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Fostering Scientific Research Ability of Graduate Students in Chinese Local Universities: A Critical Review

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Abstract: Local universities and colleges constitute a significant portion of China's educational landscape, with graduate enrollment increasing steadily each year. Against the backdrop of escalating technological competition between nations, the cultivation of Scientific Research Ability (SRA) among graduate students has garnered increasing attention. While the initial aim of postgraduate education is clear – to nurture research-oriented talent for future academic pursuits – the objectives of graduate training have evolved over time. Today, they encompass not only the development of academics but also the cultivation of high-level professionals for various industries. This paper offers a systematic overview of relevant studies in the field of postgraduate SRA cultivation, delving into the entrenched challenges within Chinese educational institutions regarding the fostering of SRA among postgraduates. Additionally, it proposes a theoretical model for SRA-oriented training and provides insights into future reforms and developments in this area.

Keywords: Scientific research ability; Graduate student; Chinese local universities

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1. Introduction

Local colleges and universities in China represent the largest proportion of the higher education system and play a crucial role in cultivating numerous applied and technical talents. In comparison to national and key universities, local institutions serve as an essential link between research-oriented and vocation-oriented educational entities. According to statistics from the Ministry of Education in China, there are only 116 higher educational institutions directly affiliated with the ministry, focusing on exploring reforms and assuming a guiding role in enhancing teaching, scientific research, and social services. Conversely, more than 2,500 colleges and universities receive funding from local administrative departments [1]. As the primary entities in Chinese higher education, these universities are dedicated to serving regional economies and social development. Of the 479 colleges and universities offering postgraduate education in China, 390 local institutions are qualified for postgraduate training, accounting for 81% [1]. Furthermore, the number of postgraduate training units and majors in local colleges and universities continues to grow.

Postgraduate education serves as a primary mechanism for enhancing the quality of the workforce in China's infrastructure construction sector. Local universities produce a significant number of graduates capable of engaging with diverse populations, thereby forming the backbone of China's construction workforce. The large-scale infrastructure development demands a plethora of highly skilled professionals with both strong theoretical foundations and extensive practical experience. Statistics indicate that in 2019, there were 805,000 new students enrolled in postgraduate education, with 2.639 million students pursuing postgraduate studies (including exam-free and doctoral students) and 578,000 graduates [2].

A considerable proportion of postgraduates in local colleges and universities are graduates from third-tier or junior colleges. These institutions face challenges such as enrollment difficulties, poor quality of enrolled students, and challenges in training. For instance, at Shenzhen Polytechnic University, graduate enrollment in Civil Engineering and Architecture programs shows that 52.0% of applicants and 40.1% of admitted students are graduates from third-tier or junior colleges. Consequently, there exists a significant gap in basic abilities between these graduate students and those from top-tier universities or universities with first-class disciplines. Many view postgraduate entrance exams merely as a stepping stone for future development, making it challenging to ensure educational quality. Therefore, enhancing the Scientific Research Ability (SRA) of postgraduates has emerged as a major bottleneck in the professional development of similar colleges and universities.

2. Research status on SRA

Qian Xuesen's Question has long been a serious issue in the reform and development of China's higher education: "Why do our universities always consistently fail to produce outstanding talents?" Against this backdrop, as key entities for training high-caliber personnel, universities' cultivation of top-notch innovative individuals has garnered attention from governments and the higher education community. Postgraduate education functions as "high-level professional education featuring research after undergraduate education," with scientific research representing the crucial feature distinguishing it from undergraduate education and other educational stages [3].

The Regulations of the People's Republic of China on Academic Degrees [4] specify academic standards for postgraduates, stating that the Master's degree shall be conferred upon those who "have the ability to undertake scientific research or independently engage in a specialized technical work," while the Ph.D.'s degree shall be conferred upon those who "have the ability to undertake independent scientific research and have made creative achievements in science or a specialized technology." Hence, SRA is a critical indicator of postgraduate training quality. Research on enhancing graduate students' research ability has focused on the following four aspects:

(1) The connotation and structure of graduate students' SRA
(2) The status quo of graduate students' SRA
(3) Influencing factors of graduate students' SRA
(4) Countermeasures to improve graduate students' SRA

2.1. The connotation and structure of graduate students' SRA

2.1.1. Connotation of graduate students' SRA

SRA refers to the capacity to explore the essence and truths of things using scientific approaches. In a narrow sense, it denotes the ability to undertake specific scientific research. Different researchers [5-8] believe that SRA consists of various structural elements. The literature indicates that graduate students' SRA principally encompasses innovative abilities, including innovative environment and innovative thinking (**Figure 1**).

