科技部補助專題研究計畫報告

台灣研究型大學STEM女學生的研究所求學經驗

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本研究具有政策應用參考價值：□否 ■是，建議提供機關教育部
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中 文 摘 要 ： 本研究目的為描述台灣就讀於科學、技術、工程與數學(STEM)領域的女生於研究所生涯的求學經驗。本研究以深度訪談蒐集資料，並以質性現象學方法分析資料。來自三所大學共二十位年紀介於24到35歲的女研究生被邀請參與訪談。資料分析浮現以下主題: 學習的過程、課業表現、STEM訓練影響自我發展、男學生與女學生的互動、性別刻板印象與學習表現、學習期望與專業表現、男教授對女學生學習的影響、特權與優惠引發的矛盾、女學生的生涯期待與發展及女性角色模範。本研究發現將有助於女研究生、教師、諮商員、學生事務專業人員與政策制定者瞭解女學生於絕大多數為男性且充滿男性化特色的STEM研究所的學習與發展經驗，並能依此制定並推行合乎女研究生特質、需求與期望的服務。

中 文 關 鍵 詞 ： 女研究生、STEM、研究所、經驗、學習、發展

英 文 摘 要 ： The purpose of this proposed study described the experiences of women Taiwanese STEM students during their graduate programs. Twenty graduate students between 24 to 35 years old) from three universities attended in the in-depth interviews. A qualitative phenomenological approach was used to analyze the data collected. Themes emerged from data analysis included: process of learning STEM, academic performance, the influence of STEM training on the self-development of women students, interaction with male and female students, gender stereotypes and learning performance, expectations of academic study and professional performance, influences of male professors on female students' learning, contradictory caused by privileges or preferential treatments, career expectations and development of women students, and role models of women students. The findings valuable for women STEM graduate students, educators, counselors, student affairs professionals, and policy-makers to comprehend women students' experiences in the STEM fields which are predominant by men and hold traditional masculine characteristics; and plan for, as well as, provide appropriate services in response to students' characteristics, needs, and expectations.

英 文 關 鍵 詞 ： woman graduate student, STEM, graduate school, experience, learning, development

The Woman STEM Graduate Student Experience in Taiwan

In the past 20 years, the number of graduate schools in Taiwan has increased by over two thousand and the number of graduate students has skyrocketed from forty thousand to near two hundred thousand (Ministry of Education [MOE], 2018). According to statistics by MOE, in 2017, a major portion (45%) of the graduate students in Taiwan is in the fields of Science, Technology, Engineering and Mathematics (STEM). Women graduates in STEM fields (not including chemistry, medicine, or biology fields) are only 25.57% and 14.83% among all master graduates and all doctoral graduates respectively. The MOE statistics also reported that 20.28% of masters and 40.05% of Ph.Ds. in the engineering fields; 29.57% of masters and 15.23% of Ph.Ds. in computer science, information engineering and/or communication engineering are women. Women STEM students are severely underrepresented when contrasting to 42.5% of all master students and 31.8% of all doctoral students are women (Hsu & Hsieh, 2017).

In Taiwan, clearly, there is a gender difference in major choice in higher education. Most men major in science, engineering, computer, agriculture, medicine, ecology, and technology related fields. This indicates that fewer women students choose to major in STEM domains and/or are capable of accomplishing the academic requirements in STEM fields. In the STEM related professions, fewer women are at the top of the corporate ladder; the higher the education and/or job position level, the lower the proportion of women (Hsu & Hsieh, 2017).

Lower ratio of women students in STEM fields, especially in graduate schools has a significant link to the fewer career women in STEM related jobs. In order to train more female STEM professionals, it is important to enhance recruitment and retention of women students by offering them the required resources, support, and learning environment. It has been a global trend to support women to study and work in STEM fields. For instance, the US Congress authorized the America Competes Reauthorization Act (2010) with additional stipulations to increase the number of underrepresented minorities (URM) in STEM fields (Gonzales, 2015). Some programs help women students to be more adapted to the STEM in a more friendly and resourceful learning environment. Taiwan government and academic society have noticed such phenomenon and have taken strategies to encourage women to study and work in the STEM fields through adjusting educational policies, systems, resources, and environment. Thus, it is critical to first understand their comprehensive, holistic, and multifaceted experiences in STEM graduate programs. Such overall picture can help us better explore the factors, interactions, and mechanisms affecting the process and outcomes. Teaching and counseling resources can be provided to meet their characteristics and needs. Suitable learning strategies, methods, and programs can also be developed for them to effectively conquer stress and challenges in graduate schools. Hence, they can achieve better results in learning and development to prepare for STEM related career after graduation.

Need for the Study

Living on a competitive campus, women STEM graduate students might suffer a high degree of stress from both academic study and personal life. To date, both scholarly literature and educational practice have voids in addressing their experiences and needs. This demonstrates that the academia holds a minority position. Their accomplishments, challenges, and overall experiences are dismissed. This study as a pioneer to focus on (1) how women STEM graduate students learn and develop; and (2) which conditions can help them not only improve persistence and completion but also achieve desired academic and individual outcomes.

Results of the study will provide valuable information about learning and development of women graduate students in the STEM fields. A better understanding of their experience of STEM graduate study for women and how the STEM graduate programs may impact on these students' matriculation can help university administrators, educators, and counselors assist students to complete graduate study with their strengths, improve factors unfavorable to learning and development, and hopefully lower the dropout rate and percentage of switching majors, so that women

students can attain better academic and career achievement. Officials can also develop plans to maintain and expand the female student population.

Thus, the purpose of this study is to describe and understand the experiences of women STEM graduate students by elevating their voices. A qualitative exploration of these students' experiences will be suitable for describing the characteristics of, capturing the components of, and providing a complete, comprehensive and overall picture of how they live and manage their graduate programs. Research questions include the following: What and how do Taiwanese women STEM graduate students perceive their experiences in graduate study? What are the factors, interactions, and mechanisms related to the process and outcome of women students' learning and development in STEM graduate schools?

Women Graduate Students in Taiwan

Academic stress is viewed as the top stressor among graduate students in Taiwan (Aiou, 2005; Chang, 2005; Hsieh, 2007; Huang, 2005). Taiwanese graduate students rank self-development and self-evaluation of academic achievement as the most stressful aspect of being in graduate school (Hsu, 2003) and suffer from a high level of stress from the role expectations as a graduate student (Lin, 2005). Several studies have shared the experience of women graduate students. Chen (2006) mentioned that she had experienced pain, despair, anger, and sadness as well as joy, braveness, motivation and effort in her graduate study. She felt that pain was actually a source of strength during her graduate study. Li (2009) described the life transformation of a woman graduate student, from confusion, distrust, and heart-searching, let go, self-examination, to eventually interpreting life in a whole new way.

Wu (2014) explored her own experience of searching the meaning of life during graduate study. She interpreted her life story from different angles and was able to gain strength and grow from the self-searching process. She described her own experience of improving relationship with her mother during graduate study, and how she finally understood her positioning through conflicts and complaints. Lai (2008) presented her own story of being a woman graduate student and her experience of facing the dark experience in life and eventually clarified the meaning of life and developed self-identity through writing and actions. Ho (2007) looked back at her life experience and compared her past and present self to gain the view of self, as a result, she was able to confront with challenges in life.

Women students may face the dilemma among many roles in pursuit of academic and personal achievement. Wu, Wu, and Hsia (2013) explored the experiences of women with multiple roles in their doctoral study. Data collected from in-depth interviews from three women doctoral students with at least one child in school. After thematic analysis, the results revealed that reasons for seeking doctoral degree included (1) the demand of job, (2) self-actualization, (3) the expectations of family, and (4) peer inference. Several obstacles during the doctoral study consisted of: (1) conflicts in motherhood, (2) changes in marital relationships, (3) reduction in work quality, (4) the pressure of academic learning, (5) the impact on health, and (6) time management. Participants managed their doctoral career through: (1) seeking external assistance, (2) seeking external psychological resources, (3) proper time planning, (4) cognitive coping strategies, and (5) self-encouragement.

Only very few studies focused on the topics of women graduate students' time management in juggling between marriage, family, motherhood and graduate study can be identified. Wu (2004) discussed study, employment, and motherhood of women graduate students who were working and with kids and presented the life experience, multiple roles and empowerment of these students through writing. Wu emphasized that they were under great pressure and learned how to self-adjust to adapt to the busy life of graduate study. Chu (2013) explored the adjustments made by married women graduate students. They had to face various assistance and resistance from marriage, reach consensus and gain support from significant others, adjust pace of study and life, and find the balance point under conflicts of multiple roles. Liao (2014) examined time management issue of women graduate students as they had juggled

multiple roles. They had to set priorities, actively engage in academic study, leverage learning resources, and gain support from family members to better allocate their time.

Women Graduate Students in Other Countries

More women students than males enrolled at both the undergraduate and graduate level in the United States (National Center for Education Statistics, 2018). However, in many fields, women graduate students are more likely to leave before completing their doctoral programs, to end their graduate educations after acquiring master's degrees, or to consider withdrawing from graduate education before having their degrees. Although women perform at the same levels, they tend to have less confidence in their abilities and individual accomplishments than men (Cohoon, 2001).

Moyer, Salovey, and Casey-Cannon (1999) invited 224 women in the life sciences, social sciences, and the humanities to describe their most important professional and personal concerns. Results revealed (1) concerns involved practical issues such as finding employment, financial stability, and growing professional expertise, and (2) elaborated wide-spread concerns about a competitive academic climate. Women graduate students with high levels of self-reliance/self-assurance entitlement are able to associate positive feedback with stable internal attributes; those with anxious attachment and narcissistic expectations and/or self-promotion entitlement are less likely to openly accept positive feedback because of perceived deficits in self-worth (Gibson-Beverly & Schwartz, 2008).

Schmidt and Umans (2014) explored how female doctoral students experienced and perceived their well-being at a Swedish university. Three main themes revealed: being true to oneself, being in the sphere of influence, and performing a balancing act. This study showed that perceptions and experiences of well-being in women PhD students could be a multifaceted phenomenon and materialized through interaction of different aspects of "self" (agent) and "others" (structure).

Mehta, Kenner, & Shrier (2013) explored the perceived advantages and disadvantages of being women graduate students who pursued master's degrees in psychology or social sciences in the USA and the UK. They reported that advantages consisted of being the minority in their fields and receiving more compassionate treatment from faculty; and shortcomings comprised being viewed in stereotypical or conventional gender roles and receiving undesirable sexual attention.

