different countries share the same vocational attitudes and behaviors; therefore, cross-validations of the instrument with various Chinese-speaking populations are necessary.

In conclusion, our findings suggest that STEM-CCIS possesses adequate reliability and factorial validity, replicating the sound psychometric properties of the original English version of the STEM-CIS. Measuring the STEM-CIS can be done using combined or separated scales; the present study provides strong validity evidence on the theoretical structures of this measurement scale. Self-efficacy beliefs, which are informed by contextual factors and person inputs, clearly play a key role in the development of STEM career interests and STEM career goals among college students in Taiwan. The STEM-CCIS may be used as an instrument for identifying STEM career interests of Taiwanese college students or as a screening tool for intervention purposes. Economic growth and innovation worldwide depend on sufficient numbers of skilled professionals in the STEM workforce. We hope that this study can contribute to the improvement of the STEM workforce by identifying and preparing students to meet these needs.

References

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*(3), 411-423. https://doi.org/10.1037/0033-2909.103.3.411

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

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavior change. Psychological Review, 84, 191–215. https://doi.org/10.1016/0146-6402(78)90002-4

Babarović, T., Dević, I. & Burušić, J. (2019). Fitting the STEM interests of middle school children into the RIASEC structural space. *International Journal for Educational and Vocational Guidance, 19 (1)*, 111-128. https://doi.org/10.1007/s10775-018-9371-8

Beaton, D.E., Bombardier, C., Guillemin, F. & Ferraz, M. B. (2000). Guidelines for the process of cross-cultural adaptation of self-report measures. Spine, 25, 3186-3191. https://doi: 10.1097/00007632-200012150-00014

Betz, N. E. (2007). Career self-efficacy: Exemplary recent research and emerging directions. *Journal of Career Assessment, 15*, 403–422. https://doi:10.1177/1069072707305759

Cangur, S., & Ercan, I. (2015). Comparison of model fit indices used in structural equation modeling under multivariate normality, *Journal of Modern Applied Statistical Methods,14 (1)*, 152-167. https://doi: 10.22237/jmasm/1430453580

Carey, D., C. Hill and B. Kahin (2012). Strengthening innovation in the United States. OECD Economics Department. Working Papers, No. 1001, OECD Publishing, Paris, https://doi.org/10.1787/5k8zl62hxmf6-en

Cudeck, R., & Browne, M. W. (1983). Cross-validation of covariance structures, *Multivariate*

Behavioral Research, 18: 147-167. https://doi.org/10.1207/s15327906mbr1802_2

Eccles, J. S. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist. 44*, 78–89. https://doi.org/10.1080/00461520902832368

Fouad, N. A., & Santana, M. C. (2017). SCCT and underrepresented populations in STEM fields: Moving the needle. *Journal of Career Assessment*. 25, 24-39. https://doi.org/10.1177/1069072716658324

Fouad, N. A., Smith, P. L., & Enoch, L. (1997). Reliability and validity evidence for the Middle School Self-Efficacy Scale. *Measurement and Evaluation in Counseling and Development, 30*(1), 17–31. https://doi.org/10.1080/07481756.1997.12068914

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, *41,* 111-127. https://doi.org/10.1207/s15326985ep4102_4

Kier, M. W., Blanchard, M.R., Osborne, J.W., & Albert, J.L. (2014). The development of the STEM Career Interest Survey (STEM-CIS). *Research in Science Education*, *44 (3),* 461-481. https://doi: 10.1007/s11165-013-9389-3

Kim, M.S., & Seo, Y.S. (2014). Social cognitive predictors of academic interests and goals in South Korean engineering students. *Journal of Career Development, 41, (6)*, 526 – 546. https://doi.org/10.1177/0894845313519703

Lent, R. W., & Brown, S. D. (2017). Social cognitive career theory in a diverse world: Guest editors' introduction. *Journal of Career Assessment, 25*, 3-5. https://doi.org/10.1177/1069072716657811

