Asia Pacific Education Review (2024) 25:733–749
https://doi.org/10.1007/s12564-022-09775-4

The influencing mechanism of research training on Chinese STEM Ph.D. students' career interests

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Received: 28 October 2021 / Revised: 21 June 2022 / Accepted: 29 June 2022 / Published online: 21 July 2022

Abstract

Using 9277 records from the 2020 China Graduate Student Satisfaction Survey, we examined the relationship between STEM Ph.D. students' research training and their subsequent career interests. Based on the student involvement theory and social cognitive career theory, four dimensions of research training (quantitative involvement, qualitative involvement, and the advisors' instrumental and psychosocial mentoring) and a linking mechanism between research productivity and self-efficacy (a belief in one's ability to perform particular behaviors or courses of action) were identified. Using the number of participating research projects, research roles, advisor–student communication time, and advisors' psychosocial support as proxies for these dimensions, we found that quantitative involvement, non-peripheral qualitative involvement, and advisors' psychosocial mentoring are positively associated with students' subsequent interest in research-oriented careers, indicating that research training is significantly associated with future career interests. The mechanism linking research training and career interests includes the path via research productivity and self-efficacy, but it does not apply to all research roles. The associations between quantitative involvement and career interests, and between advisors' psychosocial support and career interests also show such mediation effect among students with nonresearch-oriented motivation, suggesting that they need explicit signals and direct psychosocial support to reshape their career outcome expectations.

Keywords Research training · Career interest · Doctoral education · STEM Ph.D. students · China

Introduction

The booming knowledge economy shows a growing dependence on frontier scientific and technological knowledge sustainably contributed by scientists (Bogle et al., 2011; Yoshioka-Kobayashi & Shibayama, 2021). Innovation in science, technology, engineering, and mathematics (STEM) is specifically emphasized in this process. Given that Ph.D. graduates "understand what is known and discover what is yet unknown" (Shulman, 2008) and are expected to provide intellectual leadership to face today's and tomorrow's challenges (Wendler et al., 2010), countries need to train STEM Ph.D. workforces to sustain future leadership in innovation and research (Bogle et al., 2011; Ostriker et al., 2011). Consequently, many countries, including China, have made substantial investments in training STEM scientists at the doctoral level, seeing them as key to knowledge-driven economic growth (Cyranoski et al., 2011). China is dedicated to nurturing Ph.D. students as future researchers with creativity; in 1980, China's legislature approved the *Regulations on Academic Degrees*, stipulating that Chinese Ph.D. education should train students to meet the standard of being able to undertake independent scientific research and make creative achievements in either science or a particular technology.[1] Regarding the size of the doctoral education sector, China has also become an emerging powerhouse over recent decades. In STEM fields, China has consistently awarded more doctorates than the United States since the mid-2000s, and the number of STEM Ph.D. graduates in China (excluding health sciences) is 30% higher than that in the United States in 2019 (Zwetsloot et al., 2021).

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Responding to the extensive investment in doctoral education, the orientation of Ph.D. students' career interests, or the desire to pursue a certain career, is worth focusing on (Curtin et al., 2016; Shin et al., 2018). The Ph.D. degree is a research degree, and Ph.D. degree holders are expected to be "stewards of disciplines" dedicated to research (Golde, 2006). If they ultimately find employment outside the research system, Ph.D. students may use less of their professional knowledge and research competencies (Kyvik & Olsen, 2012). This does not mean that Ph.D. graduates should only seek academic professions, since non-academic organizations, such as companies, also become essential hubs for research and development, attracting highly educated researchers (Gemme & Gingras, 2012). Thus, unlike the traditional categorization of Ph.D. graduate careers as a choice between an academic career and a non-academic career, according to whether the career involves research as the primary task, we categorize the choice as being between a research-oriented career and a nonresearch-oriented career. It is hoped that Ph.D. students can utilize their research skills in all research-oriented positions to better address the "three-way mismatch between student goals, training, and actual careers" (Golde & Dore, 2001).

The growing diversity of STEM Ph.D. students' career choices beyond purely research-oriented positions upon graduation has been a noteworthy phenomenon (Choe & Borrego, 2020; Roach & Sauermann, 2017; Sauermann & Roach, 2012; Shen et al., 2015). An analysis by the American Institutes for Research in a 2010 survey showed that 61% of United States STEM Ph.D. holders pursue careers outside of academia, and among them, 43% reported that they were not treating research as their primary work activity (Turk-Bicakci et al., 2014). In China, over 50% of STEM Ph.D. graduates have still entered universities and research institutes (the two major sectors offering research-oriented positions in China) in recent years, a lower proportion than that in the arts, humanities, and social science disciplines (Luo et al., 2022). The flow of Chinese Ph.D. graduates into the non-academic labor market is growing, and the diminishing interest in research-oriented careers is pronounced, especially in the STEM fields (Gu et al., 2018; Shen et al., 2015). It is a concern that STEM Ph.D. students' declining interest in research may reduce the inward flow of new scientists and impact future knowledge production (Mangematin, 2000; Roach & Sauermann, 2017). To cultivate the next generation of scientists, policymakers should strategize to engender STEM Ph.D. students' career interest in research and pave the way to further translate this interest into career pursuits (Gibbs & Griffin, 2013; Roach & Sauermann, 2017).

The research training of doctoral students is implied to be related to their subsequent career preferences. Doctoral research training is the initial and essential step for junior scientists to gain the knowledge and skills required to become independent scientists (Yoshioka-Kobayashi & Shibayama, 2021). Historically, research training has played a critical role in doctoral training. For example, in 1988, the United Kingdom set as its official purpose of doctoral education to "enable graduates to make original contributions to their respective disciplines" and "provide professional research training enabling Ph.D. students to become independent researchers" (Committee of Vice-Chancellors and Principals, 1988). Research training is essential because it equips students with the "capacity to innovate" (Hoyne et al., 2016), possessing a comprehensive skillset not limited to specialized technical skills but covering those broad generic skills required by research, such as leadership and critical thinking. Research training is also crucial for Ph.D. students' socialization, whereby they internalize behavioral norms and acquire the knowledge, values, dispositions, and habits of mind vital to their future careers (Gardner, 2007; Weidman & Stein, 2003). As research training is more under the control of universities and departments, understanding the relationship between research training and STEM Ph.D. students' subsequent career interests would provide practical insights for future decision-making in doctoral education.