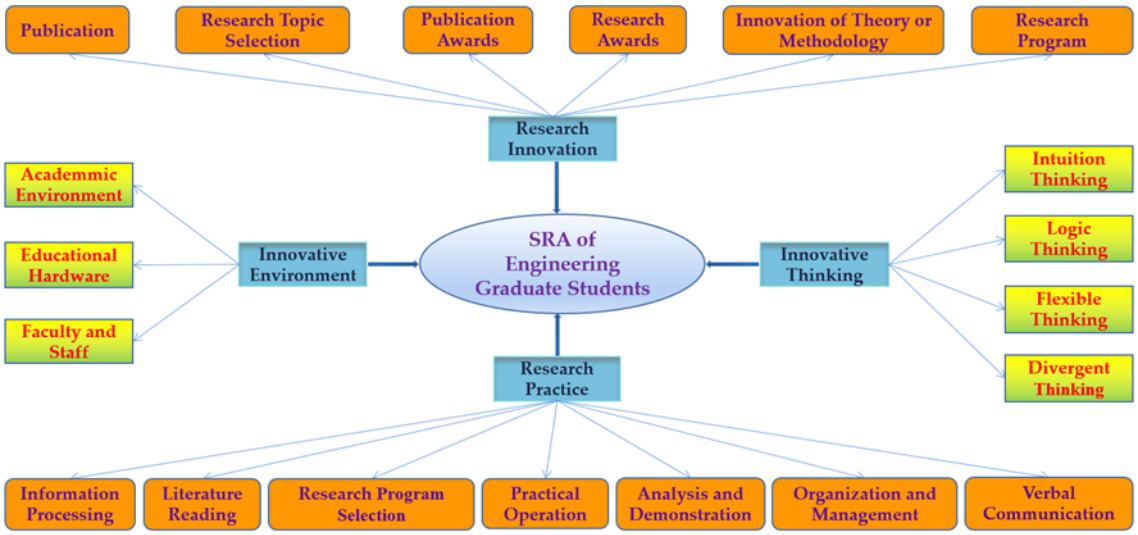

Figure 1. SRA of engineering graduate students

2.1.2. Evaluation system of graduate students' SRA

Graduate students' SRA, as a multi-dimensional and multi-layered dynamic complex, has an intimate and immediate connection with their knowledge base, innovative thinking, and research personality. Knowledge reserve forms the foundation, innovative thinking the core, and research personality the guarantee. These elements are interrelated, interdependent, and mutually supportive. Therefore, graduate students' SRA can be described as the comprehensive characterization of knowledge, thinking, and personality (**Figure 2**).

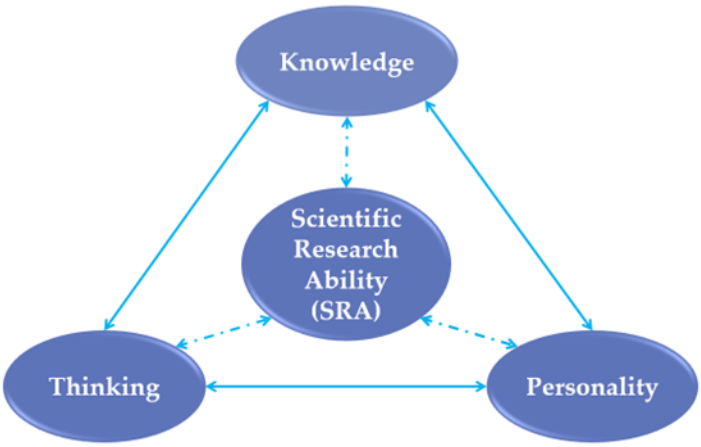

Figure 2. Composition of graduate students' SRA

The current research methods of graduate students' SRA applied in China's colleges and universities comprise optimal indices of target analysis, expert consultations, principal component analyses, questionnaire surveys, and factor analyses. Through statistical analyses, innovation ability, logical reasoning ability, data collection and processing ability, problem-solving ability, and language expression ability are ranked in order of importance.

2.2. The status quo of graduate students' SRA

Despite significant progress in China's graduate education, there remains a long path to improving the quality of postgraduate training. This can be summarized as the "three can-nots" for comprehensive quality and the "four

simple points" for research ability.

Three can-nots:

(1) Cannot write smoothly when citing.

(2) Cannot speak fluently when presenting.

(3) Cannot work diligently when conducting research.

Four simple points:

(1) Simple transplantation: Merely applying and repeating others' methods.

(2) Simple disclosure: Lack of in-depth study into the inner workings of phenomena.

(3) Simple extension: Solely confirming existing findings.