Many women graduate students are juggling multiple professional, family, civic, religious, and social responsibilities in addition to their graduate work. Aiello (2017) investigated how women with children, who are employed full-time, made sense of their experience of pursuing a graduate degree. Participants reported that they were struggling in the responsibilities of their multiple roles and often felt not fully meeting the responsibilities of any. Many of these students had concerns around the capability to be a properly parent, and felt guilty and concerned over the impact this academic striving would have on their children. Various support systems are necessary for them to cope with these challenges. A study on medical and science graduate students (Toews et al., 1997) reported that women students were struggling with multiple demands of their time and attention; however, male students in these same programs did not reveal these role struggles and showed lower levels of stress.

A qualitative study by Brown and Watson (2010) interviewed eight women on the gender impact on their doctoral study experience. They claimed that being a mother had profound implications for doctoral-level study. Results showed that (1) the timing of study was dictated by domestic demands; (2) balancing home and academic life was a source of great stress; (3) participants were torn between their roles as wife/mother and student; and (4) attendance at conferences was problematic. Participants noted that gender has an impact on the supervisory relationship. Although all of them had a male supervisor, they did not report dissatisfaction with the supervision received.

Aryan and Guzman (2010) explored the experiences of women of color in doctoral programs. They emphasized

that the processes of constructing the meaning of discriminating factors hindered their experiences in graduate programs. Attending formal support programs geared towards doctoral students of color can help them counteracting these experiences. Le, LaCost, and Wismer (2016) claimed that women international graduate students have to negotiate multiple aspects of their identities as non-native learners and women in a society with different gender norms than their home countries. The seven participants with diverse backgrounds revealed their educational experiences in the U.S. as a positive, life-changing, and transformative experience.

Rayle et al. (2006) focused on the mentoring experiences of women faculty members and students in a counseling psychology graduate program. This study focused on specific mentoring needs and wants of women graduate students to add greater depth to the existing knowledge about how women succeed and grow in mentoring relationships. Findings supported the importance of relational mentoring relationships and investment by mentors. Results suggested that women graduate students and faculty members share common views regarding mentoring relationships in higher education. This is especially true regarding what women desire in their mentoring relationship.

Koo-Ljungberg and Hayes (2006) examined how faculty mentoring influenced the transformations of 10 women graduate students' relational selves and their professional identities as researchers and scholars. Participants reported that effective mentorships often resulted in collaboration on research projects, as well as shared decision- and meaning-making. Effective mentoring led to the development of the students' research skills while concurrently building their professional and academic selves. Participants revealed their experiences of mentoring brought them into the scholarly society and ensured their competence as researchers and academics, which, sequentially, altered their larger sense of self.

Schroeder and Mynatt (1993) explored women graduate students' perceptions of their interactions with male and female major professors. They reported that, compared to those with male major professors, those with female major professors gave significantly higher ratings to the quality of interactions with their professors and to the professors' concern for their welfare. Results of this study showed that those with male major professors had the greatest number of negative psychosocial comments and met with their major professors in the fewest number of nonacademic environments.

The aforementioned studies highlighted that women graduate students possess unique characteristics within the educational contexts. They are often struggling between the responsibilities of their multiple roles. Their major concerns are finding employment, maintaining financial stability, developing professional expertise, and surviving in a competitive academic climate. Those with self-reliance and/or self-assurance tend to associate positive feedback with stable internal attributes. They also identify the importance of effective mentorships often resulted in better development of their research skills and forming their professional and academic selves.

STEM Students in Taiwan

Academic learning, experimental research, financial conditions, and time management are the major stressors for graduate students (Hsu, 2003). STEM students in Taiwan are the majority of graduate student population. Men, as the majority of the population in the STEM field, have traditionally played a dominant role. As a result, an atmosphere of masculine competition and a hierarchy of authority is prevalent. Most STEM graduate students have to conduct experiments in a lab. Lab leaders are thesis advisors, post-doctoral researchers, or senior doctoral students who lead students to work on experimental projects. Han (2009) examined power and meaning of gender in science and engineering laboratories by comparing experience of men and women graduate students. She regarded laboratory as a place for gender differentiation, the process of learning to be a scientist or engineer was also the process of gender differentiation. Laboratories were dominated by men and were operated under masculine approach for interaction, teacher-student relationship, technological risks and trainings. Such masculine culture in the laboratories was

presented through materials, statements and experiments. Eventually, graduate students were influenced by such mainstream masculine culture in the laboratory settings.

In Taiwan, there is a clear gender difference in major choice in higher education—with most men majoring in STEM and most women in humanities (Chen, 2002). STEM students in Taiwan are the majority of graduate student population. Men, as the majority of the population in the STEM field, have traditionally played a dominant role. As a result, an atmosphere of masculine competition and a hierarchy of authority is prevalent. Liu (2001) investigated process and factors of career changes of female STEM bachelor degree holders and found that their major choices were made because of "personal interest," "school and department ranking," and "test scores," "expectation of family and parents," "impact of other people," and "impact of significant events." For those who had changed their career path from STEM to non-STEM jobs, their choices were made because of "frustration from academic study or work," "career satisfaction level," "impact and support from other people," "opportunities present themselves," and "personal traits." Women's career development is often restrained by negative notion, which in turn developed lower anticipation of self-efficacy. In addition, stereotypes of gender identity and roles, occupational gender stereotypes, and gender discrimination reinforced the internal career barriers (Liu, 2001). Compared to men, women value more on marriage and family, and thus are constantly juggling between life and work, and eventually affected their career development negatively (Liu, 2001).

Wang (1990) discussed factors of selecting non-traditional career paths among 407 women university students. Their career choices were supported by parents, friends, and siblings. Yang (2002) explored the developmental context of career themes of the female undergraduate students who study in non-traditional fields of technology program. Participants revealed that reasons for selecting to study in non-traditional fields include "learning something I like," "never worry about money again, furthermore, to improve parents' living quality," and "by no means to fall behind others." This study supported the cultural context affects the process of female students' career decision-making in Taiwan.

Hsu (2000) explored career selection factors and coping process of six women working in agriculture, engineering, law enforcement, and technology. She reported that the participants were educated about the gender stereotypes since they were little. They had common personal traits such as persistent, independent, and brave; thus, they were able to select the non-traditional career paths. Key factors for them to choose non-traditional occupations include: (1) personally—interest toward the occupation, recognition toward future career path, and self-cognition; and (2) socially—changing times, updated laws and regulation, encouragement from teachers, and recognition from supervisors. However, social stereotypes, vague definition of women professional roles, and disadvantaged promotion system for women were factors weakening their development in non-traditional occupations. The initial factor for them to select non-traditional professions for women was the impact of family of origin; for married women, support from spouse and family-in-law became the critical factor. Women adjusted themselves as needed, did their best to meet occupational requirements, boosted productivity with better time management, sought help, and engaged in teamwork for coping.

Women STEM Graduate Students Worldwide

Women in STEM fields often suffer from stress and encounter a number of obstacles. Thus, like water in a leaky pipeline, women tend to leave STEM fields at every point from recruitment to attrition after graduation (Goulden, Mason, & Frasch, 2011). STEM engagement is defined as "the academic and social variables that are essential not only for retention but also for sustained investment and satisfaction in STEM fields" (London et al., 2011, p. 305). Some essential issues (e.g., stereotypes, biases, campus culture, classroom experiences, identity, and sense of belonging) had been recognized to have an impact on women's engagement in STEM fields (Blackburn, 2017). These

psychosocial variables and/or contextual factors that might undermine women's engagement in STEM fields are elaborated below.

Institutional Chilly Climate, Social Support, and Sense of Belonging

The institutional climate and lack of social support could be the key factors for the losses of women from graduate programs in science and engineering (Betz, 1994). Many women report a hostile and unwelcoming environment at a department, college, or institutional level in their STEM fields, which eventually harms their sense of fit and belonging (Brainard & Carlin, 1998; Hill et al., 2010; Settles et al., 2006). Women STEM graduate students often report unapproachable faculty, poor advising, and feeling threatened (Brainard & Carlin, 1998). Among those not highly identified with the field, feelings of belonging are a better predictor of women's interest in STEM than their concerns on negative stereotypes about their abilities (Cheryan & Plaut, 2010). Women often express feeling out of place in the male-dominated fields, such as STEM. After surveying 1152 adolescent participants in four schools, Rice et al. (2013) reported that (1) those who had perceived greater social support for math and science from parents, teachers, and friends had better attitudes and revealed higher perceptions of their abilities in those fields; and (2) social support had both a direct effect on math and science perceived abilities and an indirect effect mediated through math and science attitudes.

Mentoring

Most science and engineering faculty are male and tend to be accustomed to male students. They often prefer to be mentors to male rather than female students (Betz, 1994). Mentoring is a significant element in the success of women and persons of color in STEM and it offers information and guidance to assist student development (Frierson, 1998). Downing, Crosby, and Blake-Beard (2005), 90% of women science undergraduates had a guide (e.g., mentor, role model, or sponsor). The importance of supportive mentoring relationships for STEM success had been proved (e.g., Smith, 2005). Women and ethnic minorities often lack the opportunities to gain support and mentorship or have poorer mentoring relationships (Ferreira, 2003). The lack of good mentorship for women graduate students can lead to being excluded from informal and flexible interactions (e.g., working with a faculty to complete research, working as a research assistant, co-presenting at a conference) (MIT, 1999).

Primé et al. (2015) noted that advising (mentoring) relationship has been shown to be especially crucial for women in STEM. They reported that instrumental and psychosocial support from advisors (mentors) are two salient factors. Mentors were identified as the most influential in the women's pursuit of science as a career (Fried & MacCleave, 2009). Positive faculty mentoring is important for graduate students, especially for women and minority student, and is essential for student success and cultivation of new scholars. For women students, by having a supportive mentor in STEM, positive mentoring may signal that their gender and the pursuits in STEM career are well recognized.

Gender Stereotypes and Sociocultural Stereotypes

The presence and persistence of gender biases and negative stereotypes of women within many STEM fields existed. Women in STEM face stereotypes, discrimination, biases, chilly campus climates, and stifling classroom experiences (Kuntz, 2009; Litzler, 2010; Walton et al., 2015). A long-held belief remains pervasive that women are less naturally gifted, skilled, and represented across STEM fields (e.g., Steinpreis et al., 1999; Reuben et al., 2014). The belief creates a context of threat and alienation that has been shown to damage their career development.