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. https://doi.org/10.1006/jvbe.1994.1027

Lent, R. W., Brown, S. D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology, 47*, 36. https://doi: 10.1037/0022-0167.47.1.36

Lent, R. W., Brown, S. D., Brenner, B., Chopra, S. B., Davis, T., Talleyrand, R., et al. (2001). The role of contextual supports and barriers in the choice of math/science educational options: A test of social cognitive hypothesis. *Journal of Counseling Psychology, 48*, 474–483. https://doi.org/10.1037/0022-0167.48.4.474

Li, J., Mau, W. C., Chen, S. J., Lin, T, C., & Lin, T. Y. (2019). A qualitative exploration of STEM career development of high school students in Taiwan. *Journal of Career Development*. https://doi.org/10.1177/0894845319830525

Little, T. D., Cunningham, W. A., Shahar, G., & Widaman, K. F. (2002). To parcel or not to parcel: Exploring the question, weighing the merits. Structural Equation Modeling, 9, 151-173. https://doi.org/10.1207/S15328007SEM0902_1

Mau, W. C. (2003). Factors influencing persistence in science and engineering career aspirations. *Career Development Quarterly*, *51*, 234-243. https://doi.org/10.1002/j.2161-0045.2003.tb00604.x

Mau, W. C. (2016). Characteristics of U.S. students that pursued a STEM major and factor predicted persistence in degree completion. *Universal Journal of Educational Research, 4 (6) 1495-1500.* https://doi: 10.13189/ujer.2016.040630

Mau, W.C., Chen, S.J., & Lin, C.C. (2019). Assessing high school student's STEM career interests using a social cognitive framework. *Education Sciences*, *9(2)*, 151-162. https://doi.org/10.3390/educsci9020151

Mau, W. C., & Li J. (2018). Factors influencing STEM-career aspirations of underrepresented high school students, *Career Development Quarterly*, 66 (3), 246-258. https://doi.org/10.1002/cdq.12146

National Science Board. (2016). *Science and Engineering Indicators 2016*. Arlington, VA: National Science Foundation (NSB-2016-1)

Navarro, R. L., Flores, L. Y., Lee, H-S., & Gonzalez, R. (2014). Testing a longitudinal social cognitive model of intended persistence with engineering students across gender and race/ethnicity, *Journal of Vocational Behavior 85*,146–155. https://doi.org/10.1016/j.jvb.2014.11.004

Rottinghaus, P. J., Falk, N. A., & Park, C. J. (2018), Career assessment and counseling for STEM: A critical review. *The Career Development Quarterly, 66*, 2–34. https://doi: 10.1002/cdq.12119

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of Educational Research*, *99*(6), 323-338. https://doi.org/10.3200/JOER.99.6.323-338

Sheu, H., & Bordon, J. J. (2017). SCCT research in the international context: Empirical evidence, future directions, and practical implications. *Journal of Career Assessment, 27*, 58–74. https://doi.org/10.1177/1069072716657826

Sheu, H., & Lent, R. W. (2015). *A social cognitive perspective on career intervention*. In P. J. Hartung, M. L. Savickas, & W. B. Walsh (Eds.), APA handbook of career intervention (Volume 1): Foundations (pp. 115–128). Washington, DC: American Psychological Association. https://doi.org/10.1037/14438-007

Sheu, H., Lent, R. W., Brown, S., Miller, M., Hennessy, K., & Duffy, R. D. (2010). Testing the choice model of social cognitive career theory across Holland themes: A meta-analytic path analysis. *Journal of Vocational Behavior, 76,* 252–264. https://doi.org/10.1016/j.jvb.2009.10.015

Shin, S., Rachmatullah, A., Roshayanti, F., Ha, M., & Lee, J-K. (2018). Career motivation of secondary students in STEM: a cross-cultural study between Korea and Indonesia. *International Journal for Educational and Vocational Guidance*, *18 (2),* 203-231. https://doi.org/10.1007/s10775-017-9355-0

Tyler-Wood, T., Knezek, G., & Christensen, R. (2010). Instruments for assessing interest in STEM content and careers. *Journal of Technology and Teacher Education, 18(2)*, 341–363. Retrieved April 21, 2020 from https://www.learntechlib.org/primary/p/32311/.

