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Taiwanese Preservice Teachers' Science, Technology, Engineering, and Mathematics Teaching Intention

Abstract

This study applies the theory of planned behavior as a basis for exploring the impact of knowledge, values, subjective norms, perceived behavioral controls, and attitudes on the behavioral intention toward science, technology, engineering, and mathematics (STEM) education among Taiwanese preservice science teachers. Questionnaires (N = 139) collected information on the behavioral intention of preservice science teachers engaging in STEM education. Data were analyzed using descriptive statistics, path analysis, and analysis of variance. Results revealed that, in terms of direct effects, higher perceived behavioral control and subjective norms were associated with stronger STEM teaching intention. More positive attitude and greater knowledge were indirectly associated with higher subjective norms and perceived behavioral control, which resulted in stronger STEM teaching intention. Additionally, gender did not affect preservice teachers' intention to adopt STEM teaching approaches. However, preservice teachers whose specialization was in different fields tended to influence their knowledge and perceived behavioral control; these issues require further investigation.

Keywords: preservice teachers, STEM, teaching intention, theory of planned behavior

Introduction

Integrated science, technology, engineering, and mathematics (STEM) education has received much attention in recent years, and it may provide a key to career success in the 21st century (Bybee, 2010). The United States has made a significant investment in STEM education in an attempt to remain competitive in the global economy (Chen, 2009). Although the specific nature and significance of STEM education have not been clearly defined (Bybee, 2013), an interdisciplinary perspective of STEM has been integrated into the critical planning of scientific and technological literacy standards (International Technology Education Association [ITEA], 2007; National Research Council [NRC], 2012). Moreover, many scholars attempting to establish a mechanism for effectively integrating STEM subjects have become involved in related research to establish a basis for design, development, and implementation (Han, Capraro, & Capraro, 2014; Nathan et al., 2013; Nicholls, Wolfe, Besterfield-Sacre, & Shuman, 2010; Nicholls, Wolfe, Besterfield-Sacre, Shuman, & Larpkiattaworn, 2007).

Researchers have varying views and opinions concerning the objectives of STEM education. This study adopted Sanders' views (2012) — emphasizing a STEM teaching approach that allows students to develop integration capabilities for solving problems — and the theory of planned behavior (Ajzen, 1985) — emphasizing how individuals' behavioral intention based on attitudes, subject norms, and perceived behavioral controls can shape their behavior. This study developed a questionnaire, selected preservice teachers as the sample, and focused on exploring preservice teachers' knowledge, values, subjective norms, perceived behavioral controls, and attitudes toward STEM teaching and their behavioral intention to provide a helpful resource for planning future teacher education and professional development programs. Two research questions guided the study: (1) Do Taiwanese preservice teachers' knowledge, values, subjective norms, perceived behavioral controls, and attitudes toward STEM teaching affect their behavioral intention toward STEM teaching? (2) Do Taiwanese preservice teachers' gender and academic backgrounds affect their knowledge, values, subjective norms, perceived behavioral control, attitudes, and behavioral intention toward STEM teaching?

Background

Bybee (2013) suggested that STEM could be clarified by the teaching methods endorsed, which should focus on global issues such as climate change and energy policies. Additionally, teaching should include theory-based design to help students integrate STEM knowledge effectively through the development of engineering design, practices, and production skills. Vescio, Ross, and Adams (2008) proposed that greater attention to how teachers embody STEM teaching methods was necessary for successful implementation.

For example, in the United States, improving teachers' teaching abilities is emphasized in the implementation of STEM education plans for elementary and secondary schools (Kuenzi, 2008).

Darling-Hammond and McLaughlin (1995) proposed that successful educational reform requires that teachers be self-reflective; that is, they should attempt to reconstruct the roles played by their students and use different approaches to guide students. However, few studies have examined the behavioral factors affecting teachers' decisions to implement STEM education. Thus, teacher education and professional development programs that develop STEM teaching skills constitute important topics for future studies, which should include factors affecting teachers' intentions toward STEM teaching. The theory of planned behavior (Ajzen, 1985) that emphasized individuals' knowledge, values, attitudes, subjective norms, and perceived behavioral control and their relationships to STEM teaching intention was the foundation for this exploration.

STEM Teaching Intention

The United States has promoted STEM education and integrated standards in science and technology curricula (ITEA, 2007; NRC, 2012). Despite this emphasis on STEM topics, the significance and objectives of STEM education remain unclear with scholars having different opinions about its purpose and implementation. Bybee (2013) believed that it requires a clear practical purpose (i.e., purposeful policy, program, and practice) and should focus on environmental protection, energy conservation, and other global concerns. He also believed that STEM should adopt both inquiry-based and theory-based learning methods to promote in-depth exploration, a skill essential for success in the 21st century. However, Sanders (2012) promoted a holistic perspective of STEM education as an integrated teaching method to resolve the inapplicability of traditional, theory-based educational approaches. In this study, behavioral intention toward STEM teaching refers to preservice teachers' willingness and potential to adopt STEM teaching that includes interdisciplinary approaches, which might not have been considered in their professional education.