After examining the graduate school experience of an ethnically diverse and highly successful group of 63 women with Ph.Ds. in science and engineering fields between 1980 and 1990, MacLachlan (2006) found these women overcame obstacles in the form of sexism and racism to gain their degrees. Miller et al. (2015), examined data from more than 350,000 participants in 66 nations, reported that implicit stereotypes of women in STEM have been strong.

These biases and negative expectations (e.g., sexism, racism, stereotypes) women encounter in STEM are often prevalent at both the peer and faculty level.

A key issue encountered by many women in the nontraditional fields is a sense of mismatching between their gender and the fields they are pursuing (London et al., 2011; Rosenthal et al., 2011; Settles et al., 2009). Covert bias among science faculty could cause them to favor men over women in evaluating students' STEM ability; a self-fulfillment with gender stereotypes (Moss-Racusin et al., 2012). Sometimes, implicit biases might be manifested in overt behavioral discrimination (e.g., in the case of hiring or admissions decisions that favor men over women). Those are the messages for women in the STEM fields that they are undervalued in and unsuited for their chosen career because of their gender.

Furthermore, weak mathematics ability is another well-documented cultural stereotype that women in STEM have to battle with (Bench et al., 2015; Luong & Knobloch-Westerwick, 2017). Stereotypes about people who are interested in STEM abound in popular culture, making this one of the biggest obstacles for women (Moss-Racusin, Molenda, & Cramer, 2015; Ryan & Branscombe, 2014). Negative stereotypes and expectations of women's abilities and fit in STEM influence the larger culture of STEM by defining notions of who belongs, who is expected to be successful, and who is valued in a given field (e.g., Knobloch-Westerwick et al., 2013; Leslie et al., 2015). Women in STEM often struggle with the negative stereotypes that suspect on their abilities to perform well (Spencer, Steele, & Quinn, 1999).

The fear of confirming these negative stereotypes, namely, stereotype threat (Steele, 1997), causes women who are personally identified with the STEM field to underperform (Schmader, Johns, & Forbes, 2008) and then dis-identify with the STEM fields (Murphy, Steele, & Gross, 2007). Stereotype threat occurs when individuals fear that they will confirm to the negative stereotype of a group to which they belong (Cheryan et al., 2017). This threat is documented in women's performances in masculine stereotyped fields (O'Brien et al., 2015). Too feminine appearance may signal women are not be well suited for science (Banchefsky et al., 2016); thus, they may choose to downplay their gender as a way to conform with the environment, situational context, and immediate goals in STEM (Goldman, 2010).

Women's discouragement from STEM might be influenced by the current stereotypes of the STEM people as unsociable and preoccupied with technology (Barbercheck, 2001). STEM stereotypes are a warning to women because they are perceived as masculine and mismatched with the woman gender role (Cheryan, Plaut, Davies, & Steele, 2009; Diekman, Brown, Johnston, & Clark, 2010). These negative stereotypes perceived by women continue to hinder their recruitment in math, science, and engineering fields, negatively affect their academic performance, and restrain their retention and advancement in STEM fields (Beilock et al., 2007).

Role Models

Role modeling, according to Settles et al. (2007), is one among several levels of support in a broader framework of mentoring. Exposure to successful STEM role models predicts greater engagement and investment in the fields, particularly among women (Rosenthal et al., 2013; Stout et al., 2011). Women mentors tend to serve as role models and provide psychosocial support (Fried & MacCleave, 2009). Fried and MacCleave examined the source, nature, and degree of influence of role models and mentors on women graduate students' choice of science as a career. Their findings revealed that role models and mentors influenced students in distinct ways, and significant differences were found in gender, area-of-study, and undergraduates' country-of-origin.

Same-gender role models might bring positive impact on women. Women role models can protect women who are greatly identified with STEM against the destructive effects of negative stereotypes (Stout et al., 2011). Women who have identified with math performed significantly better on a math test when they had a woman role model than a

male one (Marx & Roman, 2002). Compared to taking a calculus course with a male professor, women who were with a female professor had better implicit math self-concept and attitudes toward math (Stout et al., 2011). Women who read about a successful female graduate of their university who majored in the same field as them rated themselves higher on success-related traits when the role model was a male (Lockwood, 2006). Lockwood (2006) assessed the impact of gender-matched and mismatched career role models on the self-perceptions of female and male participants and investigated female and male participants' description of a career role model who had inspired them in the past. The results of both studies indicated that women participants were more inspired by exceptional female than male role models. Women role models have been reported being effective for woman student recruitment and retention by improving their performance and sense of belonging in STEM fields (Drury, Siy, & Cheryan, 2011). Lack of women role models has been reported as a possible reason for women not persisting in their pursuit of STEM careers (Ehrhart & Sandler, 1987).

Campus Culture, Curricular Requirements, and Classroom Experiences

Women STEM students may be the only or one of a handful women students in class and/or the department. These women students may have to acclimate to a traditionally masculine culture (Baxter, 2010) or pay a femininity penalty (Simon, Wagner, & Killion, 2017). Obstacles for women pursuit of STEM degrees and/or careers include administrative polices (Bancroft, 2014; Hopewell et al., 2009), lack of research opportunities (Hernandez et al., 2013), lack of diversity (Vazquez-Akim, 2014), curricular requirement (DiPrete & Buchmann, 2013), and class size (Fischer, 2017). All these barriers could occur across various institutional levels. The campus culture or departmental climate per se could be a barrier (Hurlock, 2014). Curricular constraints in STEM majors may enhance gender differences.

Women are more likely than men to reveal stronger preferences for a liberal arts curriculum and to perceive their wide-ranging educational goals to be conflictual with the curricular requirements of certain STEM majors (DiPrete & Buchmann, 2013). Hartman and Hartman (2009) emphasized that (1) competitive, impersonal pedagogy is less woman-friendly than cooperative, group-oriented learning; (2) a discriminatory interpersonal or chilly climate for women where they are a minority and perceived in other negative stereotypes of women in STEM discourage them from pursuing such careers; and (3) women are under social pressure to conform to more traditional expectations in terms of career and family. Women reported some obstacles to complete STEM curriculum, such as heavy course loads, lack of connection between material and application, and perceived lack of academic skills (Vazquez-Akim, 2014).

In addition, the psychosocial environment of classrooms can make a difference in how comfortable a female student finds the overall learning atmosphere (Corbett & Hill, 2015). Women students who felt demoralized in a competitive environment (e.g., classrooms, department, institution, campus) tended to switch majors (Shedlosky-Shoemaker & Fautch, 2015). Regarding classroom experiences, women might encounter gendered issues, such as normalizing masculinity characteristics, while marginalizing and/or diminishing other gendered features.

Self-efficacy and Scientist Identity

Women, even they perform at the same levels, reveal less confidence in their abilities and individual accomplishments than men (Cohoon, 2001). Women students are often less aggressive than males in promoting themselves, trying new or challenging activities, and applying for awards or fellowships (Cuny & Aspray, 2002). Even they have similar or higher grades than their male colleagues, women report lower levels of self-efficacy in math, engineering and physics (Huang & Brainard, 2001). It is possible for women students to transfer out of engineering due to feelings of incompetence (Farver & Gattis, 2006).

With the threats and negative experiences that women often encounter in STEM fields, they may begin to doubt their own ability and whether they fit in STEM. These doubts might damage their identities as scientists. Particularly,

stereotype threat has negative impacts on women's science identity through the effects on perceptions about the communal utility value of science (Smith et al., 2015). Women perceive both the underrepresentation of women in the STEM areas and the messages from STEM representatives (e.g., professors, male peers) as they are not cherished as scientists. All the aforementioned situations might hinder the development of women's scientist identity and self-efficacy because they have to go through the judging processes by individuals who question their competence and belonging in a STEM domain (London et al., 2011; Rosenthal et al., 2011, 2013).

The above literature review highlighted women STEM graduate students need social support, a positive department/institution climate, and a sense of belonging on campus. This sense of belonging and fit could strongly predict their interest in STEM. They need to enhance differential socialization of STEM competencies and build self-efficacy and identity. Positive role models (i.e., successful women in STEM) may signal to women that their gender and their pursuits of STEM career are well-matched. However, women STEM graduate students encounter various obstacles: (1) negative individual and sociocultural stereotypes, sexism, prejudice and/or discrimination about women in STEM; (2) as minorities in the fields; (3) lack of social support, role models, mentoring, self-confidence, and/or self-efficacy for the pursuit of these fields; and (4) role conflict between career and family. Women students need a contextual and relational lens for understanding their learning and development in the STEM fields. Their learning and development could be conceptualized through the lens of relational cultural theory (RCT) and self-authorship. Thus, the notions of RCT and self-authorship will be adopted as references for this study.

Relational-cultural Theory

Relational-cultural theory (RCT) posits that people develop more fully through connections with others. Relationship, rather than autonomy, is the basis of growth. According to RCT, people become relationally complex rather than increasingly individuated and autonomous. It promotes a contextual and relational lens for understanding human development. It proposes that connection and context, rather than individuation and separation, are the basis on which development can be measured (Jordan, 2000, 2001).

Core Elements of RCT

Jordan (2000, p. 1007) summarized RCT fundamental principles as: (1) people grow through and toward relationship throughout the lifespan; (2) movement toward mutuality, rather than movement toward separation, characterizes mature functioning; (3) relational differentiation and elaboration characterize growth; (4) mutual empathy and mutual empowerment are at the core of growth-fostering relationships; (5) in growth-fostering relationships, all people contribute and grow; development is not a one-way street; (6) therapy relationships are characterized by a special kind of mutuality; (7) mutual empathy is the vehicle for change in therapy; and (8) real engagement and therapeutic authenticity are necessary for the development of mutual empathy. These principles support that people desire connections. In growing through disconnections to reconnection, and in distinguishing between growth-fostering connections and toxic or abusive relationships, people become more relationally competent. Some of key RCT concepts are elaborated below to clarify these core principles.

Growth-Fostering Relationships

When people are involved in growth-fostering relationships, each party's growth and the relationship itself become the priority (Miller & Stiver, 1997). A growth-fostering exchange means one person expresses thoughts and feelings to another; the other person is empathic and responds with his or her own thoughts and feelings, adding something more (Miller, 1986). As this exchange lasts, each expression of thoughts and feeling creates a progression or flow, enlarging and expanding the feelings and thoughts of both people. Both people build a good relationship through the exchange process. Growth-fostering relationships are characterized by mutual empathy and relational authenticity, and result in mutual empowerment. The five good things characterize the outcomes of these "good

relationships": (1) zest, (2) clarity, (3) sense if worth, (4) productivity, and (5) a desire for more connection (Miller & Stiver, 1997).