(4) Simple reasoning: Relying solely on experiments to verify known conclusions.

The deficiency of scientific research ability among graduate students is evident in the following six aspects [9-11]:

(1) Insufficient literature reading.

(2) Lack of ability to draw conclusions.

(3) Inability to formulate scientific questions.

(4) Deficiency in logical thinking.

(5) Poor writing skills.

(6) Lack of academic ethics.

3. Influencing factors of graduate students' SRA

From a philosophical perspective, the internal causes are primary, while external factors are secondary; they interact and mutually influence each other. The SRA of graduate students is primarily influenced by individual factors, while external factors include supervisors and organizations, which provide both a conducive learning environment and necessary support for scientific research. Consequently, the influencing factors of graduate students' SRA can be categorized into an interactive coupling relationship model involving individuals, supervisors, and organizations (**Figure 3**).

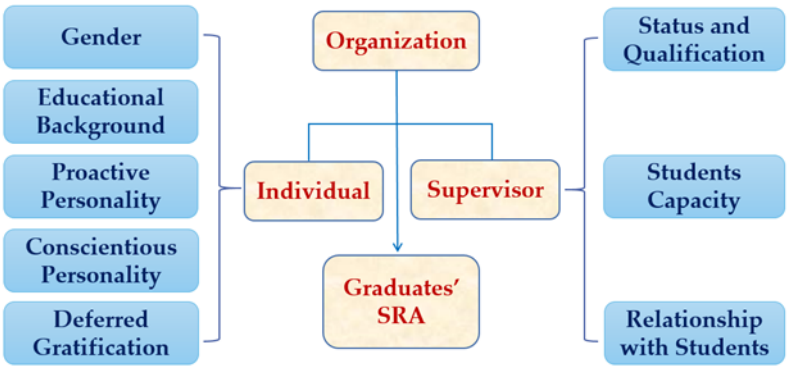

Figure 3. Theoretical model of influencing factors of graduate students' SRA

Current researchers emphasize several factors contributing to the low level of postgraduate research in China:

(1) Failings in the enrollment system.

(2) Poor consciousness of innovation among graduate students.

(3) Irrational curriculum provision.
(4) Lack of scientific and institutionalized academic exchange systems or platforms.
(5) Ineffective tutor team building.

The reasons behind Chinese graduate students' lack of innovation ability and their low level of scientific research are rooted in the drawbacks and defects of the graduate student training system, encompassing issues in enrollment, curriculum provision, training, and management [12,13]. However, the fundamental issue lies in the lack of innovation in the model of postgraduate education and the absence of scientific rules.

3.1. Influence of enrolling students' quality on SRA

Students who have research experience during their undergraduate studies are more likely to pursue academic master's degrees. Those with better academic performance, longer maternal education years, and higher occupational status among family members are more inclined to pursue academic master's degrees, while higher family income leads to a preference for professional master's degrees.

Students graduating from top institutions tend to demonstrate better research performance in their future work. Those exempted from exams typically produce better undergraduate theses than those who sit for the national graduate entrance examination. Currently, institutions of higher education are striving to attract graduates from prestigious universities to pursue postgraduate studies in their schools.

The current U.S. graduate admission evaluation system involves three parties: applicants, evaluators, and recruiters, as shown in **Figure 4**. Compared with China's system, the U.S. system includes a crucial element: third-party evaluation, which better reflects students' research abilities and overall qualities and offers better reference value [14,15].

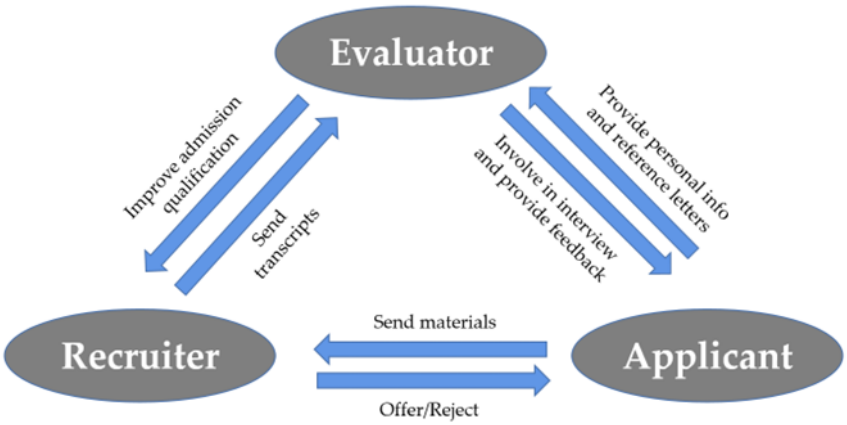

Figure 4. Graduate admission patterns in U.S. universities

3.2. Influence of course system construction on SRA

Transitioning from undergraduate to postgraduate education involves more than just an elevation in educational background. The fundamental difference lies in the shift from a teaching-based approach in undergraduate education to a focus on learning in postgraduate education.