Some evidence suggests that Chinese STEM Ph.D. students' diminishing research-oriented career interests could be related to the research training they receive. A global survey by *Nature* shows that doctoral research training in China does not generate much satisfaction, compared with that in other countries (Woolston & O'Meara, 2019). Despite initially considering research to be "beautiful and romantic before entering the laboratory," Chinese doctoral students often encounter various difficulties and struggle with reality as they go through the actual training process (Woolston & O'Meara, 2019). Given the previous finding that students' sense of progress on their research projects and satisfaction in research may account for their attrition and loss of research interest (Devos et al., 2017), it is highly likely that current research training in China is also tied to Ph.D. students' decreasing interest in a research-based career. Yet, there is still a lack of research exploring this connection.

In this study, we explore the association between doctoral research training and the career preferences of STEM Ph.D. students and the underlying mechanism for such an association, using 9277 Ph.D. students' survey responses. Specifically, we investigate various variables that contribute to STEM Ph.D. students' interest in research-oriented careers, for both those who entered their Ph.D. program with the goal of a research-oriented career and those with that of a nonresearch-oriented career. We are particularly interested in examining whether and how research training can alter one's career interest from a nonresearch-oriented career upon entering a Ph.D. program to a research-oriented career after enrolling and receiving research training. From this research, we expect to draw practical implications to inform strategies and actions that would facilitate STEM Ph.D. students' inclination for research-oriented careers. Given its size and speed of expansion, China's doctoral education is an appropriate case for our study, and our study results are expected to produce implications for other countries as well.

Literature review

Micro-level factors affecting career interests

Evidence shows that Ph.D. students' demographic features, motivation, and research training are micro-level factors affecting career interests.

Gender is considered to be closely related to the career choices of Ph.D. holders. Since research-oriented jobs are often time-consuming and stressful (Huang & Wang, 2022), they may be less appealing for women, who in general spend more time on childcare responsibilities and household tasks (Misra et al., 2012). Women were also reported to experience more research pressure, job stress, and work–family conflict than men (van Daalen et al., 2006; Zheng et al., 2022). Systematic barriers related to motherhood was also found to contribute substantially to the "leaky pipeline" in academia (Anders, 2004), the phenomenon that women leave academia from graduate study all the way to senior professorship at higher rates than men. Moreover, STEM-related occupations have long been male-dominated (Ceci et al., 2014), partly due to women's lesser self-efficacy—a belief in one's ability to perform particular behaviors or courses of action—in the STEM fields, where "brilliance" is stressed and women are doubted and disparaged by widespread stereotyped beliefs in their ability or lack thereof (Muradoglu et al., 2021).

Family background is related to students' cultural capital and career interests in STEM-related occupations and research-oriented careers (Rodriguez et al., 2020). Specifically, well-educated parents can furnish more science experience and career advice and create a family habitus for science to support their children's science career aspirations (Jones et al., 2021; Levine & Hoffner, 2006). Parents with research experience are also likely to encourage their children to likewise engage in research (Austin, 2002). In addition, family location matters in China. China established an administrative system for household registration that categorizes citizens into urban and rural residents to prevent large-scale labor migration. Rural residents generally have limited access to economic and cultural resources and related opportunities (Afridi et al., 2015). However, rural students with Ph.D. degrees are more likely to subsequently work in academia to exit the original family environment and pursue upward social mobility (Bao et al., 2020).

The motivation to pursue a Ph.D. degree may also be directly related to career interests. Churchill and Sanders (2007) identified four motivations for doctoral studies: career development and mobility, improving research skills and insights, a personal research interest, and simply drifting in. In this study, we re-categorized the motivation for research-oriented career development and mobility, improving research skills and insights, and personal research interest as research-oriented motivations and the motivation for nonresearch-oriented career development and mobility and drifting in as nonresearch-oriented motivations. Ph.D. students with a research-oriented motivation may perceive their learning and research process more positively (Shin et al., 2018) and are more likely to choose a research career. A study of 1903 Chinese Ph.D. students found that Ph.D. students with a research-oriented motivation for Ph.D. studies are more likely to be interested in research-oriented positions (Zhao & Hong, 2014). Moreover, following their entry into the program, the time duration that a student has been in the program may also be related to Ph.D. students' career interests. Golde and Dore (2001) found that although doctoral students may be motivated toward academic professions before entering the program, they might change the direction of their career interests later. It was suggested that students' research aspirations and interest in research careers diminished over time in Ph.D. programs (Guo et al., 2018; Roach & Sauermann, 2017).

Ph.D. students' research training may also impact their career interests directly (Kim et al., 2018). Studies have indicated that research training in doctoral education generally follows an apprenticeship model, where students participate in research and learn by exploring the unknown under the advisors' mentoring (Curtin et al., 2016; Delamont & Atkinson, 2001; Gould, 2015; Gu et al., 2018). Thus, two aspects are critical in the socialization process: students' research participation and advisors' mentoring (Ynalvez & Shrum, 2011). Students' participation in research is directly linked to their career development, as it is essentially the preparation required for entering the career track of independent scientists. Specifically, engaging in research projects under the supervision of established scientists is the primary approach for the development of junior scientists (Delamont & Atkinson, 2001; Yoshioka-Kobayashi & Shibayama, 2021). It engenders a learning environment and a small scholarly community where students interact and learn from other research partners, gaining the experience, skills, and norms required to propel the doctoral socialization process (Pyhältö et al., 2009; Weidman, 2006). Moreover, their advisors' mentoring may encourage Ph.D. students to pursue research-oriented positions. Several studies reveal that advisors guide Ph.D. students toward the academic world, and Ph.D. graduates' career networks and trajectories tend to be similar to those of their advisors (Blackburn et al., 1981). Ph.D. students often adjust their career expectations, following their advisors, to obtain assistance in publishing, resources, and career development (Mangematin, 2000).

Additionally, studies show that Ph.D. students' research productivity during their doctoral studies may affect their subsequent career trajectories. In most STEM fields, published papers signal student research productivity, and the experience of publishing papers during Ph.D. studies well predicts a researcher's future achievements (Gemme & Gingras, 2012; Horta & Santos, 2016). The value of publications is particularly accentuated in China's research evaluation system and Ph.D. students' mindsets (Guo et al., 2020). Most institutions require Chinese graduate students to have at least one first-authored paper, with certain levels of the journal impact factor, to get their Ph.D. degree (Woolston & O'Meara, 2019). With more published papers during their studies, Ph.D. graduates may prefer research-related jobs (Shen et al., 2018) and are more likely to find a job in academia (Conti & Visentin, 2015; Mangematin et al., 2000).