Mutual Empathy

Empathy is a complex affective and cognitive process that involves understanding the experiences of others and resonating with their feelings (Jordan, 1991). The affective component entails feeling the other person's emotions (Jordan, 2000). The cognitive process entails gaining both awareness of the source of the emotional arousal and clarity about one's own experiences and feelings as compared to the experiences and feelings of the other (Jordan, 2000). Empathy creates increased awareness and clarity about the meaning of another's experience (Jordan, 2010).

Authenticity

Authenticity refers to the capacity to fully embody ourselves genuinely in relationships (Miller, Jordan, Stiver, Walker, Surrey, & Eldridge, 2004). According to RCT, the notion of authenticity is essential to growth. People become more able to know, understand, and express their own feelings and thoughts when being authentic to the others in their lives (Miller & Stiver, 1997). Power differentials, particularly harmful abuses of power, inequities in gender and cultural experiences, socioeconomic status, health, and other factors can weaken our capacity to validly symbolize ourselves. These experiences may lead to patterns of disconnection that impede authentic relationships, connections, and growth.

Relational Resilience

Relational resilience involves movement toward mutually empowering, growth-fostering connections in the face of adverse conditions, traumatic experiences, and alienating social-cultural pressures. Resilience is the ability to connect, reconnect, and/or resist disconnection (Jordan, 2005). According to RCT, resilience has the following traits: (1) From individual "control over" dynamics to a model of supported vulnerability; (2) From a one-directional need for support from others to mutual empathic involvement in the well-being of each person and of the relationship itself; (3) From separate self-esteem to relational confidence; (4) From the exercise of "power over" dynamics to empowerment, by encouraging mutual growth and constructive conflict; and (5) From finding meaning in self-centered self-consciousness to creating meaning in a more expansive relational awareness (Jordan, 2004, p. 32).

Relational Competence

As individuals become progressively resilient, they grow their relational competence. Relational competence involves moving toward mutuality in relationships (Jordan, 2004). People care about one another and learn from their experiences with each other. While being open to the influence of others, people think of the influences they have on others. They are willing to be open and show mutuality rather than power-over relational approaches (Jordan, 2005). Research refers the support for the relational constructs of authenticity, mutuality, and power (Duffey, Haberstroh, & Trepal, 2009).

RCT focuses on a contextual and relational lens for understanding human development. The theory stresses all growth occurs in connection, that all people yearn for connection, and that growth-fostering relationships are created through mutual empathy and empowerment. It can be employed to understand the experiences of all groups, particularly those who are marginalized due to power and privilege imbalances (Jordan & Hartling, 2002). Thus, RCT is suitable for comprehending women STEM graduate students' development and growth because they are minority and inclined to suffer from stress of competition, autonomy, independence, hierarchy, and authority in the STEM fields that dominated with masculine characteristics. Therefore, in this study, the notions of RCT's eight fundamental principles, five good things, and growth-fostering relationships will be utilized as references for comprehending female STEM graduate students' experiences.

Self-Authorship

Self-authorship is defined as the ability to collect, interpret, and analyze information and reflect on one's own beliefs to form judgments (Baxter Magolda, 1998). Baxter Magolda highlighted a number of developmental tasks for the decade of people in their twenties. During this time, three major questions take precedence: "How do I know?" "Who am I?" and "How do I want to construct relationships with others?" (Baxter Magolda, 2001, p. 15)

Young adults in the journey toward self-authorship go through four phases evolving from external to internal self-definition (Baxter Magolda, 2001). In the first phase (following formulas), young adults follow the plans laid out for them by external authorities about what they should think and how they should accomplish their work. As individuals progress along their journey, they enter the second phase, "crossroads." They discover that the plans they have followed do not necessarily work well; thus, they need to establish new plans that better suit their needs and interests. Relationships are the focus of the crossroads as individuals attempted to resolve tension between what they wanted and what others wanted or expected. A clearer sense of direction and more self-confidence marked the end of the crossroads. They gradually enter the third phase of become the author of his/her life—creating the ability to choose and stand up for their own beliefs (especially when facing conflict or opposing views). In the final phase, people build internal foundation which is based in their self-determined belief system, in their sense of who they are, and the mutuality of their relationships.

Three elements of self-authorship have been identified by Baxter Magolda (2008; 2009): trusting the internal voice, building an internal foundation, and securing internal commitments. Trusting the internal voice involves people realized that while they cannot always control external events, they do have control over how they can think about and respond to those events; they are becoming more confident of their internal voices. Once they have learned to trust their internal voices, they begin building an internal foundation as a personal framework to guide their actions (Baxter Magolda, 2008). When people have achieved the third element of self-authorship, securing internal commitments, they will feel that living their convictions is as natural and as necessary as breathing (Baxter Magolda, 2008). They will have a sense of freedom to live their lives authentically by integrating their internal foundations with the realities of their external worlds.

Moreover, Baxter Magolda (1998), in a study of exploring 16 graduate students' development during graduate school, noted that three phases of development: exploring multiple perspectives, doing what feels best, and struggling toward self-authorship. Students learn to access as many perspectives as possible through focusing on class discussions of the readings (focused on learning) and know that perfect understanding of the final view is not possible. They engage themselves in the process of exploring multiple perspectives and build arguments to promote self-authorship.

In contrast to constructing arguments about issues, some graduate programs focused on experiencing work as a method to reach one's perspective. This experiential emphasis is evident in both classroom and internship dimensions of students' graduate work. These graduate programs support students toward self-authorship through focusing on forming their own theoretical basis via experience. Students should try various approaches and determine which ones fit best for them. Their needs for clarity on "what the arguments are both ways" implies that students are moving toward evaluating evidence to decide on their stance. The experiential component of graduate programs, along with processing that experience with faculty, helps students move in that direction. Students' professional work in graduate program helps to promote their self-authorship.

These educational practices in graduate programs engaged students' emerging independent knowing and the conditions for further development. Learning environments of graduate schools offered students practice in exploring many perspectives. Meanwhile, students become aware of the central assumptions of contextual knowing, namely using evidence within a context to formulate one's own perspective. Students moved into contextual knowing in terms

of understanding that some knowledge claims are better than others, that this judgment depends on evaluation of evidence in a context, and that one must support one's judgment by articulating this evidence.

These programs create conditions for self-authorship through teachers' assumptions about knowledge, their assumptions about students, and how they act on the two sets of assumptions to create teaching practice. An analysis of these three factors and their effect on students' self-authorship creates a structure for promoting self-authorship in graduate education. The graduate learning environments employed the three principles for promoting complex ways of knowing: validating students' ability to know, situating learning in students' experience, and engaging students in mutually constructing meaning (Baxter Magolda, 1992). Most of these students in these programs further developed self-authorship in their work experience after graduate school. Four dimensions of self-authorship had been addressed by Baxter Magolda (1996): trusting one's ability to make knowledge claims, establish priorities, and commit to both; the emergence of a solid sense of confidence to direct one's life; learning to balance external forces with one's own perspective and knowledge; and developing an internal identity that supports acting on one's knowledge and priorities.

In brief, the development of self-authorship among women graduate students could be viewed as: (1) knowledge is existing in a context, constructed by individuals, from multiple perspectives; and (2) women graduate students are able to read the material in the field of study, processing its multiple perspectives, thinking about the material for themselves, and developing their own perspective in light of the contexts under study.

Rationale of This Study

The author integrates the characteristics of RCT and self-authorship to formulate the rationale of this study. Women's learning and development could be viewed through the lens of RCT and self-authorship. Men, as the majority in STEM, often emphasize traditional masculine characteristics such as hierarchy, competition, individuation, separation, autonomy, independence, and authority. These mainstream characteristics echoed to the notions of traditional models of psychological growth that individuals move from dependence to independence (i.e., standing on your own two feet, to be independent, to be rational and autonomous). These characteristics in STEM domains might be incompatible with women students' needs and experiences, and might even hinder their learning and development. The critical factor is that women value to grow through connections with others and view relationship, rather than autonomy, as the cornerstone of growth (Jordan, 2000). Instead of building up individuated and autonomous traits emphasized in STEM domains, women students value to move from disconnection toward connection, and build the growth-fostering relationships through mutual empathy and authenticity.

Moreover, women students try to enhance their professional competence and personal development over the journey of graduate school. They could be viewed as (1) moving toward the development of self-authorship to prepare for the future career; (2) growing to move from external to internal self-definition; and (3) trusting the inner voices to define their reality and create their principles. They also could be conceptualized as going through three phases of development during graduate study: (1) exploring multiple perspectives, (2) doing what feels best, and (3) struggling toward self-authorship.

Method

This study employed the phenomenology approach to capturing women STEM graduate students' subjective experiences of learning and development over the graduate schools. Phenomenology could be viewed as a way of exploring lived experience-the actuality of experience from the inside (Osborne, 1994). Phenomenology uncovers, expresses, or illuminates individual subjective experiences, and describes the meaning of individual experiences. Students' learning and development can be constructed as holistic, complex, multi-layered, context-bound phenomena. The findings from a phenomenological study reveal rich descriptions of particular phenomena that offer plausible pictures of students' perceptions. Such an intended benefit is consistent with the rationale of this study. Thus, the

researcher employs this method to answer the research questions of this study: What and how do Taiwanese women graduate students perceive their experiences in graduate study of STEM fields? What are the factors, interactions, and mechanisms related to the process and outcome of women students' learning and development in graduate schools of STEM domains?

Participants

Study participants include 20 women master and doctoral students from various STEM programs at three universities in Taiwan. The reasons for selecting these students are: (1) they are minority in STEM fields, and are more likely to be under stress in graduate schools, (2) they work hard to reach the high criteria set by the graduate institute, and (3) they have high self-expectations in learning based on their previous academic success. Twelve students came from each of the three universities. Three universities with a total student body range from 13,000 to 20,000, and they are research intensive and comprehensive, and predominantly male universities in Taiwan. Participants' ages range from 24 to 35 years old. Criteria for the selection of participants include: (1) women students in the enrollment in STEM graduate programs for more than 1.5 years, and (2) willingness to openly share their life experiences in graduate school. In addition, senior participants will be preferred because they have had many experiences in the career of graduate school. So, they have rich data to share and can provide delicate details in terms of learning and development over the graduate school journey on campuses.