Knowledge of STEM

STEM education defines its objectives to be compatible with *science* education, where the main objective is the discovery and development of a proper understanding of nature (NRC, 1996) that can serve as a basis for learning about technology and engineering. *Technology* education aims to teach students ways of modifying the natural world to meet human wants and needs (ITEA, 2007). The goal of *engineering* education entails effectively utilizing limited natural resources to benefit humankind (Accreditation Board for Engineering and Technology, 2002). Finally, *mathematics* in the STEM educational context involves studying scientific models and relationships as a language among science, technology, and engineering (American Association for the Advancement of Science, 1993).

Numerous models exist for STEM studies (Bybee, 2013). The model adopted in the present study integrates relationships among STEM disciplines through the study of a particular discipline. In other words, teachers should be knowledgeable in their chosen discipline and understand the course content sufficiently to effectively synthesize this knowledge with other STEM disciplines and, in some cases, the arts, humanities, and social sciences.

STEM Values and Attitudes

Individuals' perceptions determine their valuation and resultant attitudes (Kolter, 2000). Therefore, preservice teachers' knowledge of STEM may affect their perception of the value of STEM teaching. That value is based on subjective values concerning implementation and on the manner in which the relationships among these values correlate with student and teacher evaluations, resulting in positive and negative remarks regarding teaching behaviors. These remarks with respect to STEM education from preservice teachers may also reflect their attitude toward STEM in general. Monroe, Day, and Grieser (2000) asserted that behavior is derived from an individual's knowledge and attitude, albeit not a direct causal relationship. Therefore, it is reasonable to conclude that a relationship exists between preservice teachers' behavioral intention toward STEM teaching and their attitude toward STEM.

Mahoney (2010) developed a STEM attitude scale for high school students that encompassed emotions, beliefs, and behavioral components. Attitude comprises a set of values, feelings, and motives in response to a particular environment. Taiwanese preservice teachers' attitude toward STEM in this study embodies their personal interest in STEM teaching as a means of determining the likelihood that they will implement STEM teaching.

Subjective Norms Regarding STEM

According to the theory of planned behavior (Ajzen, 1985, 1991), normative beliefs are mainly instilled through encouragement, instigation, or pressure from society to embrace a subjective norm. Therefore, when preservice teachers implement STEM teaching, it is important to explore the behavioral intentions underlying these practices that may be affected by encouragement and subjective norms imposed by educational authorities, school administrators, fellow teachers, and parents. This study assumed that STEM subjective norms embody the public's support for or rejection of the implementation of STEM teaching and the teachers' reactions to these norms.

Perceived Behavioral Control of STEM

The theory of planned behavior maintains that control beliefs address various factors affecting an individual's decision to execute or prevent certain behaviors; these factors may include the availability of resources or opportunities necessary for the enactment of specific behaviors and perceived behavioral control. Therefore, critical factors contributing to perceived behavioral control when a preservice teacher decides to implement STEM teaching include consideration of resources, opportunities, and convenience. This study assumes that perceived behavioral control with respect to STEM teaching entails the likelihood of preservice teachers controlling proper resources and successfully resolving perceived and actual teaching difficulties.

Methods

This model-verification study involved the development of a model based on selected theoretical foundations and definitions of the target outcome, the collection of data on the related variables, and statistical analyses of the relationships amongst these variables. The theory of planned behavior served as the basis for a predictive model to envisage educators' behavioral intention for STEM teaching (Ajzen, 1985; Ajzen & Madden, 1986). Here, intention refers to an individual's evaluation of a particular behavior's result, which is greatly influenced by public subjective norms and control beliefs. The central research foci of this study were to determine if the proposed model for STEM teaching intention was valid; if so, what was the strength of the relationships amongst the variables; and if not, what were the relationships not initially identified and a more explanatory model?

Research Framework: Proposed Model of STEM Teaching Intentions

The proposed model in this study employed an extended range of variables (i.e., knowledge, values, and attitudes) rather than the variables (i.e., subjective norms and control beliefs) from the original theory of STEM teaching (Figure 1). Thus, this model and approach provided the means to determine the strengths of relationships and verify whether knowledge, values, subjective norms, perceived behavioral control, and attitude toward STEM have effects on behavioral intention (see Table 1 for operational definitions).