Meso-level factors affecting career interests

Meso-level factors related to Ph.D. students' career interests include institutional prestige and environment. The prestige of doctoral institutions may affect students' career interests. Under the influence of university rankings, higher education systems across all countries become stratified and hierarchical in structure (Headworth & Freese, 2016; Oprisko et al., 2013; Yang et al., 2022). The institutional stratification of Chinese higher education is more evident due to a series of government-led national policies that promote this process. One of the latest policies is the Double First-Class Initiative, which grants a selected group of Chinese universities more concentrated financial and policy support from the government to build world-class universities (Peters & Besley, 2018). Employers may weigh institutional prestige as a variable while evaluating job candidates (Oprisko et al., 2013). For example, Hargens and Hagstrom (1967) found that the prestige of the faculty's current affiliation was positively associated with the prestige of their doctoral origins. A recent study focusing on economics shows that the probability of Ph.D. students getting a tenure-track faculty position in a top-20 department would be hugely improved by graduating from a top-ranked institution (Sullivan et al., 2018). This factor may affect Ph.D. students' confidence in securing a research-oriented position and impact their subsequent career interests.

The institutional environment can also affect Ph.D. students' subsequent career interests. A supportive research culture and atmosphere can help enhance Ph.D. students' integration into their scientific communities and reduce dissatisfaction and attendant attrition (Duke & Denicolo, 2017; Li et al., 2022). In communities where students are treated equally as faculty colleagues, they can assimilate the general norms of those communities in advance (Weidman & Stein, 2003). Moreover, taking curriculum courses provides Ph.D. students with opportunities to observe respected researchers in their field and exchange ideas within a broader community (Rosser, 2004). Communication with academic professionals and fellow candidates is an important path for Ph.D. students to acquire professional knowledge and skills, develop their passion, and forge a professional identity (Kim et al., 2018). With that identity, students may understand that their career roles fall within the category of researchers and thus gravitate more toward a research-oriented career (Golde & Dore, 2001).

Macro-level factors affecting career interests

At the macro-level, labor market conditions have been discussed as an essential factor influencing Ph.D. students' career interests. Studies have investigated the current saturation in the global academic job market; openings for professors, especially full-time ones, at research universities are becoming highly competitive, and the production of new Ph.D. degree holders outstrips the market demand (Cyranoski et al., 2011; Walters et al., 2020). Students may fear the intense competition for jobs or have pessimistic expectations for their career outcomes in the labor market. In contrast, the industry job market has strong traction for STEM Ph.D. graduates due to its growing importance in research and development and higher financial incentives (Choe & Borrego, 2020; Gu et al., 2018). However, industry jobs may not necessarily match Ph.D. students' professional and research skills and, to a large extent, only utilize their generic skills (Kyvik & Olsen, 2012).

In China, research-oriented positions (mostly centralized in universities and research institutions) remain appealing to Ph.D. graduates, even with the growing attraction of industries. China's industries grow fast. In 1978, China launched the reform and opening-up policy, revitalizing its economy through domestic market reforms and opening up to the international market. After four decades of accelerated economic growth, China has become the second-largest economy globally, creating many new jobs in various industry sectors with attendant high salaries. However, Chinese industries have a limited number of research-oriented positions; most Ph.D. graduates currently employed in enterprises lack considerable advantages in their starting salaries compared with counterparts employed in universities and research institutes (Shen et al., 2018). Jobs at universities and research institutes are regarded as stable and of high social status with more organizational premiums on income because they belong to the government-affiliated public sector, where wages and welfare are paid from public funds (Wu, 2014). Opportunities for Ph.D. graduates in the Chinese academic job market are also rich. In 2016, only 22.9% of the full-time faculty at Chinese universities and 17.6% of research and development personnel at research institutes had doctoral degrees, which is far from the saturation level (Wang & Yang, 2019). Beyond faculty positions, based on China and other countries' past growth, it is predicted that China can create at least 24,000 additional postdoc positions for Ph.D. graduates in future (Wang & Yang, 2019). Unlike other countries, Chinese postdoc positions are attractive due to better financial incentives and opportunities for direct promotions to assistant professor rank (Shen et al., 2018). For Chinese Ph.D. students who pursue a university research position, research-oriented job opportunities appear to be plentiful (Cyranoski et al., 2011; Woolston & O'Meara, 2019).

Although previous studies have laid the foundation for a comprehensive understanding of the factors related to Ph.D. students' career interests, there are also gaps. Existing studies overlooked the quantity and quality of an individual Ph.D. student's participation in research training. Ph.D. students' socialization during doctoral studies is highly contingent and complex through the interaction of individual and organizational characteristics (Weidman, 2006). Students may differ in terms of both quantitative and qualitative aspects of participation in research training—some students may be given a high degree of research autonomy to design their study and explore new knowledge independently, whereas in disciplines such as chemistry, the equipment and skills often needed for research activities and time-consuming projects may delay the Ph.D. student's development of autonomy (Barnard & Shultz, 2020). Thus, we need a more extensive framework to examine STEM Ph.D. students' research training comprehensively.

Second, the mechanism linking research training and career interests has not been fully explored. Although research training and research productivity are found to affect Ph.D. students' career interests and choices, they are not isolated, as research productivity can be developed through research training. Moreover, psychological factors, including self-efficacy, are often neglected when analyzing Ph.D. students' career interests, whereas self-efficacy is a predictor of career interests and a partial mediator between advisors' mentoring and career interests (Curtin et al., 2016). Thus, it should be beneficial to incorporate research productivity and self-efficacy into the potential mechanism in the current framework explaining Ph.D. students' career interests.

Theoretical framework

Research training: student participation and advisor mentoring

Student participation and advisor mentoring are two key aspects of research training. We use the theory of student involvement (Astin, 1999) to characterize student participation. This theory assumes that student involvement, which refers to the quantity and quality of the physical and psychological energy that students actually invest, is positively associated with student performance. Based on this theory, it was found that the frequency and quality of student participation were associated with high aspirations and attendant self-confidence of students (Foreman & Ret al.,lick, 2013; Pascarella & Terenzini, 1991).

Quantitative involvement is the amount of energy a student devotes to an activity (Astin, 1999). It is operationalized as being expressed as the number of research projects a student has been involved in. As Laudel and Gläser (2008) suggested, proceeding iteratively from one research project to the next constructs all researchers' research trails, which constitute their research trajectories throughout their careers. Although it does not necessarily lead to the expected outcomes such as research productivity and skill development, the number of research projects participated in embodies how extensively the students have formed their diachronic and continuous structure of research that thereby gradually extends their cognitive boundaries (Laudel & Gläser, 2008). This measure has also been applied by other studies to measure aspects such as the degree of research collaboration (Ynalvez & Shrum, 2011).

Hypothesis 1 STEM Ph.D. students' quantitative involvement is associated with career interests.