Interviewer

The interviewer has a master's degree in counseling or education, and has completed courses including qualitative research, interview skills, and research methodology. She conducted several pilots to sharpen her interview skills. She built a trustful relationship with the participants, and kept an open attitude and a nonjudgmental manner during interviews.

Researcher

The researcher of this study works at a university in Taiwan, has been a full-time teacher and a part-time counselor who teaches, advises and counsels students. She has had the opportunity to advise and counsel women graduate students, and observes them experiencing stress and challenges, particularly for studying in male-dominated STEM graduate programs. With more than 20 years' experience, she further observes women graduate students' learning and growth as being critical for their own professional, career and personal development over the journey of graduate school. Having worked extensively with women STEM graduate students, the author recognized that they suffer from a high degree of stress, and need assistance to learn and develop effectively over their graduate studies. Thus, she intends to explore the experience of women students over graduate schools in the STEM fields.

Interview Guide

The research team comprised of the author, a counselor, and two women graduate students. An interview protocol (Appendix A) was formed over four weekly group meetings. Literature related to women STEM students' learning and development was reviewed independently before any group discussion. The formulation of interview questions was based on the existing literature, team members' personal experiences, and the relevance of the issues. Team members first identified the important issues to be explored in the interview. Those issues corresponded to a comprehensive understanding of students' viewpoints on the elements, factors, interactions, processes, and outcomes related to the content and process of student learning or development, and the influences on them. These interview questions reflected research team member's conceptualization of students' learning and development in previous literature and from their observations as well as experiences were then developed, discussed, and refined in later group meetings. Subsequently, the interview protocol (Appendix A) was finalized.

Interview questions or topics were designed around a broad range of concepts of students' learning or

development. Participants of this study will be invited to describe their viewpoints in the following aspects: (a) the content and processes of, (b) the dynamic mechanisms of, and (c) the impact of the sociocultural, institutional, and/or environmental factors on their learning or development over the journey of graduate program in the STEM fields.

Participants will be asked to verbally describe factors, components, and dynamic mechanisms related to women students' learning or development. The RA will request them to provide details and to describe the content, interactions, and mechanisms of students' learning or development occurred in their graduate school. The interview guide (Appendix A) consists the topics to be addressed during the interview, but the order of presentation or precise wording of questions will not be as specified. The interviewer will be free to explore topics not listed on the interview guide and to probe the meanings of students' responses.

Data Collection

The research assistant screened prospective students and invite the first student to join the study. At the end of the interview, he/she recommended the next participant. Twenty participants were interviewed till the data saturation. The RA contacted the prospective participants by phone, e-mail, or letter to schedule appointments. Each participant was asked to read and sign an informed-consent letter before being interviewed. In-depth interviews were conducted within a one-month time frame and comprise the principal data for the study. Each interview, which was semi-structured and consist of broad, general, and open-ended questions, last for 90-120 minutes. Sample guiding questions included: Please describe your experiences throughout your graduate school career. Were there any impressive events, and what was the impact of those events? What changes had you made since you enrolled in this graduate school? Please describe your experiences in either academic learning or your personal life after studying at this graduate school? Please describe your growth and development since you became a graduate student? Taped interviews were transcribed into verbatim for data analysis.

Data Analysis

The author was the data analyst. She conducted data analysis in accordance with methodology outlined by Giorgi and Giorgi (2003). First, she described explicitly why she was interested in this topic, and completed a personal statement related to the topic. The step ensured the researcher's objectivity or removed the bias, and raised her consciousness. Second, the researcher obtained a concrete description of the phenomenon as lived through by a person. She (1) established a sense of familiarity with it; (2) gained a sense of the whole and established meaning units; (3) transformed each meaning unit into expressions and gain psychological significance and the psychological sense contained within the data; and (4) described the transformed meaning units derived to form a general structure of the experience of the phenomenon.

The researcher adopted criteria of credibility, dependability, confirmability and transferability proposed by Lincoln and Guba (1985). She utilized the strategies of dependability proposed by Gibbs (2007). The analyst (1) documented the steps of the procedures, and set up a detailed protocol and database; and (2) checked transcripts to ensure accuracy during the process of transcribing, and constantly compare data with the codes and write memos about the codes and their definitions. Moreover, the strategies proposed by Creswell and Miller (2000) were implemented to assure the credibility of this study. The analyst (1) triangulated different data sources by examining evidence from the sources and using it to build a coherent justification for themes; (2) employed member checking to determine the accuracy of the findings through taking the report and specific descriptions or themes back to the participants and determining in whether the content is accurate; (3) used rich and thick description to convey the findings, transport readers to the setting, give the discussion an element of shared experience, provide detailed descriptions of the setting, offer many perspectives about a theme, and generate realistic and rich results; (4) initiated self-reflection to create an open and honest narrative and to contemplate how the interpretation of the findings are

shaped by her own background; (5) presented negative or discrepant information that runs counter to the themes or contradictory evidence; and (6) spent prolonged time in the field, develop an in-depth understanding of the phenomenon and convey details about the site and the people that lead credibility to the narrative account. In addition, a peer debriefer was invited to review and ask questions, and an external auditor was employed to review the entire project.

Results

Themes were emerged from data analysis to describe the experiences of women STEM students over the journey of graduate school. Participants' words were quoted to echo the themes.

(A) Process of learning STEM

(a) Academic challenges

Participants were shocked when they first enrolled in the STEM program of the university, the courses were difficult and abstract, and the teaching and evaluations were challenging. Participants, at the beginning stage, often self-doubt whether they are suitable for studying in STEM? Participants carefully considered their own abilities and gritted their teeth, went through a difficult process of coping, worked hard to study courses, and finally passed the evaluations. One said: "University stuff (mathematics course) is too abstract, so it takes a long time to think about it...it (mathematics course) is too abstract, so I have to understand it for a long time... At that time, I wanted to transfer to the electrical engineering department...I have passed it, so keep reading."

(b) Self-expectation and self-adjustment

Participants mentioned that they are under pressure and frustration in the process of studying in STEM. They are aware of their own limitations and realize that learning science and engineering requires patience and perseverance. Due to the abstract and complex academic problems, it is necessary to think hard, discuss with peers or consult a teaching assistant to solve the problem. Participants gradually adjust themselves, and affirm themselves, from low self-esteem to self-affirmation, from blaming their weaknesses to affirming their strengths in certain areas. One said: "My expectation for myself is... because you (I) work hard and study hard, that's why you have such an achievement." Another said: "(I think) it proves that girls can actually read. (Technology)...My personality is relatively unwilling to admit defeat. When encountering this (difficult) situation, I will want to say that I must do better, so that you (others) think that girls can actually do it (read well) Science and engineering)." Another said: "When I first came to this (science and engineering) environment, I felt more inferior, that is, I was inferior to the people around me (peers) in many places (study in science and engineering), ... I felt that I was more inferior. Stupid? Later... I slowly looked at the places where I was good, and I was less likely to criticize the places where I was weaker."

(c) Self-achievement and efficacy

Participants continue to study and conduct experiments, overcome difficulties and setbacks, accumulate knowledge and ability, improve self-efficacy, and gradually gain a sense of self-accomplishment. They give full play to their abilities in academic work, contribute to the experimental team, or serve as a teaching assistant to assist junior students to gain a sense of accomplishment. One said: "Sometimes XX is used in the laboratory, and then they have no choice. Then the professor will ask me to help, and then at this time, I think it is very useful for me to learn XX before." Said: "I still like XX very much, that is, although I read very hard, but when I finish reading and then learn something, I feel very happy... When I was a junior or senior, I would be an assistant teacher... I can teach others. , I feel a sense of accomplishment." One said, "I think writing a program is a sense of accomplishment for me, that is, it is something I thought of myself, and then I write and run the program, and I will feel quite happy of."

(B) Academic performance

Some participants believe that gender has no effect on STEM studies, and that the results of academic learning

are mainly determined by personal traits and hard work. Women are no worse than men in STEM. They believe that the so-called quick response of men and good thinking ability in science and technology are gender stereotypes. They believe that acquired influences (popular encouragement and high expectations) is better than innate influences (thinking and reasoning ability). One said: "In terms of (science and engineering performance), I think gender is not an important factor, because I think since everyone has studied the same subject for interest, there is no difference between boys and girls." One said: "Some Traditional ideas tell us that their (boys) science and technology minds are faster or easier to understand these (science and engineering courses).... That is acquired (stereotype)."

On the other side, some participants think that the thinking and reasoning reaction, male students are faster than women, and the way of thinking about logics is different from men and women. It seems that they have an advantage in studying science and engineering. They mentioned that the male student seems to be able to understand a large amount of curriculum, complete homework and prepare for examinations in a short period of time, and achieve good results, but she, a female student, needs to work hard for a long time to read and understand slowly to achieve the same outcome. She identified quite a lot of male peers show good talent and performance in learning STEM. She said: "Hey, I think it's easy for them (science and technology boys) to study, why do they all understand this?...They (male science and technology students) can understand a lot of things at once, but I (science and technology girls) may Every day, little by little (accumulate) this way.... It takes me a lot of effort to get the same effect as the (study) effect of boys with a little effort. I feel very tired."

Moreover, some participants mentioned that male students have confidence in their own thinking ability and logical judgment, challenged the teacher's ideas, escaped from the experimental framework given by the advisor, and tried to conduct experiment with their own conceptual framework. One said: "(Male classmates) can escape the idea that the teacher gave them because they can judge that what the teacher said is wrong or not necessarily right. They will not follow the teacher's idea completely... I will. Because of the teacher's opinion, I gave up my own ideas, and I can't judge whether the teacher's ideas are more reasonable? Or my ideas are more reasonable?...They (male students) can judge by logic...decide whose (idea) they want to adopt."

(C) The influence of STEM training on the self-development of women students

(a) Professional confidence and efficacy

Participants study hard in the field of STEM, continue to accumulate professional abilities, gradually gain a sense of accomplishment, and enhance professional self-efficacy. One said: "I think the most fulfilling thing is to learn programming." One said: "I no longer feel that I will not feel that because I am not good at something, and then I lose something to others, or feel myself This is not good....I can spend more time and effort to do what I like (specializing in certain areas)." One said: "I often feel like a boy,... I don't need to be affected by this. (Gender) framework influence. I am now considering going to a doctoral class and continuing to study (science and engineering) like this."