Usher, E. L. (2009). Sources of middle school students' self-efficacy in mathematics: A qualitative investigation. *American Educational Research Journal, 46(1),* 275–314. https://www.jstor.org/stable/27667179

Weston, R., & Gore, P. A. (2006). A brief guide to structural equation modeling. *Counseling Psychologist*, *34*(5), 719-751. https://doi: 10.1177/0011000006286345

Wang, M-T., & Degol, J. (2013). Motivational pathways to STEM career choices: using expectancy-value perspective to understand individual and gender differences in STEM fields. *Developmental Review*, *33(4),* 1-47. https://doi.org/10.1016/j.dr.2013.08.001.

Wang, XL. (2013). Modeling entrance into STEM fields of study among students beginning at community colleges and four-year institutions. *Research in Higher Education*, *54 (6),* 664-692. https://doi.org/10.1007/s11162-013-9291-x

Weston, R., & Gore, P. A. (2006). A brief guide to structural equation modeling. Counseling Psychologist, 34(5), 719–751. https ://doi.org/10.1177/00110 00006 28634 5.

Table 1

Descriptive Statistics of STEM-CCIS Subscales

Subscales	*N*	Items	Mean	*SD*	Alpha
Person Inputs	320	4	12.05	3.69	.87
Contextual Factors	320	8	22.78	6.50	.77
Self-Efficacy	320	8	26.51	6.80	.90
Outcome Expectation	320	8	29.47	6.64	.89
STEM Interest	320	8	25.16	6.84	.88
STEM Goal	320	8	26.54	6.59	.89
Math	320	11	32.64	9.61	.90
Science	320	11	37.07	9.12	.93
Engineering	320	11	38.23	8.59	.91
Technology	320	11	34.55	9.25	.91

Notes. Item choices were on a Likert-type scale, ranging from “strongly disagree” (1) to “strongly agree” (5).

Table 2

Summary of Measurement Models and SEM Model

Models	Parameters	*df*	χ^2	*CMIN/df*	TLI	CFI	SRMR	RMSEA
Measurement Model								
1. Initial six factor 44 item	103	887	6524.51	7.36	0.55	0.58	0.11	0.14
2. Modified six factor 24 item	115	185	800.41	4.33	0.89	0.93	0.07	0.10
Structural Equation Model								
3. Initial model 24 item	18	3	14.28	4.76	0.96	0.99	0.02	0.11

Notes. TLI = Tucker-Lewis Index; CFI = comparative fit index; SRMR = standardized root mean square residual; RMSEA = root mean square error; *CMIN* = minimum discrepancy.

.

Table 3

Final Structural Equation Modeling: Standardized Path Coefficients

Variables	Person Inputs	Contextual Factors	Self-Efficacy	Outcome Expectation	STEM Interest
Contextual Factors	0.66 (0.00)				
Self-Efficacy	0.36 (0.25)	0.37 (0.00)			
Outcome Expectation	0.00 (0.40)	0.16 (0.18)	0.49 (0.00)		
STEM Interest	0.14 (0.54)	0.30 (0.22)	0.42 (0.09)	0.19 (0.00)	
STEM Goal	0.00 (0.59)	0.00 (0.44)	0.28 (0.36)	0.17 (0.10)	0.53 (0.00)

Notes. The numbers in the table represent standardized path coefficients; numbers outside parentheses are direct effect and numbers in parentheses are indirect effect.

Figure 1. SCCT Model of STEM Career Interests. Numbers outside parenthesis are standardized path coefficients and numbers inside the parenthesis are standardized errors.