Research Open

Psychology Journal: Research Open
Volume 7 Issue 4

Case Report

Navigating a Male-Dominated Discipline: Learning and Development of a Female Master's Student in Pure Sciences in Taiwan

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Received: August 12, 2025; **Accepted:** August 19, 2025; **Published:** August 26, 2025

Abstract

This case report examines the learning and developmental experiences of "Ann," a 24-year-old female master's student and the sole woman in a theoretical physics program at a research-oriented university in Taiwan. Using a phenomenological qualitative approach, data were collected through semi-structured interviews and analyzed thematically. Four primary themes emerged: antecedent factors influencing her decision to pursue theoretical physics, experiences of collaboration with male peers, persistence in continuous learning, and factors facilitating her success in a male-dominated field. The report concludes with recommendations for policy and practice to support women in pure sciences, as well as directions for future research.

Keywords: *Female graduate student, Pure sciences, Learning, Development, Competence*

Introduction

In Taiwan, mathematics and science remain strongly male-dominated, with scientists frequently perceived as predominantly male. According to Ministry of Education statistics [1], women represent only 32.61% of graduate students in physics, chemistry, or earth science, and 31.83% in mathematics or statistics. Within pure sciences—such as pure mathematics, theoretical physics, and mathematical physics—female representation is even lower than in other STEM disciplines. This scarcity may discourage prospective female students from entering these fields, perpetuating gender disparities. Addressing this imbalance requires a deeper understanding of the lived experiences of women in pure sciences. This study focuses on "Ann," who completed a bachelor's degree in physics and is now pursuing a master's degree in theoretical physics at a research-oriented university in Taiwan. Her coursework spans a broad range of pure science subjects. Here, "pure sciences" refers to disciplines grounded in theoretical principles, while "theories" denotes the concepts, principles, and knowledge specific to these fields.

Gender Roles and Higher Education in Taiwan

Traditional Taiwanese cultural norms have long emphasized female domestic responsibilities—childbearing, childcare, and elder care—alongside values of female submissiveness and male dominance [2]. However, shifts in women's educational attainment, delayed marriage, and increased workforce participation have led to evolving gender roles [3]. Many female university students now seek autonomy, independence, and professional competence, yet still navigate tensions between traditional expectations and more egalitarian ideals [4]. Gender disparities in higher education persist: men are more likely to pursue STEM majors, while women are concentrated in the humanities [5,6]. Studies of Taiwanese STEM environments reveal that science and engineering laboratories often reflect masculine cultures, with hierarchical structures privileging male members and marginalizing women [7,8]. Female STEM graduates' career choices are shaped by personal interest, academic performance, institutional prestige, family expectations, and significant life events [9], yet constrained by gender stereotypes, discrimination, and work–family conflicts [10].

Research on successful female scientists in Taiwan highlights qualities such as intellectual curiosity, perseverance, time management, and passion for research, supported by parental encouragement, mentorship, and professional opportunities [11]. Other studies emphasize the importance of interest-driven learning, supportive peer networks [12-14], diverse career values, and opportunities for creativity and problem-solving [15,16]. However, persistent gendered stereotypes in science and technology remain embedded in both cultural narratives and media representations [17,18].

Female STEM Students Worldwide

Globally, women in STEM face systemic challenges. Institutional climate, lack of social support, and feelings of alienation in male-dominated fields contribute to attrition from graduate programs [19]. A sense of belonging is crucial for sustaining engagement, yet studies show it often declines over time, particularly in engineering [20,21]. Barriers include male dominance, limited awareness of opportunities, the scarcity of female role models (FRMs) and mentors, heavy time demands, insufficient encouragement, and perceptions of a glass ceiling [22]. Support networks play a protective role. Social support from family, peers, and teachers is linked to more positive attitudes and stronger self-perceptions in STEM [23]. Female classmates and FRMs can reduce isolation, foster collaboration, and provide emotional support. The presence of female faculty improves satisfaction, career aspirations, and academic outcomes [24,25], while same-gender mentors enhance comfort in research settings for underrepresented students [26].

Persistent stereotypes about women's ability in STEM—such as assumptions of weaker mathematical skill [27] or lesser innate talent [28]—erode self-efficacy [29] and scientific identity [30]. Female role models have been shown to counter these effects, improving performance, retention, and belonging [31,32].

Relationships, Connection, and Engagement

Relational-Cultural Theory [33,34] emphasizes that human growth occurs within relationships, and that women, in particular, are driven by the need for connection. Growth-fostering relationships are marked by mutual empathy and empowerment. Women tend to prioritize intimacy, trust, and mutual support in friendships, engaging in greater emotional self-disclosure and communication compared to men [35-38] .In Taiwan, academic involvement and peer relationships significantly shape university students' psychosocial development [39,40]. Student engagement—defined as the degree of connection to meaningful academic and social activities—is a strong predictor of success [41-43]. Engagement reflects both the time and effort students invest and the institutional supports that encourage participation.