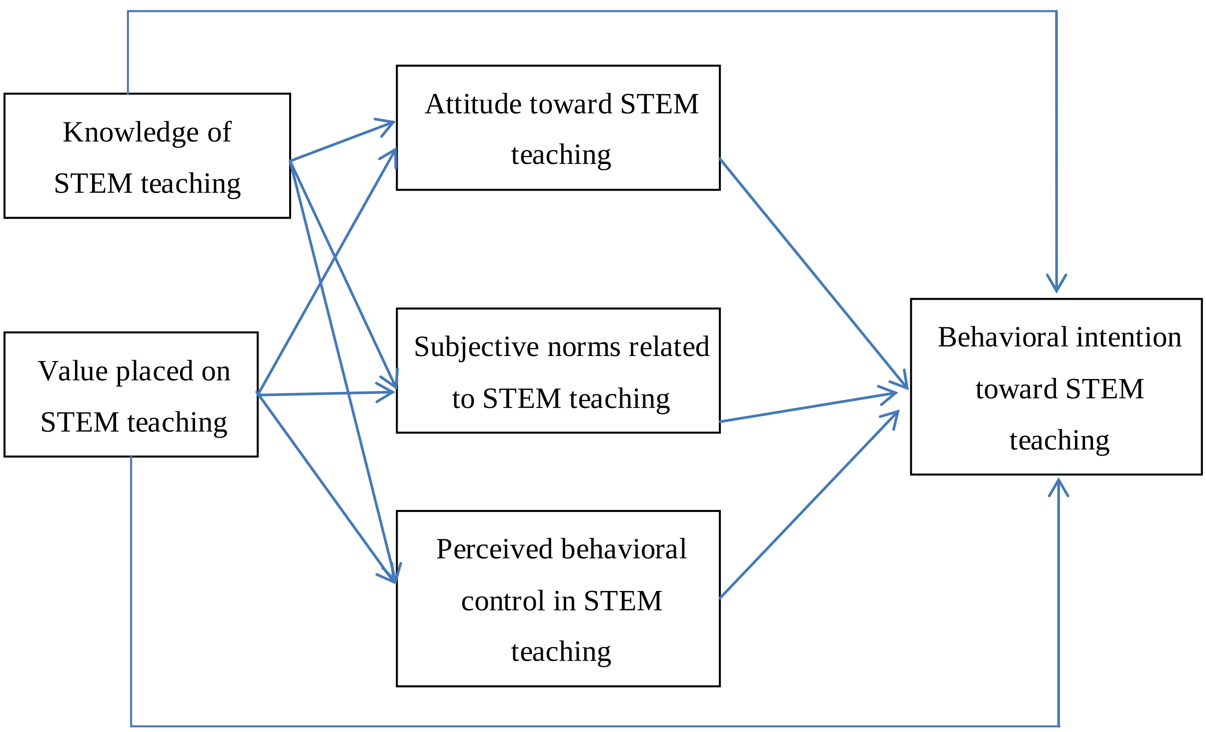

Figure 1. Research framework for model of STEM teaching intention.

Table 1

Operational Definitions of the Variables Used

Variable	Operational definition
Knowledge	The level of understanding of STEM.
Values	Changes in an individual's set of criteria regarding STEM teaching and the manner in which these affect one's self-evaluation and evaluation of students' remarks concerning its practice.
Attitude	An individual's interest in STEM teaching and the likelihood that he/she will apply or discuss topics related to it.
Subjective norms	The individual impressions of important reference groups (e.g., school principal, colleagues) regarding their support of or opposition to the implementation of STEM teaching, in addition to the individual's degree of compliance with these norms.
Perceived behavioral controls	Degree of difficulty (e.g., the lack of facility or equipment) faced by an individual in choosing to adopt STEM teaching and the degree to which he/she can control and adjust relevant resources while doing so.
Behavioral intention	The intention and likelihood that an individual will adopt STEM teaching in his/her future teaching career.

Target Sample

Because the STEM teaching approach is not implemented widely in Taiwan, it is difficult to explore teachers' actual integrative STEM teaching intention. Therefore, this study focused on preservice teachers as they faced future implementation of STEM programs. Potential participants were in university courses offering formal integrative STEM teaching activities before they were asked to complete a survey. The students were informed about the purpose of the survey and that participation was voluntary and would not affect any academic evaluations. The initial sample consisted of 144 preservice junior high school science and technology (S&T) teachers from one of the three main educational institutions that educate preservice science teachers, a normal university located in northern

Taiwan. Preservice teachers wanting to become a S&T teacher must, first, successfully complete either the "Introduction to Science" or "Introduction to Technology" course and, second, apply for and successfully complete a middle school internship. There were 303 preservice teachers who applied for the S&T internship in the year that this study was conducted (Ministry of Education, 2013). Therefore, the sample (~47% of the specific year's S&T teaching candidates) was believed to be reasonably large and representative of S&T preservice teachers in Taiwan.