Qualitative involvement is the psychological energy a student devotes to an activity in occupying different types of roles (Astin, 1999; Foreman & Retallick, 2013). It is evaluated in this study by asking about the types of roles a student has occupied in research projects. As novice researchers, Ph.D. students do not necessarily undertake major roles in research projects; they may start with more manageable parts of research projects to learn research skills (Delamont & Atkinson, 2001). The need to occupy different roles also derives from the demand for collaboration in modern research, which increasingly centers on complex scientific problems and requires the collective strengths and expertise of team members (Gibbons et al., 1994). Following Ni et al.'s (2021) classification of research work, we classify the research roles as literature

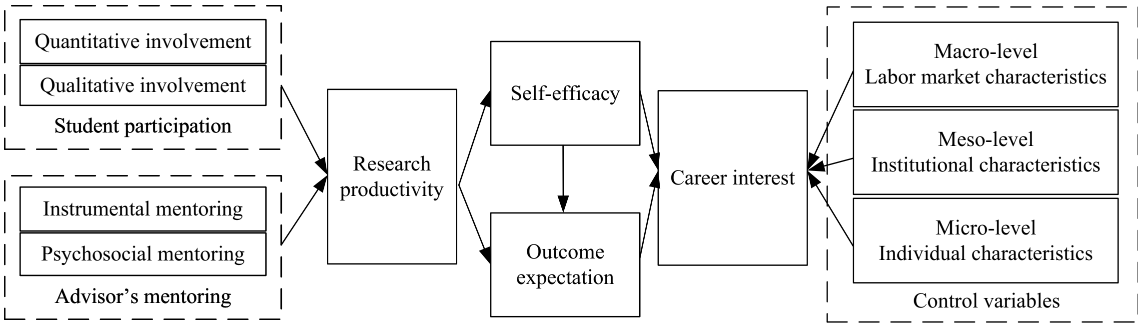

Fig. 1 Conceptual framework of the relationship between research training and career interests

reviewer, study designer, data collector, data analyst, manuscript writer, and auxiliary assistant. The auxiliary assistant role usually contributes to projects by performing management and coordination tasks and technical work, such as managing a lab and installing software (Roach & Sauermann, 2017).

Hypothesis 2 STEM Ph.D. students' qualitative involvement is associated with career interests.

In addition to student participation, advisor mentoring is an important aspect of research training (Kim et al., 2018). This study draws on two variables, the advisor–student communication time during the research (hereafter, the advisor–student communication time) and the psychosocial support provided by advisors, corresponding to Kram's (1988) two dimensions of mentoring, namely, instrumental and psychosocial mentoring. The first focuses on imparting the skills and knowledge thought essential for successful research performance. The second denotes giving psychological and social support, encouragement, and advice. Both dimensions are positively associated with students' research training satisfaction (Zhao et al., 2007).

Hypothesis 3 Advisors' instrumental mentoring is associated with STEM Ph.D. students' career interests.

Hypothesis 4 Advisors' psychosocial mentoring is associated with STEM Ph.D. students' career interests.

Mechanism: social cognitive career theory

Social cognitive career theory (SCCT) suggests a potential mechanism linking research training and subsequent career interests. It assumes that career interest is related to a group of variables, including self-efficacy, outcome expectations, personal input, and contextual affordances, i.e., environmental and background variables (Gibbs & Griffin, 2013; Lent & Brown, 2013). Career interest derives from self-efficacy and outcome expectations, a belief about the consequences of performing a particular behavior (Landry, 2003; Lent & Brown, 2013). It is believed that performance accomplishment strengthens or weakens one's self-efficacy and outcome expectations, thereby influencing career interests (Lent & Brown, 2013). Based on SCCT, we hypothesize that research training (the behavior) leads to superior research performance, which enhances students' self-efficacy and finally increases their career interest in research. The research performance is approximated here by the research productivity.

Hypothesis 5 The association between research training and STEM Ph.D. students' career interests is mediated by research productivity and self-efficacy.

In sum, Astin's theory of student involvement, Kram's theory of mentoring, and Lent and Brown's theory of SCCT provide this study with a foundation for constructing a joint theoretical framework for investigating the association between Ph.D. students' research training and career interests and its potential mediators (see Fig. 1). The first two theories help conceptualize apprenticeship research training at the doctoral level and postulate that quantitative involvement, qualitative involvement, and advisor mentoring affect research productivity. From the starting point of research productivity, SCCT further assumes that better performance in research productivity can enhance students' self-efficacy toward pursuing research-oriented careers. Meanwhile, variables of the micro-level personal input and the meso- and macro-level contextual affordances may also influence the process. The subsequent sections of this study examine the validity of this framework.

Data

Source

We used data from the 2020 China Graduate Student Satisfaction Survey (CGSSS). CGSSS is a nationwide survey

Table 1 Variable definitions and descriptive statistics

Variables	Assignment	Size	Mean	SD
Dependent variable				
Career interest	1 = in research-oriented positions; 0 = in non-research-oriented positions	9,277	0.85	0.36
Independent variable				
Research project number	Continuous. 0~3 = zero~three; 4 = four or above	9,277	1.94	1.23
Research role				
Literature reviewer	Ordinal. 0 = The fourth or below major role having been played in research projects; 1~3 = The third~the first	8,220	1.39	1.35
Study designer		8,220	1.21	1.26
Data collector		8,220	1.42	1.18
Data analyst		8,220	0.99	1.01
Manuscript writer		8,220	0.65	0.89
Auxiliary assistant		8,220	0.10	0.44
Advisor-student academic communication time	Ordinal. 1 = below 1 h/week; 2 = 1–5 h/week; 3 = 6–10 h/week; 4 = over 10 h/week	9,277	2.06	0.78
Advisor's psychosocial support	Ordinal. 1~5 = Very small~Very large	9,277	4.25	0.97
Mediating variable				
Published paper number (first or corresponding author)	Continuous. The range is 0~21	9,277	1.33	1.86
Research ability increase	Ordinal. 1~5 = Very little~very much	9,277	4.45	0.67
Control variable				
Gender	1 = Men; 0 = Women	9,277	0.63	0.48
Institutional prestige	Ordinal. 3 = Double First-Class Universities, 2 = First-Class Disciplines Universities, 1 = Others	9,277	2.59	0.62
Parents' highest educational level	1 = Attained higher education or above; 0 = Did not attain	9,277	0.26	0.44
Family location	1 = In rural areas; 0 = In urban areas	9,277	0.49	0.50
Year in the program	Ordinal. 1 = First year, 4 = Fourth year or above	9,277	2.34	1.16
Motivation for Ph.D. studies	1 = Research-oriented; 0 = Non-research-oriented	9,277	0.84	0.36
Curriculum usefulness	Ordinal. 1~5 = Very little~very much	9,277	3.84	0.83
Academic atmosphere	Ordinal. 1~5 = very weak~very strong	9,277	4.25	0.81

administered annually by *Academic Degrees & Graduate Education*, a journal hosted by the Academic Degrees Committee of the State Council of China. The questionnaire design and revision of 2020 CGSSS was assisted by the Institute of Education, Tsinghua University. The survey was distributed in March 2020 among graduate students enrolled in 112 randomly selected four-year universities authorized to confer graduate degrees. The survey was distributed via email and popular social media applications with the cooperation of the 112 institutions. Participation in the survey was anonymous and completely voluntary. The survey collected 110,256 responses, among which 109,253 (99.1%) were complete and valid. The responses included 13,263 Ph.D. students, on which we examined the sample representativeness and possible biases with national data sources (see Appendix Supplementary Information, Table S1–S2).