(b) The ability of rational analysis, independence, autonomy, and responsibility

Participants agreed that the study and training of science and engineering made them more independent and capable of thinking and solving problems. One said: "I think it is possible to be more independent and responsible in doing things... This department is my choice. I must be responsible and learn it well. Understanding the way of thinking will make people (me) more efficient in doing things. With the effect, you (me) will solve it step by step...and draw a flow chart....Now that you will analyze things when you encounter them, what analysis will be drawn (pictures)...it's quite helpful for doing things, and the efficiency is pretty good."

(D) Interactions with male and female students

(a) Adaptation to the male-dominated environment

A small number of participants have been in an environment with more men since they were young, and they

seem adjusting to STEM environment after enrollment to the graduate programs. Most of the participants said that they were not comfortable with the male-dominated environment in STEM. Over time, they become accustomed to this phenomenon. Some participants can interact with men freely, but some still maintain a certain boundary with male students. One said: "In the beginning, I would feel uncomfortable, that is, I have not adapted to the environment (more men and fewer women) during my freshman year, but I have adapted later, knowing that the teacher must be a male teacher in class, and then the classroom will be able to There are a bunch of male classmates. So in the back (after the sophomore year), I am very comfortable with this environment. There is no special expectation that there will be girls in the classroom." Another said, "I was in a girls' school in high school before, and it took about one (for freshman). I adapt during the semester, because it suddenly feels like a boys' school....After the junior or senior year,...you will find that there may be only me in the class, and then there are 40 or 50 boys in the class. "

(b)Female peers tend to gather into small groups

Women are easy to gather into a small group, support each other after getting to know each other, communicate easily, and empathize with each other's experience of learning as a female in STEM programs. Because of the small number of women, it is easy for women to get acquainted with each other quickly. They tend to gather together in classrooms, labs or other locations to support and assist each other, such as forming a study group, discussing schoolwork, writing homework, and preparing for exams. After the following class, women students might chat and eat together, go shopping together or share their thoughts. Participants feel comfortable with women because they do not need to mind the boundaries. The interaction among women is less rigorous. One said: "Boys and girls still need to be a bit of a line!... There are some gaps, there are some boundaries, boys can't get too close to girls."

Women tend to understand and support each other and work together to overcome academic problems. Another said: "Sit in the classroom, maybe girls will sit in a circle by themselves.... Girls will interact more often, ... most of them still talk to girls." One said: "(In the laboratory) I will stick to another girl, because we are both girls and we can talk to each other better, and there will be a slight gap with other boys. But we (with boys) I still talk, but because of the gender relationship, there is such a difference (closer to women)." Another said: "There are very few girls in the first place,...they will be very familiar, and they will help each other pretty well. Yes, except for the few of you who can help each other, there is no one else!" One said: "I am very happy that there are girls in the (lab) who can chat with me, and some girls can discuss topics together,...to me It's already very satisfying."

(c)Adapt to male communication style

Participants in STEM learned to adapt to the male communication styles. Men may speak more straightforward, less coherent, rude and straightforward, and even swear words. The content of men's conversations is different from that of women, and they tend to attach importance to video games, ball games, games or other male issues. One said: "The first one is mainly about speaking, because it is used to talking to girls, and then you will talk to boys and suddenly don't know how to say it? That's because they may think differently from girls, so they just I often don't know what they' re talking about? Or they don't understand what I'm talking about. After about a semester, I am more and more familiar with their (boys) (talking) patterns...They are all rude in speech...not like girls The words spoken will be modified, as far as they are speaking, they will be straightforward... It may be that swear words are floating around over there."

Participants did not like some male classmates to make jokes about gender, but over time, they gradually adapted to the gender jokes sometimes presented in this environment. One said: "Some people (boys) use gender to make jokes, I think why are they like this?" Another said, "A few (boys) might tell girls some pornographic jokes... I feel very broken. …I think I don't like it very much...In the freshman year and sophomore year, I will be less able to accept it,...in the third year and fourth year...only then will I understand their (boys) lifestyle like this!

(d)Rational and efficient communication

In STEM environment, students tend to value rational evidence, seek truth from facts, be more straightforward and dislike vague communication. One said: "If you want to talk about things, I hope that the other party can convince me, or give me... Students) will be more straightforward, and some people may speak more vaguely, then I don't think I can understand, because I don't really know what he wants to do?...I may need a clearer statement that you should tell me How to do it? Or what do you want me to do?" One said: "I may be more rational. I just look at things more.... If you can't do this (to complete the task), then you can change it." Li said: "I'm used to doing things like this (in the field of science and engineering) (rational efficiency)...Because there are too many things, you (me) must handle everything efficiently. I want to achieve my goal (just go do)."

(e)Interpersonal self-efficacy

Participants value the ability of interpersonal interaction, including caring about and empathizing with others' feelings. One said: "For interpersonal relationships... you must think from the perspective of others, "Why is he like this?" The participant reminded himself that he needs to be concerned about the feelings of others and empathize with others' thoughts and emotions. One said: "(I) often remind myself that you (I) still have to think about other people's thoughts, that is, you may have to be softer to see how his thoughts (and feelings) are?"

(E) Gender stereotypes and learning performance

(a)male students outperform women students in learning

Some participants agree that men's performance in STEM studies is generally better than that of women, but some disagree that their academic performance is worse than male counterparts. They pointed out that academic performance is mainly determined by personal traits and acquired efforts, and has nothing to do with gender. One said: "Most of the boys around are also very good.... They seem to be more relaxed about understanding this aspect... I listen carefully in class, but it takes a long time to understand this. Yes, um, it seems to them. This seems to be a very simple thing... is their innate advantage."

(b)Obvious gender stereotypes

Participants said that some male teachers and peers consider women in STEM do not need to work too hard or to be too serious in study. They tend to ignore the learning needs of women in STEM, believing that women should not engage in related professions after graduation. One said, "Some teachers will say, "Hey, why are girls reading so many books? Just let boys make money! There will be some gender stereotypes. Or gender bias... I just I think um, this logic is pretty weird,...this logic is ridiculous." Another said, "I've met some boys, and they don't think they need to talk to girls more, but they think girls are less capable or I feel that girls shouldn't have to work so hard (studying science and engineering courses)....They feel that they are devalued by (science and engineering men), that is, I am looked down upon by you, so I have to do less than others (men). Kind of feeling."

(c)Subtle gender stereotypes

Teachers in STEM sometimes employ lower or looser standards to measure the performance of female students, and do not require them to meet high standards of academic study or professional performance. One said, "Professors seem to think so (it's harder for girls to study science)." Another said, "Actually, everyone (male teacher and male classmate) will treat you more...tolerate or compare. Relax... They may think that because you are a girl, they may first assume that you are not as good as them... or as good as them, so they will be more relaxed when dealing with (girls' performance) a little."

(F) Expectations of academic study and professional performance

(a)Lower expectations

Some teachers, peers or the society tend to hold low expectations for women in STEM, and believed that women

do not need to perform well or own good ability in STEM. One said, "They (male teachers and peers) have a low standard for me at first, but if I exceed this standard, they will think that I am doing very well... and then if they get their recognition or recognition, they will feel very Happy." One said, "Everyone thinks that girls are very popular at TSMC. You don't have to do anything, you can get the same salary, but (girls) do less things. I think this kind of remarks are for girls. One kind, so you think girls are less capable of this kind of feeling."

(b)The impact from the society

Participants realized that the science and engineering field is dominated by men after they studied in STEM, participated in academic activities or visited STEM companies. The male-dominated environment of STEM seems to lower women's confidence and expectations for pursing their occupations and careers in STEM. One said: "When we participate in the seminar,...you will find that the proportion of boys is much higher than that of female professors....Whether it is in Eastern or Western society,...male (expected) achievements are higher than females, and many people think that girls too If you are looking for a good husband or something, you don't care about your own achievements. From the psychological, external environment and education will affect the mentality of girls to identify themselves....(This is for women's) achievements and limitations have a great impact. "Another said: "The general impression of everyone (the general public)... is that (girls) should be able to speak well and go to the law department, or do some administrative positions, such as accounting, etc., but they are not suitable for that. This kind of (science and engineering) work may be due to this phenomenon that there are more girls in the social group, and then there are fewer girls in the natural group.... One thing is social expectation, that is, it is difficult for some people to be taught mathematics, which is very difficult for girls. It's difficult. She doesn't want to touch that concept, or dare not touch it. Yes, this will make it easier for girls to lean towards the essay group."

(c)Influences from family members

The participant mentioned the influences of parents and family members on their career development. Parents tend to urge her not to reveal strong abilities and not to have high expectations for professional development in STEM. Some parents are reluctant for their daughters to major in engineering because they think majoring or working in engineering field is not suitable for women. One said: "My mother felt... She kept telling me that girls are better than boys (weaker), just don't be as strong as boys. This is how she kept telling me... My mother didn't ask me to be certain. Be as good as a boy." Another said: "My parents would not like me to take the engineering class, but they would think that engineers are very hard, and then it's not for girls to go.... At that time, my first selection was actually related to construction and civil engineering. My parents view the civil engineering is very tiring and hard, so they think that girls are not suitable for studying or working in it."

(G) Influences of Male Professors on Female Students' Learning

Participants mentioned that most of the students in the STEM contacted male teachers, and a small number of participants had heard incidents of a few male teachers sexually assaulting female students. One said: "I saw a (female) XX PhD student before,...was harassed by a male teacher, and he was threatened that if you don't sleep with me, I won't let you graduate." Another participant mentioned some male teachers lowered the requirements for schoolwork and experimentation for female students. One said: "When calculating grades in the semester, girls will add 3 or 5 points... the professor will let the girls pass... Usually the professor will tell everyone at the beginning of the semester... that he has this preferential treatment for girls."

Some male teachers express or implies that they have lower expectations of female students in academic and professional performance. One said: "Some male teachers will presuppose you (girls) first, you will get married and have children in the future, so he doesn't like to accept (girls are students who are mentoring students)... He doesn't want to teach his whole body skills It's a waste of time for you." Some male teachers find it difficult to understand the

needs of female students or to empathize with their physical condition (discomfort in the menstrual cycle), which makes female students feel troubled.