A series of activities was conducted in the Introduction to Technology course to help these preservice teachers implement STEM teaching. For example, one semester (3 hours weekly for 18 weeks) was devoted to providing detailed descriptions of STEM courses that allowed participants to develop an in-depth understanding of the practices, purposes, and values of STEM. Other activities (e.g., balloon cars, mousetrap cars, a throwing machine, sorting devices, and bridges) allowed teachers to experience STEM learning.

Participants were required to follow the design and production procedures provided for each activity and to apply STEM knowledge during all procedures to ensure the integration of theory and practice. After the students completed these activities, the researchers administered the STEM teaching intention questionnaire. The course was conducted twice each year to accommodate a reasonably large number of preservice teachers seeking to teach STEM.

Instrument

The questionnaire was developed according to the theory of planned behavior and the six variables, using a 7-point Likert scale (Ajzen & Madden, 1986). The 31-item questionnaire included four knowledge-related questions; five each on values, perceived behavioral controls, and behavioral intention; and six each on attitude and subjective norms. The items presented a positive-oriented statement related to the specific variable to which respondents expressed their level of agreement or disagreement (7 = very strongly agree … 1 = very strongly disagree). An expert panel of four professors in relevant fields and four junior high school teachers reviewed the questionnaire for its face validity; items were modified according to their input.

An exploratory factor analysis on pilot study responses (N = 172) was performed to review the structural validity (categories and content of questionnaire factors) and to eliminate questions or adjust question topics appropriately. Factor analysis was used to locate factors with eigenvalues greater than 1 and was followed by Promax rotation to maximize differences in factor loadings. After the second factor analysis, items that did not match the original factor structures and those whose loadings were < 0.3 were removed. A third factor analysis revealed six main factors with loadings > 0.4 for each item in the original structure: knowledge, values, perceived behavioral controls, behavioral intention, attitude, and subjective norms. Finally, the questionnaire's and the subscales' reliabilities were explored using Cronbach's α for internal consistency; analysis revealed acceptable α coefficients (DeVellis, 2003) for the subscales: knowledge = 0.79, values = 0.91, attitudes = 0.85, subjective norms = 0.80, perceived behavioral controls = 0.88, behavioral intentions = 0.86, and overall questionnaire = 0.94. Collectively, these psychometric results suggest that the questionnaire was of high enough quality for this low-risk study (see Appendix for questionnaire).

Data Collection

The study began in the first semester in which 61 preservice S&T teachers participated and 60 valid questionnaires were returned; it continued during the second semester in which 83 preservice S&T teachers participated and 79 valid questionnaires were returned; the final sample for analysis consisted of 139. Participants' descriptive characteristics for gender (60 males, 43.2%; 79 females, 56.8%) and their six disciplinary majors (16 physics, 11.5%; 11 chemistry, 7.9%; 34 life science, 24.5%; 13 earth science, 9.4%; 47 technology, 33.8%; 18 nonscientific majors interested in teaching science, 12.9%) were recorded for future consideration.

Data Analysis

The theoretical model was tested using a partial least squares (PLS) approach and structural equation modeling (SEM), also known as PLS path modeling (PLS-PM), because the sample was < 200 participants. PLS-PM, a component-based estimation method, utilizes an iterative algorithm that separately resolves the blocks of a measurement model and estimates the path coefficients in a structural model (Tenenhaus, 2008; Vinzi, Trinchera, & Amato, 2010). PLS-PM examined the path coefficients for the model of the participants' STEM teaching intention and analyzed the effects of latent variables in the model. At this point, the model-validation process comprises parameter inference, where the significance of estimated parameters is tested (Chin, 1998) and significant bootstrap parameter estimates are used to explore the path coefficients among latent variables in the structural model (Chin, 2010). Data from the 139 questionnaires were analyzed using independent samples *t*-test and one-way ANOVA to determine whether changes in independent variables (i.e., gender and major study area) had significant effects on STEM teaching intention. When the findings were significant, the Scheffe method was used as a posttest to assess differences in the independent variables.

Results

The results are reported with respect to the stated research foci. First, the model verification findings are reported; second, the strength of relationships among variables, identification of latent variables, and alternative model are reported.