Given the target of this study, 9277 responses by STEM Ph.D. students enrolled in 50 universities were extracted (see Appendix, Table S3, for the sample distribution). It should be noted that the disciplines in the questionnaire were classified according to the official discipline classification system by the State Council Academic Degree Committee Subject Categories of China (2011 version). The classification system is hierarchical, with 13 broad-level superordinate categories and 111 subordinate fields. We selected three categories—Natural Science, Engineering, and Agriculture (see Clarivate (2021) for the subordinate fields)—as Ph.D. graduates from these three categories have similar employment structures (see Appendix, Table S4), offsetting the possible interference of the labor market in the analysis.

Variables

Based on the structural design of the survey and literature review, we set out variables as follows (see Table 1). The dependent variable was the career interest of STEM Ph.D. students, divided into research-oriented and nonresearch-oriented career interests. Independent variables included the number of research projects, research roles, advisor–student communication time, and advisors' psychosocial support.

The mediating variables were research productivity and improvement in self-efficacy. Research productivity was measured by the number of published papers, including the papers authored by the student as either the first author or the corresponding author, which better represents their academic contribution (Ni et al., 2021). Given Ph.D. students' apprenticeship and learning role during doctoral programs, the survey also considered students to be major contributors when the advisor was the first-named and the student was the second-named in the byline of publications, which is often called "student first authorship" in China. To assay self-efficacy, we used principal component analysis and extracted one factor from the self-reported enhancement in research-related abilities from their doctoral programs—professional knowledge, problem-solving skills, self-study skills, research skills, leadership, communication and cooperation skills, critical thinking skills, and presentation skills (all factor loadings > 0.8).

Control variables included career interest-related demographical and contextual factors: gender, institutional prestige, parents' highest educational level, family location, year in the program, motivation for Ph.D. studies, curriculum usefulness, and academic atmosphere. Admitting the potential role of student ability, we used institutional prestige as a control variable to mitigate its confounding impact in our study. Although institutional prestige is far from being a direct measure of student ability, we believe that the former is indicative of the latter in the context of China. Chinese universities often combine multiple methods to evaluate Ph.D. program applicants, striving to place students with high academic and generic ability in prestigious universities that offer an education commensurate with their ability (Horta & Santos, 2016; Wang, Li et al., 2021). In accounting for institutional prestige, we adopted the list of the Double First-Class Initiative released in 2017 by the Ministry of Education of China (Peters & Besley, 2018).[2]

Results

Research training and career interests

We first ran binary logistic regressions including the dependent variable and three independent variables: research project experience (whether a student has participated in at least one research project; by recategorizing the number of research projects into a binary variable), advisor–student communication time, and advisors' psychosocial support. Research roles were not considered here as such because those who had no participation in any research projects logically did not have any research role. The results in Table 2 show that all three independent variables had significant positive associations with career interest (research project experience: odds ratio [OR] = 1.320, standard error [SE] = 0.134, p = 0.006; advisor–student academic communication time: OR = 1.108, SE = 0.043, p = 0.008; advisors' psychosocial support: OR = 1.191, SE = 0.045, p = 0.000). Aggregating by motivations for Ph.D. programs (research vs. nonresearch), we observed heterogeneity of the contribution by the advisor–student communication time. Advisor–student communication time was a significant contributor to career interests in research for the research motivation group (OR = 1.125, SE = 0.063, p = 0.036), but not the nonresearch motivation group.

To quantify the association between the number of research projects and research roles with career interests, we selected students who had participated in at least one research project and ran a binary logistic regression (see Table 3). The results suggest that overall, the number of research projects (OR = 1.078, SE = 0.035, p = 0.022), research roles other than auxiliary assistants (from literature reviewer to manuscript writer: OR = 1.108, SE = 0.045, p = 0.011; OR = 1.180, SE = 0.056, p = 0.001; OR = 1.150, SE = 0.055, p = 0.003; OR = 1.119, SE = 0.057, p = 0.027; OR = 1.174, SE = 0.084, p = 0.024), and advisors' psychosocial support (OR = 1.189, SE = 0.046, p = 0.000) were positively associated with a research-oriented career interest. Aggregating by types of motivation, the results show that the advisors' psychosocial support was the only variable showing a significant contribution to a research-oriented career interest for both research-oriented (OR = 1.195, SE = 0.066, p = 0.001) and nonresearch-oriented (OR = 1.181, SE = 0.086, p = 0.022) motivation groups. Another notable finding is that the number of research projects only showed significance in the nonresearch-oriented motivation group (OR = 1.167, SE = 0.057, p = 0.002), whereas the research roles other than auxiliary assistant only showed significance in the research-oriented motivation group (from literature reviewer to manuscript writer: OR = 1.149, SE = 0.051, p = 0.002; OR = 1.225, SE = 0.064, p = 0.000; OR = 1.171, SE = 0.055, p = 0.001; OR = 1.162, SE = 0.064, p = 0.007; OR = 1.218, SE = 0.096, p = 0.013).

The mediation effect of research productivity and self-efficacy

Mediation effect analysis helps explain the mechanism of two variables' association by examining the adjustment

[2] In 2015, China initiated the Double First-Class University plan, which superseded the former Project 211 and Project 985. In the first round (2016–2020), 42 universities were designated as Double First-Class Universities (universities aiming to build both world-class universities and world-class disciplines) and 95 institutions were designated as First-Class Disciplines Universities (universities aiming to build only world-class disciplines). In this list, Double First-Class Universities are generally perceived as more prestigious than First-Class Disciplines Universities.