Currently, graduate courses are characterized by a limited range of knowledge, outdated teaching materials, and monotonous teaching methods, hindering the cultivation of innovative abilities among graduate students. A comprehensive course system featuring up-to-date content, advanced teaching methods, and heuristic education is conducive to constructing innovative knowledge structures and fostering self-learning abilities among

graduate students. The system structure model of China's postgraduate education is illustrated in **Figure 5**.

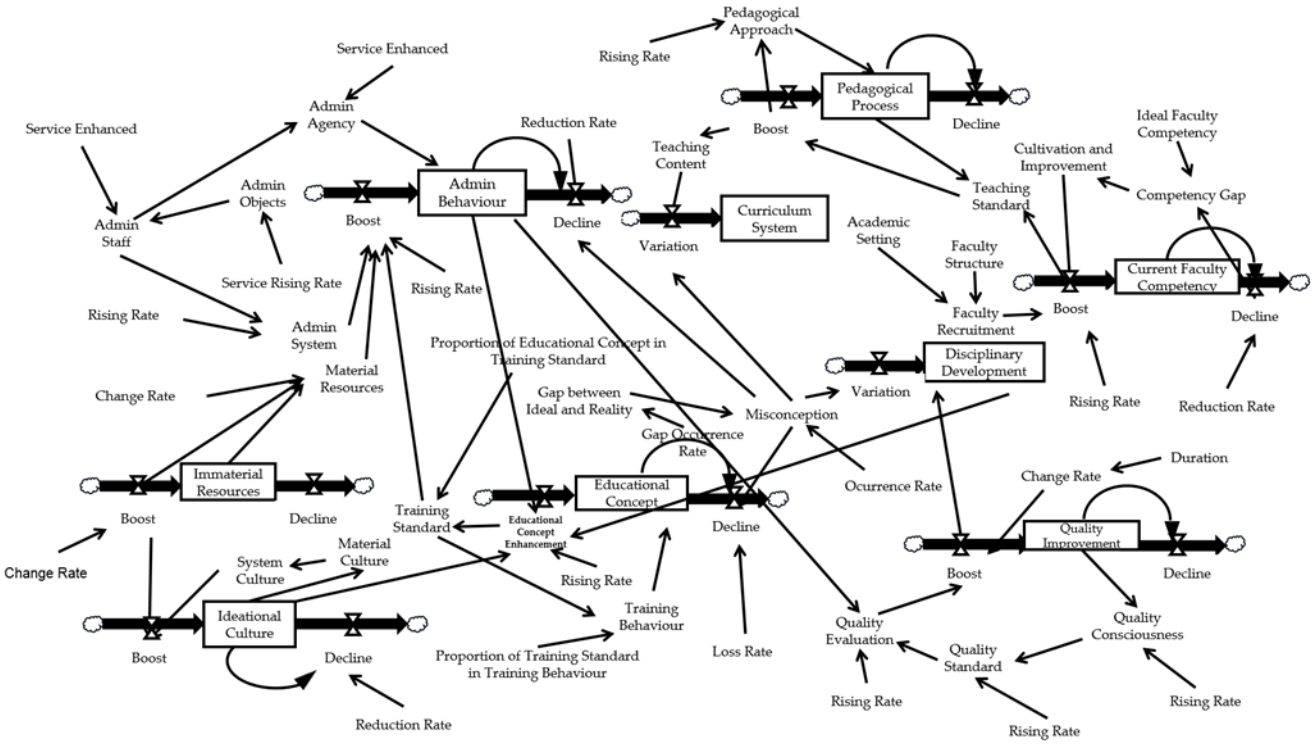

Figure 5. System structure model of China's postgraduate education

Reforming the curriculum does not mean reducing the number of courses or abolishing them altogether, but rather aims to ensure that courses serve to enhance the innovation of postgraduates through the reform of the graduate course system [16]. Firstly, in terms of curriculum system reform, it is essential to establish a teaching model focusing on "personality development" supplemented by "stimulating thinking" to enhance the scientific research abilities of graduate students. Secondly, various teaching methods should be employed, such as problem-based teaching, discussion-based teaching, case-based teaching, and lecture-based teaching.

3.3. Influence of tutor's instruction on SRA

The ability and expertise of postgraduate tutors directly impact the quality of postgraduate research and innovation abilities.