A Theoretical Model of Preservice Teachers' STEM Teaching Intention

This study of the proposed behavioral intention model of preservice teachers in relation to STEM teaching and six variables were analyzed. The mean response (7-point scale), standard deviation for each variable, and correlation coefficients amongst the variables are summarized in Table 2. Correlations among the six variables were all significant ($p < 0.001$). Results showed that values, attitudes, subjective norms, and perceived behavioral controls might play important roles in establishing STEM teaching behavioral intention; however, the knowledge–intention correlation was noticeably lower. Inspection of the results revealed that the correlations between knowledge and other variables were low, with the knowledge–attitude correlation being the lowest. These correlations indicated low direct associations between these preservice teachers' knowledge about and other factors and intention toward STEM teaching.

Table 2

Summary of the Mean, Standard Deviation, and Correlation Coefficients of Questionnaire Variables (N = 139)

	Knowledge (K)	Values (V)	Attitude (A)	Subject norms	Perceived behavioral	Behavioral intention

				(SN)	controls (PBC)	(BI)
K	1					
V	0.33***	1				
A	0.30***	0.65***	1			
SN	0.32***	0.59***	0.58***	1		
PBC	0.43***	0.48***	0.39***	0.51***	1	
BI	0.37***	0.72***	0.58***	0.68***	0.68***	1
M/SD	5.06/0.93	5.64/0.84	5.58/0.78	5.29/0.80	4.78/0.93	5.16/0.84

Note. Questionnaire design used a 7-point scale.
***$p < 0.001$

PLS regression was used to test the proposed model's appropriateness for the behavioral intention toward STEM teaching in preservice S&T teachers. Since PLS does not provide a *p*-value, the bootstrap method was used to calculate the *t*-value where the *Z* distribution was applied as a standard due to the study's sample size (i.e., >120 participants) to suggest a level of significance with *t*-values greater than 1.96. Based on the bootstrap method that draws samples randomly from a pool and returns them before the next draw, 100 participants were extracted from the 139 total. This process was repeated until the hundredth participant was extracted; these 100 participants were then used to conduct analysis and obtain a set of estimated results. This operation was repeated 200 times to obtain a distribution of estimated results and the resulting *t*-value. The bootstrap procedure was used to compute standard error *t*-values of outer loadings, outer weights, and path coefficients (Table 3). *t*-values greater than 1.96 denoted significant path coefficients; that is, the direct and indirect effects for these teachers' behavioral intention toward STEM teaching can also be explored.

Table 3

Bootstrap Estimation of Variable Results

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	Standard error (STERR)	*t*-statistics (|O/STERR|)
A→BI	0.05	0.05	0.06	0.06	0.78
K→A	0.10	0.10	0.08	0.08	1.30
K→BI	0.00	−0.01	0.06	0.06	0.04
K→PBC	0.30	0.31	0.10	0.10	2.84*
K→SN	0.14	0.15	0.09	0.09	1.48
PBC→BI	0.36	0.37	0.09	0.09	3.77*
SN→BI	0.26	0.25	0.09	0.09	3.00*
V→A	0.62	0.62	0.08	0.08	7.83*
V→BI	0.36	0.36	0.10	0.10	3.54*
V→PBC	0.40	0.40	0.07	0.07	5.72*
V→SN	0.58	0.57	0.09	0.09	6.23*

*$t > 1.96$

PLS data analysis revealed that behavioral intentions, attitudes, subjective norms, and perceived behavioral control were explained effectively. A revised model (Figure 2) based on the estimated results illustrated several points concerning these teachers' STEM teaching behavioral intention. First, their STEM teaching behavioral intentions were significantly influenced by their subjective norms (t = 3.00), perceived behavioral control (t = 3.77), and values (t = 3.54) but their attitude did not affect behavioral intention directly. Second, their STEM knowledge did not directly affect behavioral intention although it could do so through perceived behavioral control. Finally, values had secondary impacts on behavioral intention that were mediated by subjective norms and perceived behavioral controls.