One said: "Sometimes you have to ask a male teacher for this (physiological) leave, and some (male) teachers will think, why do you take this leave every month?...it feels a little sad." The interviewer mentioned that some male professors have authoritarian qualities and speak harshly to students or instruct her, making her feel scared and anxious. One said: "As long as he (male teacher) finds that the student's logical thinking is wrong, he will immediately interrupt the student and prevent the student from continuing." Some participants affirmed that some male teachers believed in the abilities of female students and were willing to guide Female students, flexibly and freely let female students realize their potential, and have consistent attitudes, expectations and requirements for female students and male students. One said: "The teacher thinks that girls and boys can do it, so I want to prove it to him more. If I work hard for a long time, I can still do the same things as boys (achieve the same performance)." Participants mentioned that male teachers are concerned about female students' academic performance, and that the department should recruit more female students and earnestly assist female students in completing their academic and professional studies.

(H) Contradictory caused by privileges or preferential treatments

Participants said that women in STEM enjoy some privileges or benefits. For example, male students are responsible for carrying heavy tasks, and are responsible for some physical-related chores in the laboratory, while women are more relaxed or responsible for accounting and administrative tasks. One said: "Naturally, all the sweeping work is left to boys. Teachers are really good to female students." Female students don't have to do heavy work while male students often need to be responsible for physical activities.

In addition, because of the small number of women, it is easier for women students to get the attention of teachers in classes or labs, and sometimes it is easy to get assistance. For example, when adding additional courses, teachers are given her priority. One said: "(Male teacher) will tell the newcomers that girls are more struggling in science, so they will take special care of us in schoolwork." Another said, "Professors mean that girls are engaged. This piece is very small, so they all hope that girls can join their laboratory, and then they will use encouragement, and then let the girls participate in science matters more, so that girls will not behave badly or read well. I was frustrated, and then I left this field." One said: "(Some) teachers are also very clear, I just want to accept a girl (to guide and study in the laboratory)... They will hope that a girl will do it (experiment)."

Participants mentioned that sometimes STEM women behave similarly as their male peers, but they are more likely to be noticed and may get opportunities to develop their abilities. One said: "If a girl is thrown into an environment where there are many boys, she is especially easy to look at, and then it is easier for everyone to see her good....Even if she does not perform very well, it is still easy to be noticed,... easy to take Get some opportunities... It's easier to be accepted by (teachers and peers)... I feel that sometimes it's a bit unfair. For boys (for boys), they also do the same thing, but because I (a girl,) may be because of this. It's praised, but they won't."

Participants mentioned that some teachers would provide women students with lower standards, allowing them to pass the course or experimental research. Some teachers ensure that all female students in the course pass. One said: "Initially, there are very few girls studying science. The professor encourages girls to study science, so they think that adding points (letting girls pass) is an encouragement." Participants mentioned that male teachers may speak harshly to male students, especially when male students did not perform well in experiments, they would be blamed. However, some male teachers tend to be gentler to women students and be more patient to guide them. Another said: "Girls are in an environment where there are many boys. In fact, everyone will be more...tolerant, or more relaxed...They may think that because you are a girl, they may first think that you will not be like them. They are so good at...or as good as they are, so they will be more relaxed when dealing with them." One said: "At first they seemed to be less approving

of girls, or more degrading, they would feel that when women's performance is not as good as theirs, their standards are lower, but when you have the ability to exceed their imagined standards,...it seems to be recognized by them (male teachers and male classmates)." One said "In the experiment, the teacher would use curse or fierceness when dealing with boys, but (yes) girls would not, he would tell you carefully about what you did wrong or what you did. If it's a boy, he will use scolding."

Participants in this study have conflicting feelings about having certain preferential or special treatment or privileges in STEM while they realized that they disagree with gender stereotypes imposed on them. They think that women can study in STEM as well as men. Therefore, they disagree with the society's views that men are more suitable for studying and working in STEM than women. At the same time, they also seem to be able to accept the special treatment, preferential treatment or privilege given by some male teachers. On the one hand, women as a minority group could to be protected. On the other hand, participants feel that these privileges or privileges seem to devalue women's abilities and are unfair to other male students. They admit that they study in STEM to become a minority, making them more noticeable. They seem to enjoy the glory of being a female studying in STEM, and at a certain level enjoy the preferential treatment that may be obtained in this field. One said: "I chose to read the three categories at the beginning, that is, I want to be watched among a group of people (males).... Then male and female students (gender) are the easiest to distinguish, so it's special.... When you are in An environment that is entirely male, and only you and one or two girls, you are especially easy to be watched." She also said, "I once signed a course. At that time, there were me and there were four boys behind me. In the end, The teacher only signed me, and none of the boys signed."

(I)Career expectations and development of women students

(a) female professionals in STEM

Participants realized that it is not easy for women in STEM to enter the workplace. In the past, they may have lost employment opportunities because of gender. Taiwanese society has gradually opened up to accept women into the workforce of science and technology. One said: "Sometimes your (employment) opportunities will be directly deprived of you because you are a girl.... I think this situation is rare now. After all, I think the current society is still more open. Everyone already knows that boys and girls are more open. It is possible to (employment), ... it is less likely that you will not be allowed to do something (science, technology, and technology work) because you are a girl."

(b) Concerns about investing in science and engineering professional work in the future

Participants believe that women's career development in STEM fields conflicts with future marriage, family, and childbirth. Due to the rapid changes and competition, women feel difficult to return to the STEM workplace and they might stop ongoing research in latest technology or experimental research while they are married and having children. One said: "Everyone expects you (female) to get married to have a baby, and then to take care of the baby... Experimental research will definitely be affected. After all, XX-related research requires a lot of time in the laboratory,...very It's hard to run on both sides like this... I know a very good senior sister, because you got married... or gave birth to a child, and gave up your original career... Girls are still more likely to be sacrificed... The laboratory has no way to stop and stop,... once you stop, you It's just a few steps late for others,...it's hard to keep up...sometimes (professional work and family) are hard to take care of."

(c)Possible compromises in the career development in STEM

Some participants think that if they choose to enter a marriage and family in the future, they may need to deal with conflicts between family life and career development, and try to reach a compromise. Some participants mentioned that they are struggling with the conflicts between professional development in STEM and the pursuit of

marriage and family. Although they value their own interests and abilities in STEM, they have to compromise and sacrifice jobs in competitive, challenging, and fast-changing industries of STEM after they are married and having childbirth. One said: "If I really want to go down the road of research, I can't have the quality of family life. If I want to have the quality of family life, I might become a XXX and go to work normally like this... There is no way to take this road and family into consideration at the same time...Sometimes I feel unwilling, because my previous ideal is that I can continue to do research, and then I want to study new things to benefit the patients (assistance) to get rid of their pain , That's how your ideal is, but sometimes if you meet someone you like or want to raise a child,... these two (professional development and marriage child) are very desired and must be taken into account...(Think about the maximum concession (compromise)."

(d)Make good use of the advantages of women in STEM

Women have advantages and can contribute to STEM fields by providing women's perspectives. Women's thinking might be different from that of men. Women's perspectives may help the STEM industry to be more refined. One said: "For a girl, I think I can go and maybe help him see some of the more subtle parts like this... Boys and girls have different strengths and complement each other... This is an opportunity for cooperation.... Girls do things with Boys are different, because boys may be the purpose, and as a result,...girls may...make some small changes, optimize or be more comprehensive and exquisite small details..."

(J) Role models of women STEM students

The participants mentioned that there are very few female teachers in the graduate programs, sometimes there are only one or a few, and there are often dozens of male teachers. Participants also noticed that almost all outstanding scientists and scholars in the fields of science, engineering and natural sciences are men. Even though there are very few female professors in STEM, participants identified women professors' outstanding teaching and research performance which has a profound impact on them. Participants admire the academic and professional abilities of female professors, and agree with their care and empathy for students. They shared the journey of being a woman in a male-dominated STEM field, inspiring the participant's vision and motivation. One participant agreed with the attitude of female teachers caring for students: "There is a female teacher in the department. In addition to letting you learn and absorb some difficult knowledge, she also provides emotional and physical support... He also understands what to ask for leave (girls' physical leave),...(female) teacher is very tolerant of students." Another agreed with the teaching ability of female teachers: "She actually teaches classes in a very relaxed way. …Speaking of difficult concepts very simply,…really learned a lot,…she is quite good at teaching…my university teacher is only her as a girl,…it's to put a lot of ideas…with very daily examples to let you (Students) understand."

Discussion

Women STEM graduate students in this study recognized the high pressure of studying in STEM. The study results echoed the notions of high stress among graduate students in Taiwan (e.g., Aiou, 2005; Chang, 2005; Hsieh, 2007; Huang, 2005). Participants in this study and acknowledged the importance of peers (peer mentors) for assistance, which assist them deal with big challenges in academic studies. They requested help from their peers and sought academic help especially from senior peers with outstanding performance. The participants initially doubted their own abilities, and even considered to give up their majors and switch to other fields. They gradually overcome difficulties with efforts and perseverance, gradually adapt to the process of learning and experimental research, and have a deep awareness of their strengths and weaknesses. One participant expressed that "make good use of your strengths to overcome challenges, adjust your expectations or perceptions, and find the right pace of learning." Participants tend to affirm their own efforts, believing that studying in science and engineering is very hard, but studying hard can accumulate professional knowledge and improve self-efficacy

As a minority group, the number of women in STEM is small and they often get acquainted with each other quickly. They tend to form a small group with other female peers, chat and share with each other, care for and cooperate, connect and interact with each other in closeness, creating a sense of belonging and cohesion, and forming a social support network. The female group helps them obtain psychological comfort, emotional relief, and reduce anxiety. The study findings echoed that notions that engagement in STEM is important for retention (London et al., 2011) and social support and feelings of belonging are a better predictor of women's interest in STEM (Rice et al., 2013).

Women graduate students in STEM form study groups, cooperate to solve academic problems, and complete assignments, experiments and exams. Small groups of women have emotional connection and instrumental (academic problem-solving) functions. Participants affirm the importance of interpersonal interaction and emotional connection with a small number of female peers (classmates and upper-class or under-class students), and the small groups of female peers provide important academic and psychological support for their studies in STEM. A sense of fit and belonging is important for women in STEM (Brainard & Carlin, 1998). The study results echoed the notions of RCT (Jordan, 2000) that women grow through relation connection. With growth-fostering relationships, women reveal mutual empathy and empowerment. Participants in this study addressed the importance of STEM women students' relationships with characteristics of sharing, caring, supporting, authenticity and connections. These characteristics echoed the notions of RCT (Jordan, 2000; Miller & Stiver, 1997).