Table 2 Binary logistic regression results of research-oriented career interest among the full sample

	(1) All	(2) Research-oriented motivation	(3) Non-research-oriented motivation
Independent variable			
Research project experience	1.320**	1.262*	1.486**
	(0.134)	(0.149)	(0.218)
Advisor-student academic communication time	1.108**	1.125*	1.073
	(0.043)	(0.063)	(0.071)
Advisor's psychosocial support	1.191***	1.222***	1.146*
	(0.045)	(0.063)	(0.076)
Control variable			
Gender (man over woman)	1.173*	1.169	1.174
	(0.082)	(0.104)	(0.119)
Institutional prestige			
(First-Class Disciplines University over others)	0.832	0.804	0.935
	(0.102)	(0.117)	(0.327)
(Double First-Class University over others)	1.025	1.015	1.067
	(0.087)	(0.130)	(0.333)
Parents' highest educational level	1.070	1.141	0.902
	(0.078)	(0.116)	(0.124)
Family location (rural areas over urban areas)	1.390***	1.564***	1.014
	(0.109)	(0.147)	(0.147)
Year in the program			
(second year over first year)	0.919	0.911	0.944
	(0.074)	(0.110)	(0.131)
(third year over first year)	0.842*	0.806	0.916
	(0.069)	(0.090)	(0.196)
(fourth year and above over first year)	0.662***	0.617***	0.787*
	(0.066)	(0.076)	(0.096)
Motivation for Ph.D. studies (Research-oriented over non-research-oriented)	4.845***		
	(0.264)		
Curriculum usefulness	0.850***	0.786***	0.971
	(0.037)	(0.035)	(0.070)
Academic atmosphere	1.089	1.111	1.050
	(0.077)	(0.090)	(0.090)
Constant	0.622	3.359***	0.522
	(0.164)	(1.120)	(0.246)
Observations	9277	7823	1454

Note Coefficients are odds ratios. Robust standard errors in parentheses, adjusted for clustering at the institution level

***$p<0.001$, **$p<0.01$, *$p<0.05$

of mediating variables on the relationship. Given our framework, we constructed a mediation effect model with a binary outcome to examine research productivity (*M1*) and self-efficacy's (*M2*) mediation effects between each research training variable (*X*) and career interest (*Y*) (MacKinnon, 2008) (see Table 4). We used bootstrapping procedures by random sampling with replacement 5,000 times from the sample to compute bias-corrected confidence intervals and test the statistical significance.

The result shows that for the whole sample, the number of participated research projects ($\beta=0.344$, SE $=0.019$, $p=0.000$), study designer ($\beta=0.062$, SE $=0.022$, $p=0.004$), data collector ($\beta=-0.080$, SE $=0.023$, $p=0.001$), manuscript writer ($\beta=0.102$, SE $=0.031$, $p=0.001$), advisor–student communication time ($\beta=0.060$, SE $=0.029$, $p=0.042$), and advisors' psychosocial support ($\beta=0.072$, SE $=0.031$, $p=0.019$) were associated with *M1*; *M1* was positively associated with *M2* ($\beta=0.019$, SE $=0.004$, $p=0.000$); and *M2*

Table 3 Binary logistic regression results of research-oriented career interest among Ph.D. students who have participated in research projects

	(1) All	(2) Research-oriented motivation	(3) Non-research-oriented motivation
Independent variable			
Number of participated research projects	1.078*	1.044	1.167**
	(0.035)	(0.045)	(0.057)
Research role			
Literature reviewer	1.108*	1.149**	0.955
	(0.045)	(0.051)	(0.083)
Study designer	1.180***	1.225***	1.019
	(0.056)	(0.064)	(0.093)
Data collector	1.150**	1.171***	1.029
	(0.055)	(0.055)	(0.095)
Data analyst	1.119*	1.162**	0.952
	(0.057)	(0.064)	(0.079)
Manuscript writer	1.174*	1.218*	0.997
	(0.084)	(0.096)	(0.102)
Auxiliary assistant	1.133	1.201	0.903
	(0.117)	(0.126)	(0.168)
Advisor-student academic communication time	1.058	1.081	1.018
	(0.040)	(0.060)	(0.075)
Advisor's psychosocial support	1.189***	1.195**	1.181*
	(0.046)	(0.066)	(0.086)
Control variable			
Gender (man over woman)	1.133	1.130	1.139
		(0.118)	(0.136)
Institutional prestige			
(First-Class Disciplines University over others)	0.811	0.797	0.854
	(0.121)	(0.134)	(0.324)
(Double First-Class University over others)	1.020	1.011	1.034
	(0.115)	(0.146)	(0.348)
Parents' highest educational level	1.043	1.116	0.886
	(0.086)	(0.115)	(0.148)
Family location (rural areas over urban areas)	1.365***	1.525***	1.014
	(0.110)	(0.151)	(0.158)
Year in the program			
(second year over first year)	0.932	0.937	0.927
	(0.081)	(0.140)	(0.145)
(third year over first year)	0.800*	0.797	0.792
	(0.085)	(0.117)	(0.179)
(fourth year and above over first year)	0.627***	0.602**	0.693*
	(0.076)	(0.100)	(0.104)
Motivation for Ph.D. studies	4.762***		
(Research-oriented over non-research-oriented)	(0.277)		
Curriculum usefulness	0.867***	0.816***	0.969
	(0.038)	(0.043)	(0.071)
Academic atmosphere	1.101	1.132	1.035
	(0.076)	(0.093)	(0.091)
Constant	0.347***	1.486	0.718
	(0.097)	(0.509)	(0.466)
Observations	8220	6939	1281

Note Coefficients are odds ratios. Robust standard errors in parentheses, adjusted for clustering at the institution level

$^{***}p<0.001$, $^{**}p<0.01$, $^{*}p<0.05$

Table 4 Mediation effect analysis results of research-oriented career interest among Ph.D. students who have participated in research projects