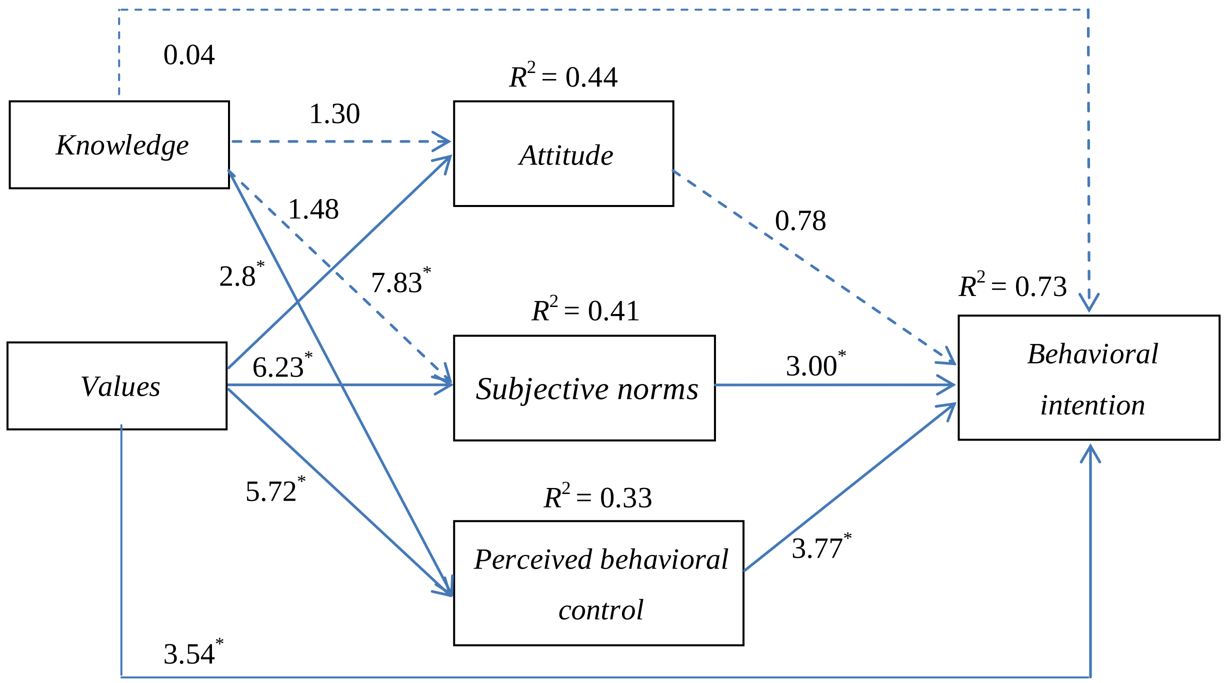

Figure 2. Behavioral intention: path to preservice teachers' STEM teaching intention.

These results demonstrated that these preservice teachers' values, subjective norms, and perceived behavioral control affected their behavioral intention directly. Therefore, if we expect to enhance the likelihood that STEM programs will be implemented as indicated by a preservice teacher's behavioral intention toward STEM teaching, then the focus should be on: (a) developing a positive appreciation regarding STEM teaching (values), (b) strengthening principals' and teachers' supports for implementing STEM teaching (subjective norms), and (c) developing preservice teachers' competency in resolving difficulties related to STEM teaching and instruction resources (perceived behavioral control). The revised model (Figure 2) provides a relational map of these variables that suggests points to consider for the future promotion of STEM programs and practice.

Differences in Demographic Factors in Relation to Differences in STEM Teaching Intention

The demographic effects on the questionnaire responses considered gender and disciplinary majors. These grouped results were described (i.e., mean response value and standard deviation) and tested (i.e., ANOVAs, *t*-tests) for each variable.

Gender differences. A series of independent-sample *t*-tests examined gender differences in STEM teaching factors and behavioral intention among the participants (Table 4). Differences in the mean responses for these variables were slight with mixed directionality; some favored females while others favored males. However, the *t*-tests revealed no significant ($p > 0.05$) differences between male and female teachers in the six variables, suggesting that gender had no effect on these teachers' intentions toward STEM teaching behavior.

Table 4
t-test Analyses of Male and Female Preservice Science Teachers' Behavioral Intention for STEM Teaching

	Male (*N* = 60)		Female (*N* = 79)			
Variable	*M*	*SD*	*M*	*SD*	*t*	*p*
Knowledge	5.2	0.85	4.95	0.98	1.61	0.11
Values	5.68	0.71	5.61	0.93	0.47	0.64
Attitude	5.55	0.78	5.61	0.78	−0.45	0.66

Subjective norms	5.19	0.76	5.36	0.83	−1.27	0.21
Perceived behavioral control	4.84	0.92	4.73	0.94	0.64	0.52
Behavioral intention	5.15	0.74	5.17	0.92	−0.14	0.89

Differences in major. The differences in STEM teaching behavioral intention among the preservice S&T teachers of six different specializations was explored with a series of ANOVAs to analyze cross-disciplinary main effects. ANOVA results (Table 5) revealed significant (p = 0.001) knowledge and perceived behavioral control main effects across different specializations. The significant knowledge main effect, $F(5,133) = 4.20$, p = 0.001, was explored using post hoc comparisons (i.e., Tukey's test) that revealed physics majors have significantly better STEM knowledge than did students in chemistry and in other nonscience disciplines. The significant cross-disciplinary main effect for perceived behavioral control, $F(5,133) = 4.20$, $p = 0.001$, was explored using post hoc comparisons and revealed that technology majors had significant greater perceived behavioral control than life science students.