As a minority group, women in STEM learn to get along with many male peers and gradually adapt to the communication mode of their male counterparts. Most of the participants had previously attended a girls' school and were not comfortable with many male students in classes and activities at the early stage of enrollment. However, over time, participants became more comfortable and were able to master the ways of communicating and interacting with male students, including direct clarity, rational thinking, and judgment based on evidence. Participants often remind themselves to maintain a certain boundary with their male peers, and understand that male peers may present certain gender-biased remarks or behaviors in the environment, such as having pornographic jokes.

Participants presented two perspectives on the performance of male and female students in STEM. Some participants believe that gender has no influence and that both men and women can perform well in science and technology. They think that even if they are women, they can stay abreast with men. Through hard work, women will perform well in STEM. These participants have also obtained satisfactory academic and experimental results due to their own long-term efforts.

Some participants think that male students tend to respond quickly, understand quickly, think logically, and seem to be able to learn more course content in a short period of time. These participants feel that their understanding of curriculum is slower and needs to be study for a long time. They feel that their abilities seem to be relatively inferior to their male counterparts, so they can only prepare courses, write homework and prepare for exams in advance through hard work and active consultation with teaching assistants, senior sisters or peers. The study results echo that women tend to reveal less confidence in their abilities and individual accomplishments than men (Cohoon, 2001); women feel lower levels of self-efficacy (Huang & Brainard, 2001) and feelings of incompetence (Farver & Gattis, 2006) in STEM. Although I feel frustrated, I also noticed my own strengths and weaknesses in the process, and realized that I was not as good as the male student's aptitude and understanding reaction ability, but with acquired efforts, he can still achieve similar academic performance results as the male student.

Participants said that gender bias and stereotypes still exist in the science and engineering environment. A few women mentioned that they had observed instances of male teachers' sexual harassment. A few also mentioned that the pornographic jokes made by male peers aroused their disgust. They also mentioned the existence of certain males

in the STEM environment. The study results, at a certain level, echo that an unwelcoming environment which makes women feel out of place in the male-dominated field of STEM (Hill et al., 2010; Settles et al., 2006). Some male teachers and peers believe that women do not need to work hard or study hard, because they may not be engaged in STEM work in the future. They believe that women will still enter marriage and family in the future, serving as traditional husbands and children. Women in STEM face obstacles in the form of sexism (MacLachlan, 2006) and stereotypes (Walton et al., 2015). The biases and negative expectations (e.g., sexism, stereotypes) women encounter in STEM are often prevalent at both the peer and faculty level (Miller et al., 2015).

Participants perceive that there are still obvious and/or subtle stereotypes in STEM, which come from teachers, peers, family, parents, or the public. Participants perceive and think about the impact of stereotypes on themselves or on female students. Most participants believe that acquired society's many stereotypes of women studying in science and engineering are an important reason for the low attendance rate of women in science and engineering. For example, girls have poor abilities in science and engineering and are not suitable for jobs in science and engineering, because female main repairmen are too hard and don't need to devote themselves to science and engineering studies. They just need to consider their future marriage and have children. Because women are not a major source of family income, they don't need to work hard to improve their professional abilities. It does not need to be too strong or strong, and does not need to compete excessively with men.

The above-mentioned stereotypes affect women's motivation for study or employment. Most of the participants perceive the influence of many prejudices and stereotypes imposed on women in science and engineering by the social environment. They tend to play down the influence of various stereotypes on themselves through understanding, and some work harder to study and make breakthroughs with practical actions. The stereotypes that women are not suitable for STEM studies or careers proves that women can still study and develop well in science and engineering fields. Some participants considered many problems that may be encountered in entering the science and engineering professional workplace after graduation. They mainly focused on the high competition and rapid changes in professional work. If they need to invest in professional work, they may conflict with running a marriage and family and having children. The interviewer is aware of this situation and also thinks about possible compromises. The study findings echo the notions of women are not suitable and less competent in STEM (Litzler, 2010; Rosenthal et al., 2011; Spencer, Steele, & Quinn, 1999).

Women students recognized the importance of role models, especially female role models. They identified the professional competence and positive images of female professors in STEM. Female professors as role models reveal good teaching, research and professional abilities; share experiences; and offer caring and empathy to women students in STEM. The study results echo the importance of role models for STEM women, especially same-gender role models who offer psychosocial support (Fried & MacCleave, 2009); women role models can protect women against the destructive effects of negative stereotype (Stout et al., 2011).

Participants are ambivalent about certain preferential treatment, attention, praise, or privileges that female students have received in the field of science and engineering. On the one hand, it is believed that women can work as repairmen with men, and there is no difference, and that parents, teachers, and the general public should not hold stereotypes or prejudices about female repairmen or careers in science and engineering. But they get praise or attention because of the main repairman, and this aura also makes them feel valued or their own special characteristics. Some participants mentioned that in the science and engineering environment where there are many men, women's performance is average or slightly better, that is, they may receive attention or affirmation, and they are more likely to be noticed or given the opportunity to perform than men with the same performance. Women in the field of science and engineering may be judged at a lower standard. Some male teachers tend to give discounts to female students so

that they will not be eliminated because of failing in their studies.

Women are given preferential treatment to encourage them to stay in the field of STEM. On the one hand, they feel that they are valued or cared for. On the other hand, they also understand that the special courtesy and loose standards they enjoy seem to devalue the ability of women in science and engineering, that is, they do not trust them to play their abilities like men, pass the test, and meet the standards of polytechnic learning. Some participants feel that these preferential treatments are not fair to male students. Participants also hold ambivalent attitudes towards family society or the lower expectations of the majors of the department for the development of women in science and engineering. They also have conflicting feelings about certain preferential treatments or privileges enjoyed by studying in science and engineering.

Implications

University policy makers and leaders of graduate schools could consider to providing assistance to STEM women students and offering resources to them, especially for new students in the first semester or year to adapt to the environment of the graduate school. In a male-dominated environment, they need to adapt to complex and difficult tasks, such as getting along with the lab group and adapt to communication with male teachers and peers. Teachers, counselors, or student affairs professionals should support the formation of support groups for STEM women students. Female peers in the same and different cohorts can provide instrumental and emotional assistance to women students, form connections, establish social support networks, and assist academic learning tasks. Women students overcome difficulties and adjust pressure in STEM. Professionals in higher education could design and develop peer mentoring systems/programs suitable for SYEM women to form study and support groups to assist them in their learning and development.

More gender education lectures or workshops could be offered to help students and teachers detect and change gender stereotypes and discriminations in the environment, operate a gender-friendly environment, and avoid sexual harassment or inappropriate remarks or behaviors that cause dissatisfaction or discomfort among women in STEM.

Teachers and policy makers should carefully consider whether to set up lower or loose academic standards for women STEM students in order to keep their retention in STEM. In this study, participants have been aware of special treatments and/or privileges for women students and they seem to feel conflictual and contradictory in having the special treatments and seeking for gender equality or breaking gender stereotypes in STEM fields. However, education professionals should consider to provide women students with more effective learning resources, such as teaching assistants and/or peer mentors. Male teachers need to be aware of their own views on women STEM students, and avoid passing on the myth stereotype that women are not suitable for studying or working in STEM.

University and department supervisors should consider increasing the employment of female teachers in STEM. Female teachers serve as role models for women students. The care and assistance from female professors are beneficial to students to promote their study, career and professional development. Policy makers and leaders could help women deal with the conflicts between career development and marriage/family. The STEM industry could formulate policies to reduce the women’s dropping out through assisting women handle the needs of marriage and childbirth, and working in STEM.

Researchers could focus on the operation and efficacy of small groups of women in STEM, and explore in depth the contradictory complex between the preferential/special treatment and/or privileges that women receive in the STEM and their own challenges to break gender stereotypes. Researchers could explore the impact of role modeling of female professors on women students in STEM. The influence of models on female students of science and engineering can also be explored for the effect of male teachers' attention and assistance to women in science and engineering.

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Appendix A

Interview Guide

1. Please describe any of your experiences during the years in your graduate program in the STEM fields. Let's start with the experience that you feel most impressed by, and please describe it in details.
2. What is the overall experience of being as a minority student in this graduate program in which the majority (students and faculty) are men? Please describe your feelings, thoughts, perceptions, and reactions; as well as the features of the above-mentioned experience?
3. Please describe the peer relationships/interactions in your graduate program in the STEM fields?
4. Please describe the advisor-advisee (or faculty-student) relationships/interactions in your graduate program in the STEM fields?
5. Please describe your experience in terms of learning (e.g., curricular and extra-curricular domains) and development (e.g., personal and professional growth) at the program, department, college, and institutional level in the STEM fields.
6. Please describe the pros and cons as a woman student in a male-dominated and masculinity-disciplined graduate program in the STEM fields? (e.g., role modeling, mentoring, sexism, gender stereotypes and sociocultural stereotypes, coping with multiple roles, conflicts between family, study, and life, etc.).
7. Please describe your self-confidence, self-efficacy and self-identity in terms of your expertise over the graduate study in a given profession in the STEM fields.
8. Please describe the impacts of graduate school (e.g., factors, features, and policies), campus culture (e.g., climate, sense of belonging), and environment (e.g., physical and/or humanistic domains) on you as a woman graduate student studying in the STEM fields.
9. How do you perceive the above external/environmental factors operate to affect your learning and development at the program, department, college, and institutional level in the STEM fields.
10. If you have a chance to offer advice/suggestion to a new woman student enrolled in a graduate program in the STEM fields, what would you advise her in managing her graduate education experience?
11. Anything else that you would like to share with us regarding issues of women students in STEM graduate programs?

108年度專題研究計畫成果彙整表

計畫主持人：林旖旎	**計畫編號：**108-2629-H-007-001-
計畫名稱：台灣研究型大學STEM女學生的研究所求學經驗	

成果項目			量化	單位	質化 （說明：各成果項目請附佐證資料或細項說明，如期刊名稱、年份、卷期、起訖頁數、證號...等）
國內	學術性論文	期刊論文	0	篇	International Journal of STEM Education（待投）
		研討會論文	1		科技部性別研討會（Feb, 2021）
		專書	0	本	
		專書論文	0	章	
		技術報告	0	篇	
		其他	0	篇	
國外	學術性論文	期刊論文	0	篇	
		研討會論文	0		
		專書	0	本	
		專書論文	0	章	
		技術報告	0	篇	
		其他	0	篇	
參與計畫人力	本國籍	大專生	0	人次	
		碩士生	0		
		博士生	0		
		博士級研究人員	0		
		專任人員	0		
	非本國籍	大專生	0		
		碩士生	0		
		博士生	0		
		博士級研究人員	0		
		專任人員	0		
其他成果 （無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。）					