Rationale of the Study

Engagement is central to academic success, persistence, and satisfaction [44]. In STEM contexts, it encompasses the academic and social dimensions essential for retention [45] and is shaped by stereotypes, bias, campus climate, identity formation, and belonging [46]. This study applies Fredricks et al.'s [47] three-dimensional engagement framework: (1) behavioral engagement — effort, persistence, attendance, and constructive participation, (2) emotional engagement — positive and negative reactions toward peers, teachers, and academic content, reflecting belonging and identification, and (3) cognitive engagement — self-regulation, deep learning strategies, and sustained effort to master complex material. These dimensions are examined in the context of Ann's higher education experience, focusing on instructor–student interaction, peer collaboration, and positive coping strategies within a science-supportive culture. This framework provides the lens through which her learning and development in a male-dominated pure sciences program are explored.

Method

This study adopted a phenomenological approach, which aims to provide detailed descriptions of individuals' ordinary, lived experiences and to identify the essential structures of those experiences. This approach was used to explore and articulate the learning and developmental experiences of a female graduate student enrolled in a theoretical physics program in Taiwan.

Participant

The participant, referred to as Ann, is a 24-year-old master's student at a research-oriented university in Taiwan, majoring in theoretical physics. She is the only female student in both her academic program and research team. Ann voluntarily participated in the study, sharing her reflections on her learning trajectory and personal development in the male-dominated field of pure sciences.

Interviewer

Data collection was conducted by a research assistant (RA) with a master's degree in counseling. The RA had completed formal coursework in interviewing skills, qualitative research, and research methodology, as well as pilot studies to refine her interviewing competence. She established rapport with Ann prior to the interviews and maintained an open, nonjudgmental stance throughout the process.

Data Collection

Two in-depth interviews were conducted, each lasting between 90 and 120 minutes. Prior to participation, Ann was fully informed about the study's purpose and procedures and provided written informed consent. The interviews were designed to elicit rich, detailed narratives of her experiences. Sample guiding questions included: "Please describe your learning and development experiences in the field of pure sciences." "Please share any significant or memorable perceptions and reactions you have had during your academic career in pure sciences at the higher education level." "If applicable, what advice would you offer to prospective female students considering enrollment in a pure sciences program?"

Data Analysis

The author conducted the data analysis following Creswell's [48] phenomenological procedures. To minimize bias, the researcher engaged in bracketing, setting aside personal assumptions about female students in pure sciences to focus on uncovering new and fundamental meanings from the data. The analytic process included the following steps: (1) reviewing transcripts, scanning materials, typing field notes, and organizing data from multiple sources, (2) reading the entire dataset for a holistic understanding, reflecting on overarching meanings, and recording general impressions, (3) dividing the text into meaningful segments and applying initial codes, (4) developing detailed descriptions of the participant and context, grouping codes into preliminary themes, (5) refining themes through iterative analysis to construct a comprehensive thematic framework, (6) building complex connections among themes and integrating them into an overarching narrative, and (7) formulating a final description that captures the essence of the participant's lived experience.Several strategies were employed to enhance the study's validity and reliability. A detailed research protocol and database were maintained [49]. Transcripts were checked for accuracy, and codes were continuously compared with the raw data. Validation strategies recommended by Creswell and Miller [50] were used, including prolonged engagement, persistent observation, and triangulation of multiple sources and methods. Rich, thick descriptions were produced to convey contextual detail. Member checking was conducted by inviting Ann to review preliminary drafts and provide feedback. Finally, a peer external to the research team served as an auditor, reviewing both the research process and the findings for consistency and rigor.

Results

Antecedent Factors for Learning

Intrinsic Motivation: Learning Science to Understand the World

Since her senior year of high school, Ann has been deeply motivated by a desire to understand the world through the study of pure science theories. She explained, "As long as students enter the field of pure sciences, they have a dream to explore and understand the world. I belong to this group, and I desire to learn theories to reach this goal."

Academic Goal: Enhancing Professional Competence

As the only female graduate student in her theoretical physics research team, Ann seeks to strengthen her academic abilities and establish herself as a competent professional. She enrolled in the program to prove her capability in mastering pure sciences, aspiring to perform at a level equal to or higher than her male peers: "I am the only female in our entire research team… I want to encourage young women to join this program. The first thing is to make myself better, even better than my male peers. I work hard to be a competent student who stands on my own feet!"