Table 5

ANOVA Results of STEM Teaching Behavioral Intention across Participants' Specializations

	Physics (*N* = 16)		Chemistry (*N* = 11)		Life Science (*N* = 34)		Earth Science (*N* = 13)		Technology (*N* = 47)		Other (*N* = 18)			
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*-value	*Tukey's* test
Knowledge	5.63	0.66	4.50	0.77	4.88	0.96	5.31	0.72	5.23	0.93	4.57	0.89	4.20*	a>b a>f
Values	5.75	0.87	5.18	1.03	5.61	1.02	5.69	0.48	5.65	0.74	5.83	0.79	0.92	
Attitude	5.48	0.98	5.35	0.92	5.52	0.75	5.42	0.57	5.70	0.78	5.76	0.70	0.78	
Subjective norms	5.22	0.66	5.09	0.96	5.14	0.88	5.27	0.71	5.55	0.74	5.06	0.76	1.75	
Perceived behavioral controls	5.21	0.88	4.25	1.30	4.46	0.79	4.78	0.62	5.10	0.87	4.46	0.90	4.20*	e>c
Behavioral intention	5.16	0.72	4.84	1.03	5.04	0.92	5.23	0.66	5.34	0.89	5.07	0.64	0.98	

*p = 0.001.

Discussion

The results suggest that these Taiwanese preservice S&T teachers' STEM teaching behavioral intentions were mainly related to their values, perceived behavioral control, and subjective norms — not knowledge about and attitude toward STEM teaching. Preservice teachers apparently need to have positive evaluations of the effects of STEM teaching, believe that their education community stakeholders share these value-judgments, and need to have access to and control of the necessary instructional resources to implement STEM programs.

Bybee (2013) asserted that the effective promotion of STEM education could help students develop valuable skills for addressing 21st century issues. It is important to consider the access and management of resources when implementing STEM teaching during preservice S&T teacher education programs. Access and control of the instructional resources may be expensive and unavailable in schools that are less-well-funded or –equipped and where hands-on inquiry and design activities are not assigned high priority (Gura, 2012; Roberts & Cantu, 2012). When promoting STEM teaching, teachers are influenced by various members and factors of the education community (i.e., Ministry of Education officials, school administrators, other teachers), parents, and the public.

Therefore, educational authorities and school administrators need to explicitly support teachers in STEM implementation.

Surprisingly, not all social influences are directly connected to STEM programs. Huang (2012) noted that emphasis on the Taiwanese entrance examination has played a key role in many educational reforms; moreover, if school administrators, teachers, and parents continue to focus solely on low-level, knowledge-oriented entrance examinations, such behavior will inevitably and negatively affect preservice S&T teachers' implementation of STEM education. That is, preservice teachers may focus solely on teaching science knowledge for the entrance examination instead of trying to use interdisciplinary STEM teaching in developing students' engineering design, problem-solving, and higher-level thinking skills. Thus, if we can improve preservice S&T teachers' STEM values, perceived control of the needed resources, and teaching intention within a positive social context, then middle and secondary school students may have the chance to develop these skills.

Gender had no effect on knowledge, values, subjective norms, perceived behavioral control, attitude, and behavioral intention toward STEM teaching among these preservice S&T teachers. STEM teaching appears to avoid the long-known gender differential toward traditional science (e.g., physics education) programs that favored males. However, this finding was not supported by Price (2010), who found that teachers' gender and ethnicity impact on students was likely to continue in STEM curricula and that female students preferred female teachers. Hence, the presence of additional female teachers when implementing STEM teaching could boost female students' interest in STEM studies.

The effects of different specialties indicated some predictable relationships and may provide insights into the disappointing nonsignificant relationship between knowledge and intention. Preservice teachers majoring in physics reported better knowledge of STEM teaching compared with other disciplines, possibly reflecting the strong relationship of physics with technology, engineering, and mathematics and suggesting the need to provide nonphysics majors supplemental content knowledge about underlying physics-STEM concepts. Technology majors performed better than life science majors regarding perceived behavioral control, possibly because preservice teachers involved in technology courses experienced more flexible design, evaluation, and redesign laboratory activities with multiple or constrained materials. Consequently, when school funds are low, preservice technology teachers can more easily adapt laboratory activities (e.g., Lego Robotics, infection detection activities, kitchen tools, simulated design and refinements, etc.) based on the school's circumstances.