	All			Research-oriented motivation			Non-research-oriented motivation		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	M1	M2	Y	M1	M2	Y	M1	M2	Y
Mediating variable									
M1		0.019***	0.118***		0.017***	0.105**		0.042***	0.155**
		(0.004)	(0.032)		(0.004)	(0.033)		(0.012)	(0.047)
M2			0.182***			0.186***			0.167*
			(0.042)			(0.055)			(0.066)
Independent variable									
Number of participated research projects	0.344***	0.022**	0.031	0.350***	0.022*	0.002	0.307***	0.025	0.105
	(0.019)	(0.008)	(0.036)	(0.019)	(0.009)	(0.046)	(0.047)	(0.018)	(0.054)
Research role									
Literature reviewer	-0.042*	0.041***	0.099*	-0.036	0.037***	0.134**	-0.058	0.070*	-0.050
	(0.021)	(0.010)	(0.041)	(0.024)	(0.009)	(0.045)	(0.064)	(0.033)	(0.089)
Study designer	0.062**	0.049***	0.150**	0.062*	0.047***	0.188***	0.068	0.066	-0.003
	(0.022)	(0.011)	(0.048)	(0.025)	(0.011)	(0.054)	(0.071)	(0.036)	(0.091)
Data collector	-0.080***	0.052***	0.138**	-0.087***	0.046***	0.159***	-0.040	0.087**	0.020
	(0.023)	(0.009)	(0.047)	(0.026)	(0.009)	(0.048)	(0.084)	(0.030)	(0.087)
Data analyst	0.028	0.047***	0.099	0.022	0.045***	0.139*	0.067	0.060	-0.071
	(0.030)	(0.009)	(0.051)	(0.029)	(0.008)	(0.056)	(0.082)	(0.041)	(0.084)
Manuscript writer	0.102***	0.031*	0.142*	0.105**	0.019	0.183*	0.096	0.096**	-0.036
	(0.031)	(0.012)	(0.072)	(0.032)	(0.013)	(0.079)	(0.070)	(0.033)	(0.100)
Auxiliary assistant	0.043	-0.004	0.121	0.018	-0.006	0.186	0.150	0.015	-0.129
	(0.041)	(0.025)	(0.104)	(0.053)	(0.028)	(0.108)	(0.119)	(0.053)	(0.183)
Advisor-student academic communication time	0.060*	0.064***	0.040	0.061	0.073***	0.059	0.074	0.007	0.007
	(0.029)	(0.012)	(0.038)	(0.035)	(0.013)	(0.057)	(0.060)	(0.024)	(0.068)
Advisor's psychosocial support	0.072*	0.343***	0.104*	0.063	0.340***	0.112	0.106*	0.352***	0.095
	(0.031)	(0.011)	(0.042)	(0.034)	(0.012)	(0.063)	(0.045)	(0.027)	(0.080)
Observations	8220	8220	8220	6939	6939	6939	1281	1281	1281

Notes M1 is the number of published papers, M2 is the enhancement in self-efficacy, and Y is the research-oriented career interest. Robust standard errors in parentheses, adjusted for clustering at the institution level

***$p<0.001$, **$p<0.01$, *$p<0.05$

was positively associated with career interests ($\beta=0.182$, SE = 0.042, $p=0.000$). The bootstrapping results demonstrate that the path effects were statistically significant (see Appendix, Table S5). These variables also showed effects via *X–Y, X–M1–Y*, or *X–M2–Y*, which suggests that *X–M1–M2–Y* performed partial mediation. The roles of literature reviewer and data analyst were significantly associated with career interests via *X–Y* and *X–M2–Y*. The role of auxiliary assistant did not show any significant association. Disaggregated by motivations, we found that the results were robust among those with research-oriented motivations. Within the nonresearch-oriented motivation group, only the number of participated research projects ($\beta=0.307$, SE = 0.047, $p=0.000$) and advisors' psychosocial support ($\beta=0.106$, SE = 0.045, $p=0.020$) showed a significant association with M1. M1 was associated with M2 ($\beta=0.042$, SE = 0.012, $p=0.000$), which was associated with career interests ($\beta=0.167$, SE = 0.066, $p=0.011$).

Discussion

Using data from the 2020 CGSSS, we examined the association between research training and career interests among Chinese Ph.D. students in the STEM disciplines. The results support Hypotheses 1, 2, and 4; participation in research projects, non-peripheral research roles, and advisors' psychosocial support were positively associated with STEM Ph.D. Students' research-oriented career interests. However, as the advisor–student communication time was not significant among those who participated in research projects, Hypothesis 3 was not supported. For Hypothesis 5, it was found that the number of research projects, study designer, manuscript writer, advisor–student communication time, and advisors' psychosocial support were positively associated with research-oriented career interests via the path including research productivity and self-efficacy; however, that path showed a negative coefficient for the association between data collector and a research-oriented career interest. The above hypotheses were generally supported among those students with a research-oriented motivation. However, the nonresearch-oriented career motivation group showed a different picture. The number of research projects and advisors' psychosocial support were significantly associated with research-oriented career interest, and the association was mediated via the path including research productivity and self-efficacy.

Overall, the results validate our tripartite theoretical framework of student involvement, mentoring, and SCCT; adequate research projects and undertaking essential research roles offer STEM Ph.D. students platforms and resources to improve research productivity, which further enhances students' competence and self-efficacy in discovering knowledge and justifies their research-oriented career interests (Austin, 2002; Gardner, 2009). Aligning with Curtin (2016), advisors' psychosocial support also showed its effect via this approach. This support could be vital to students' development. The Confucian tradition of filial piety and respecting teachers embeds Chinese Ph.D. students in the advisors' research micro-communities (*Shi-men*), where the advisors care for students as parents do and students support peers as if they were siblings (Guo et al., 2020). The shift from the apprenticeship relationship to the family model strengthens the emotional and social bond between advisors and students and even shapes students' personal attachment to advisors (Zhang & Zhang, 2021), thus reinforcing the advisors' role in subsequently shaping career interests.

The framework also needs improvement. Unlike other research roles, the role of an auxiliary assistant was not significantly associated with career interests. Devos et al. (2017) noted that Ph.D. students' perception of ownership of their research projects is vital to their academic success. In contrast, a peripheral auxiliary role generally makes less of a sense of involvement in research. Meaningful, non-auxiliary research roles prevent students from feeling like "outsiders" (Pyhältö et al., 2009). Developing research autonomy, rather than doing auxiliary work under others' demands, is the key to the extent of involvement and research productivity (Barnard & Shultz, 2020; Horta & Santos, 2016). Students need to be encouraged to reflect continuously on their individual research experiences and proactively create learning opportunities via interactions with other research roles (McAlpine & Asghar, 2010).

The associations between some roles, including literature reviewer and data analyst, and research-oriented career interests were only mediated by enhancement in self-efficacy; the role of a data collector actually negatively correlated with research productivity, which affects students' self-efficacy. One potential reason lies in different roles' perceived importance and required investments. Ni et al.'s (2021) survey found that scientists in STEM fields rated the manuscript writer role as the most important. In contrast, although data analyst and data collector roles are also important, they are generally more explorative, are time-consuming, and require iterations of trial, error, and retrial (Bucher & Stelling, 1977). The literature reviewer role, also requiring time and effort, is rated as even less important. Occupying these roles, therefore, likely decreases efficiency and the possibility of publishing papers as key contributors. Another reason may be the power inequality in publication. Faculty may be ranked higher in author bylines since positions in the academic hierarchy may affect credit attribution (Paul-Hus et al., 2020). In the advisor–student apprenticeship, students may become de facto "cheap labor" in laboratories (Zhao et al., 2007), exploited by the faculty in research but receiving disproportionate rewards, including their deserved authorship. Studies focusing on China reported that advisors may abuse their authority in *Shi-men* to exploit student labor, and students are often acquiescent to that behavior to protect their private interpersonal relationships (*guanxi*) with their advisors (Zhang & Zhang, 2021). This authoritarian mentoring style will significantly undermine students' interest in a career in academia (Kim et al., 2018).