Personality Traits: Persistence, Patience, and Flexibility

Ann describes herself as introverted, autonomous, and independent, qualities she believes are well-suited for studying pure sciences. She emphasizes her persistence, tolerance for solitude, and ability to adapt in challenging learning environments: "I am less afraid of being alone, and I am less likely to give up because of difficulties in learning… My introverted personality makes me quite suitable for studying pure sciences." She further notes that, unlike many female students who may feel isolated in male-dominated programs, she has prepared herself to manage such solitude: "Few or no female companions in the program make it unbearable for most female students, not for me. As the only female student in pure sciences, I mainly count on myself."

Resilience and Independence in a Gender-Imbalanced Environment

Ann acknowledges that many female STEM students prefer programs with greater female representation, partly to avoid feelings of isolation. She believes that women considering pure sciences must develop resilience, problem-solving skills, and a capacity for independent thought: "I prepare myself to be independent, enhance my problem-solving abilities to manage my studies and life, and tolerate solitude."

Navigating Collaboration with Male Peers

Collaborative Learning as a Strategy to Overcome Barriers

Given the scarcity of female students in pure sciences, Ann relies on male peers for academic discussions, which she considers essential for mastering complex theoretical concepts: "Because academic discussions occur frequently among men, they gather and discuss theories anytime, anywhere… Without academic discussions, it is difficult for female students to learn theories in pure sciences."

Maintaining Professional Boundaries

While engaging in collaborative learning, Ann is deliberate about maintaining clear professional boundaries to avoid misunderstandings or unwanted social complications: "I believe that there must be a clear boundary between males and females… I have to maintain a clear boundary to demonstrate that we are partners in learning."

Persistence and Long-Term Learning Strategies

Steady Effort in a Challenging Field

Ann views learning theoretical physics as an inherently slow and incremental process. Despite the difficulty, she remains committed to steady progress: "If I learn theories, I won't necessarily achieve significant outcomes soon… studying theories takes time and proceeds step by step with patience."

Preparation and Focused Discussions

Before approaching peers with questions, Ann engages in independent literature review and problem analysis: "If I want to discuss something… I first think about it carefully and check with the relevant literature to gain a certain degree of understanding."

Gradual Development of Self-Reliance

Over time, Ann has cultivated enough expertise to work more independently. Being appointed as a teaching assistant was a milestone that reinforced her confidence and self-efficacy: "When I'm good enough… I don't need to depend on others much… I don't feel like being the only female in this team is bad anymore."

Factors Promoting Learning

Female Role Models

Ann underscores the motivational influence of female scholars, teachers, and senior students in pure sciences. These role models inspire her through their dedication and passion: "I met a senior female graduate student who had a great impact on me… She, majoring in pure mathematics, claims that she is unique because a majority of people in the world cannot understand what she is studying."

Female Peer Networks

Although she lacks female peers in her immediate research group, Ann builds friendships with women from other departments, valuing emotional support and shared experiences: "Women can establish close friendships… and better support each other in daily lives."

Career Orientation and Patience for Non-Mainstream Fields

Ann acknowledges that pure sciences research is often more aligned with cutting-edge exploration than with popular industry applications. She accepts that her career path may diverge from mainstream STEM employment trends: "We are usually doing more cutting-edge research, not like semiconductors… that are currently popular in Taiwan."

Interpersonal Adaptability

Recognizing that many in her field are introverted or self-focused, Ann actively adapts her interpersonal approach to work effectively with colleagues of varying personalities: "To survive in pure sciences, I have to be brave enough to get along and work with these men… with different characteristics."

Family Support

Ann credits her family's encouragement and lack of financial pressure as key enablers of her academic persistence: "My parents respect my personal interest and decision… My family did not push me to find a job soon, did not blame me for majoring in pure sciences because of its non-mainstream position in the job market."

Discussion

Awareness of Gender Stereotypes

Ann is acutely aware of gender stereotypes in mathematics and science, particularly the perception that pure sciences—especially theoretical disciplines—are male domains. Such stereotypes, which assume that men have greater aptitude for theoretical work, discourage many young women from enrolling in STEM majors. Ann's awareness echoes findings that male-dominated images of engineers persist in Taiwan and that the gender structure in Taiwan's science and technology fields remains unfavorable to women.

She also observes the scarcity of female classmates in pure sciences, which reinforces the field's lack of appeal for women and perpetuates the cycle of underrepresentation. This reflects literature linking gender stereotypes to the association of men with science and women with non-science in Taiwan [51]. While pure sciences are male-dominated and masculinity-oriented, Ann appears largely unaffected by these stereotypes. She adopts coping strategies to overcome learning obstacles, improve performance, and maintain progress. One of her motivations is to prove that women can succeed in pure sciences, a finding consistent with research on Taiwanese female mechanical engineering students who aimed to counter gender stereotypes through achievement.Although she faces barriers common to women in STEM—male dominance, limited awareness of opportunities, and a lack of female role models and mentors —Ann demonstrates resilience and problem-solving ability. This contrasts with Liu's finding that negative stereotypes lower self-efficacy for female STEM graduates in Taiwan. Ann's experience is atypical, differing from studies that describe women's inferior status in STEM due to combined internal and external barriers such as low self-efficacy, limited support, and gender-biased environments.