Conclusion and Implications

The theory of planned behavior was predictive of some direct effects: higher values, greater perceived behavioral control, and stronger subjective norms were associated significantly with greater STEM teaching behavioral intention. For the indirect effects, greater knowledge operating through subjective norms influenced stronger STEM teaching behavioral intention. Moreover, greater attitude toward STEM teaching was not directly associated with teaching intention and greater knowledge was not associated significantly with more positive attitude toward STEM, which in turn was not significantly related to STEM teaching intention. In short, for advancement of STEM, it is critical that teachers, teacher educators, and researchers understand the potential effects of the cognitive and affective network connected to STEM teaching intention. The centrality of values, social norms, and perceived behavioral control demonstrates their importance and that preservice S&T teachers need explicit educational experiences to enhance their values for STEM education, insights into accessing and enhancing stakeholders' normative priorities for STEM education, and management and acquisition of resources needed for implementing STEM teaching. Further research studies should explore the critical knowledge and attitude needed to directly or indirectly influence positive STEM teaching intention within the cognitive-affective network for STEM teaching practices. STEM teacher education programs must stress developing preservice teachers' behavioral intention toward STEM teaching and related socioaffective factors and not just emphasize developing their knowledge in science, technology, engineering, and mathematics. The most important factors appeared to include developing preservice teachers' (a) positive appreciation regarding STEM outcomes and teaching and (b) competency in resolving difficulties related to STEM teaching. Finally, STEM advocates (e.g., sponsors, change agents, etc.) need to promote subjective norms among parents, educational authorities, and school administrators that support educators in pursuing STEM teaching and de-emphasize an examination-based culture, which inevitably tends to marginalize activities that are not stressed or difficult to measure with traditional assessment techniques.

Lack of gender differences and the limited disciplinary influences among preservice teachers related to their STEM intention should inform teacher education and recruitment efforts. Hiring more female teachers could improve female students' interest in STEM and prove beneficial in future promotion of STEM teaching practices without affecting STEM intention. Owing to the greater knowledge and perceived behavioral control in physics and technology, greater emphasis should be placed on developing relevant concepts, technological design, and engineering practices in planning future STEM teacher education courses.

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Appendix: The Preservice Teachers' Integrative STEM Teaching Intention Questionnaire (7-point Likert Scale)

Knowledge Items

1. I am familiar with the Science knowledge in the middle school level (e.g., Newton's laws of motion).
2. I am familiar with the Technology knowledge in the middle school level (e.g., technological problem-solving process, material processing, tool using).
3. I am familiar with the Engineering knowledge in the middle school level (e.g., engineering design, mechanical structure).
4. I am familiar with the Mathematical knowledge in the middle school level (e.g., measure, calculation, analysis).

Value Items

1. I think it is important to help students in learning how to collect STEM-related data during the learning process.
2. I think it is important to help students in learning how to use STEM-related data during the design process.
3. I think it is important to help students in learning how to use STEM-related data during the test and modify process.
4. I think it is helpful to improve students' learning performance by guiding them in integrating STEM-related issues during the learning process.
5. I like to implement integrative STEM teaching activity.
6. I think it is helpful to teaching by caring for the STEM-related activities and news.

Attitude Items

1. I will implement integrative STEM teaching if media advertisements (e.g., newspaper, television) ask me to do this.
2. I will implement integrative STEM teaching if the school environment asks me to do

this.
3. I will implement integrative STEM teaching if my university professors ask me to do this.
4. I will implement integrative STEM teaching if my colleagues ask me to do this.
5. I will implement integrative STEM teaching if my educational ideas ask me to do this.
6. I will implement integrative STEM teaching if my students ask me to do this.

Subjective Norm Items

1. In the teaching environment, I think I have enough ability in implementing integrative STEM teaching.
2. I know how to improve students' learning performance through integrative STEM teaching.
3. I think it is easy for me to use my own STEM knowledge in implementing integrative STEM teaching.
4. I think I know how to propose STEM-based suggestions to students during the design process.
5. I think I know how to propose STEM-based suggestions to students during the test and modify process.

Perceived Behavioral Control Items

1. I will try my best to implement integrative STEM teaching in the future no matter what the future teaching environment is.
2. I will try to teach students in thinking how to propose their ideas according to their STEM knowledge during the design process.
3. I will try to teach students in thinking how to modify their product according to their STEM knowledge during the test and modify process.
4. I will try to remind students in solving problems according to their STEM knowledge instead of intuition.
5. I will try to collaborate with other teachers in STEM fields for implementing integrative STEM teaching.

Behavioral Intention Items

1. The integrative STEM teaching is helpful in developing students' ability in integrating theory and practice.
2. Students can have better performance in hands-on learning activity if they can integrate their STEM knowledge in the process of design and making.
3. Students can solve problems appropriately in their daily life if they can integrate their STEM knowledge in the process of problem solving.
4. Students can explore their interest in STEM fields through integrative STEM teaching.
5. We can develop future talents in STEM fields through integrative STEM teaching.