Although the association between advisor–student communication time and research-oriented career interests was mediated by research productivity and self-efficacy, it did not show a significant association with the career interests of Ph.D. students. While it aligns with Curtin's (2016) finding that instrumental mentoring enhances self-efficacy, which focuses on instructing in the skills and knowledge essential for successful research performance and beliefs, other factors may counteract the effect on career interests. For example, excessive communication time on research may increase the students' intra-role stress by making them feel that they must work harder to meet advisors' expectations or increase inter-role pressure by intensifying the conflict between work and non-work roles (Grady et al., 2014). The interactive mechanisms between instrumental mentoring and students' career interests open up opportunities for future research.

Finally, the significant effects of quantitative involvement and the advisors' psychosocial support on the association between research training and career interests among STEM Ph.D. students within the nonresearch-oriented motivation group imply that they may need explicit signals to reinforce their self-efficacy and refresh their career outcome expectations. As Gemme and Gingras (2012) noted, For students who did not start accumulating signs of scientific affiliation (such as publications and prestigious scholarships) during their undergraduate years (or even before!), faculty positions may not initially have belonged to the realm of possible (or even thinkable) outcomes. However, later rewards…may have warmed up their academic aspirations.

Having come to the doctoral program with a nonresearch-oriented motivation, those students may doubt their ability in doing research and do not consider, or even dare not consider, finding a research-oriented position, thereby constraining their career interests. The qualitative enculturation process in research roles is insufficient to break the constraint, and students need to find explicit "reasons" to redirect their career interests. The increase in the number of research projects, as shown in the mediation effect analysis, leads to growth in their research productivity, signaling acknowledgment from the scientific communities and credit for their work (Merton, 1969). Their career outcome expectation may then be revisited when they have recognized that research-oriented positions are actually suitable for them. Advisors' psychosocial support is another signal that directly adjusts their state of mind and establishes career cognition toward research-oriented careers (Sauermann & Roach, 2012). Therefore, visualizing their competence through research performance and delivering direct career mentoring may be pivotal in inspiring students toward a research-oriented career path.

Conclusions

This study constructed a joint theoretical framework for understanding the relationship between research training and the career interests of Ph.D. students and empirically tested its effectiveness with a view for further improvement. We framed research training into four dimensions (quantitative involvement, qualitative involvement, and advisors' instrumental and psychosocial mentoring) and found that quantitative involvement, non-peripheral qualitative involvement, and advisors' psychosocial mentoring were positively associated with students' intention to pursue a research-oriented career. More importantly, our results suggest that the mechanism linking research training and career interests includes the path via research productivity and self-efficacy. The associations between quantitative involvement and career interest and between advisors' psychosocial support and career interest were shown to be mediated by the mediators among students with a nonresearch-oriented motivation, suggesting that they need explicit signals and direct psychosocial support to reshape their career outcome expectations.

This study offers insights for related stakeholders into actions to reform STEM doctoral education for the future training of scientists. Certain levels of quantitative involvement and non-peripheral qualitative involvement should benefit STEM Ph.D. students by being integrated into the disciplinary culture, driving their socialization, and inspiring their research-oriented career interests. It also manifests the Ph.D. advisor's pivotal standing and responsibility in research training, which are crucial in the doctoral training system in China. Raising advisors' awareness of ensuring sufficient research instruction and psychosocial mentoring toward research should be an important, persistent goal to achieve a mentoring cultural change (Wichmann-Hansen et al., 2020). More importantly, while research training needs to lead STEM Ph.D. students to contemplate the possibility, as future scientists, of being pioneers exploring new knowledge near the boundaries of human cognition, it also needs to enhance training in producing visible, accessible research outcomes, such as providing academic writing and creative design skills training. Doctoral training is a crucial site for translating research integrity into practice (Sarauw et al., 2019), which may be impaired by unfair credit attribution and the exploitation of "cheap labor." A balance of different research roles should be achieved based on democratic negotiation and the expertise of students.

As the survey data are only from China, the study may be limited in its potential generalizability in other contexts. The cross-sectional data also prevent this study from observing time-series trends of STEM Ph.D. students' career interests and their actual career choice behaviors after graduation. Due to the anonymity of the questionnaire, we cannot redistribute the questionnaire among the same respondents to trace any change in career interests. We only counted the number of research projects and published papers without measuring the significance and workload requirement of each project and paper. Other forms of outcomes, such as patents and books, were not counted, bringing possible biases to the mediation effect testing. Finally, although we selected three STEM disciplines with similar employment structures to mitigate the potential confounding effect of market factors, our data do not allow us to entirely control that effect.

Future research may extend our study in two directions. First, our mediation effect analysis revealed that research productivity is only a partial mediation in enhancing self-efficacy, regardless of the motivation for entering into Ph.D. programs. It suggests that there may be a broader space for exploring the mechanisms linking research training and career interests beyond our theoretical framework. For example, the "idle curiosity," or the pursuit of knowledge as an end in itself (Brubacher, 1982), the tacit knowledge of what their disciplinary values comprise (Becher & Trowler, 2001), the acquisition of knowledge and skills, and other forms of research outcomes nurtured by research training may make up the STEM Ph.D. students' reasons to continue with research after graduation. Scrutiny of these factors can further enrich the theoretical framework. Second, future studies can examine the impact of research training in countries outside China and/or through longitudinal surveys to characterize STEM Ph.D. students' career interests and consequent career choices. We will suggest that CGSSS add an optional question asking respondents to leave their contact information voluntarily. Future researchers may use that information to track students' career choice behaviors to assess how career interests lead to their actual career choices.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12564-022-09775-4.

Acknowledgements We thank the editors and anonymous reviewers for their valuable comments that have greatly strengthened our work. We appreciate the support from our colleagues in *Academic Degrees & Graduate Education*, Beijing, China, for the access to the survey data and special thanks to Liujian Gu at Tsinghua University for his comments on the methods.

Author contributions XZ and CW conceived the main idea, designed the questionnaire and study, and investigated and collected the supporting materials. WZ organized the survey and preprocessed the data. XZ wrote codes for analysis and wrote the first draft. XZ, CW, and CN contributed to the final manuscript. CW coordinated and supervised the overall study.

Funding This study was supported by National Natural Science Foundation of China (Grant No. 71904100).

Declarations

Conflict of interest The authors attest to no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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