Personal Interests and Personality Characteristics

Ann's decision to specialize in pure sciences stems from her personal interest, career goals, and motivation to pursue knowledge, alongside support from parents, female teachers, and peers. This aligns with research showing the influence of personal interests [52] and high motivation in STEM career choices. Recognizing her aptitude for theoretical study, Ann is driven by passion, ambition, and a commitment to becoming a scholar.Her perseverance, independence, courage, resilience, and persistence align with Hsu's [53] observation that women in nontraditional fields often display these traits. Ann's time-management skills, professional growth, and steadfastness reflect characteristics of outstanding Taiwanese female scientists and technologists. She approaches problems with curiosity and adaptability, consistent with Sung and Kao's findings on positive traits among Taiwanese female STEM undergraduates. Ann's clear academic goals, combined with her willingness to endure solitude and sustain effort, help her overcome gender stereotypes and barriers in male-dominated environments. This mirrors Swafford and Anderson's conclusion that persistence and personal expectations are key for women in STEM, and further contrasts with Liu's view that stereotypes lead to internal barriers.

Connections with and Social Support from FRMs and Female Peers

Ann values friendships with female peers, especially in dormitories and clubs, for emotional support and connection. This aligns with research showing that women value supportive, cooperative learning relationships [54]. Supportive peer and faculty relationships have been shown to influence female engineering students' career choices. She notes that the absence of female companionship can lead women to drop out of STEM programs, echoing concerns about inadequate mentorship and social support. Interactions with female peers proficient in mathematics can boost identification with the subject and persistence. Ann's emphasis on meaningful relationships and emotional intimacy aligns with findings that women place high value on connection and supportive growth.Ann also recognizes the importance of female role models (FRMs) in providing support and enhancing belonging in STEM [55]. However, due to the scarcity of FRMs in pure sciences, she actively seeks female mentors and peers through conferences and external academic activities. Such connections reinforce her confidence and identity as a scientist.

Collaboration with and Adjustment to Male Peers

In a male-dominated field, Ann collaborates with male peers for problem-solving while maintaining professional boundaries to avoid misunderstandings. She acknowledges that the abstract nature of theoretical work requires continuous discussion, and that engaging with male peers is often necessary due to the scarcity of women in her field. This partially reflects Fairlie's [56] finding that female–male partnerships in STEM do not necessarily hinder academic outcomes. However, Ann also notes that men more easily navigate resources and systems in masculine academic cultures, reinforcing her need for female peer and mentor connections. The findings are consistent with Han's assertions, which highlight how hierarchical structures tend to privilege male members while systematically marginalizing women.

Support from Parents and Family Members

Ann emphasizes the importance of family support in her decision to pursue pure sciences. Free from immediate financial pressure due to her family's backing, she can focus on long-term academic and career goals. This supports prior findings on the positive impact of parental encouragement on women entering STEM or nontraditional fields. Her experience contrasts with Liu's and Hung's [57] findings on women prioritizing family over career or abandoning aspirations due to economic pressures, and aligns with Rice et al.'s findings on the benefits of broad social support.

Engaged Learner and Professional Identity Building

Despite her awareness of gender bias, Ann remains committed to her goal of becoming a pure scientist. Her dedication reflects trends in Taiwanese women increasingly rejecting traditional gender roles. Ann shows strong behavioral engagement (attendance, effort, persistence), cognitive engagement (self-regulation, group discussions), and emotional engagement (positive attitudes toward peers, faculty, and her academic environment). This multidimensional engagement fosters her academic success and sense of belonging, consistent with Fredricks et al. and Kuh et al..Through her participation in the pure sciences community, Ann develops professional pride and identity, equipping herself with both academic competence and career readiness. This reinforces the importance of personal and career interest, recognition of career pathways, and self-awareness in women's choice of nontraditional fields [58].

Implications and Conclusions

To attract and retain more women in pure sciences, universities should actively recruit female professors, professionals, and students, and provide resources such as mentorship programs. Counseling and educational initiatives should counter gender stereotypes and cultivate supportive institutional climates. Activities that foster interpersonal support and social networks are essential. The presence of female peers and FRMs can inspire persistence, while male peers can contribute by facilitating integration into study groups and research teams.

Acknowledgements

This study is a part of a project. It was sponsored by a grant (MOST 108-2629-H-007-001) from the National Science and Technology Council, Taiwan.

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Citation:

Yii-Nii L (2025) Navigating a Male-Dominated Discipline: Learning and Development of a Female Master's Student in Pure Sciences in Taiwan. *Psychol J Res Open* Volume 7(4): 1-6.