The current situation of the tutor team is challenging. A common issue is that some tutors' knowledge cannot keep pace with the times, reflecting an aging knowledge structure [17]. Generally, the age of tutors negatively affects the research performance of graduate students, while tutoring experience has a positive impact on the research performance of doctoral students [18].

The construction of the tutor system lags behind. Firstly, the in-service management system for tutors remains imperfect, characterized by a lack of in-service training. Many tutors possess strong research abilities but struggle to effectively guide and instruct graduate students. Secondly, there is a lack of strict supervision over tutors and a sound evaluation indicator system. The ways, timing, methods, and content of instruction are left to the discretion of tutors according to training programs. However, the management department tends to place evaluation indicators on scientific research projects, publications, patents, and appropriations, and a specific and comprehensive tutor evaluation indicator system has yet to be established.

The guidance and influence of tutors on students need to be strengthened. Issues such as ineffective guidance and supervision during thesis and scholarly paper writing, a lack of communication between tutors and graduate students, and inadequate discussion and monitoring during the tutor-student supervision process must be addressed. A survey has indicated that during thesis discussions, 65.87% of tutors can effectively communicate with their graduate students, while 27.16% do so rarely, and 6.97% never engage in discussions with their students [19].

3.4. Team-based training model

In recent years, significant development and remarkable achievements have been observed in the team-based training model at well-known universities such as Tsinghua University and Wuhan University.

To establish a team-based postgraduate training model aimed at producing first-class talents, it is imperative to address issues related to resources, institutional environment, and innovation culture during system design. Creating environments conducive to nurturing outstanding talents is essential [20]. Additionally, it is crucial to develop comprehensive training programs focusing on the qualities of top talents, including their thoughts, knowledge structure, practical abilities, and innovation capabilities. A systematic approach to team-based postgraduate training is illustrated in **Figure 6**.

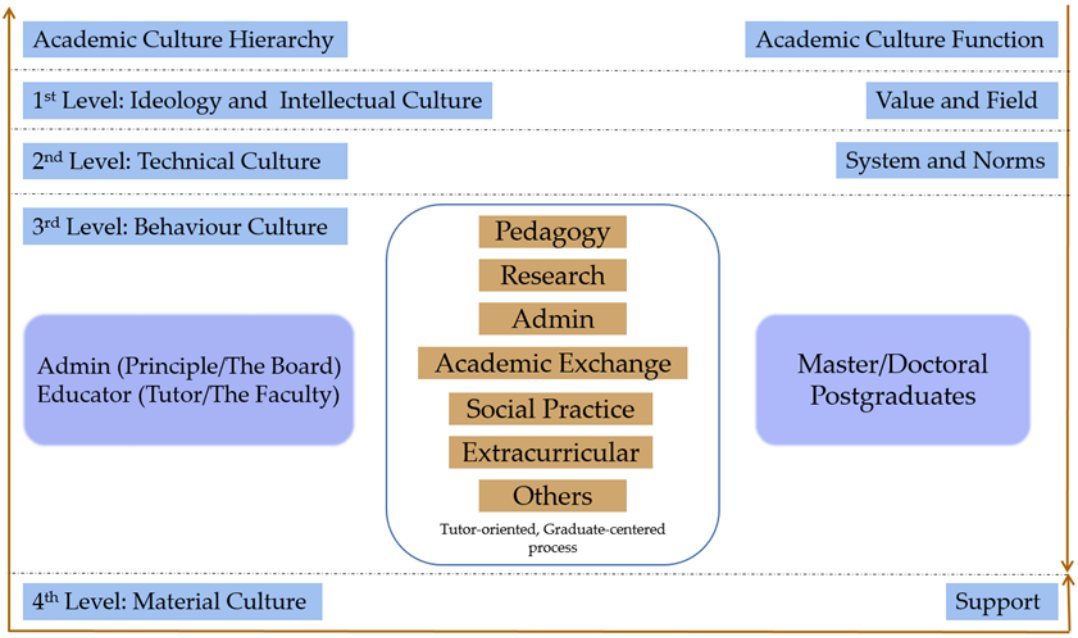

Figure 6. Theoretical framework of graduate team academic culture

3.5. Scientific research atmosphere and soft environment

The scientific research atmosphere plays a crucial role and significantly contributes to students' research performance. A positive atmosphere for cooperation and team satisfaction enables individual researchers to coordinate scientific tasks more efficiently, resolve problems effectively, and ultimately achieve higher research performance [21]. Individuals working in highly cohesive teams tend to produce more significant output in scientific research compared to those in less cohesive teams. **Figure 7** illustrates the organization of regular academic meetings in Chinese and American universities [22].

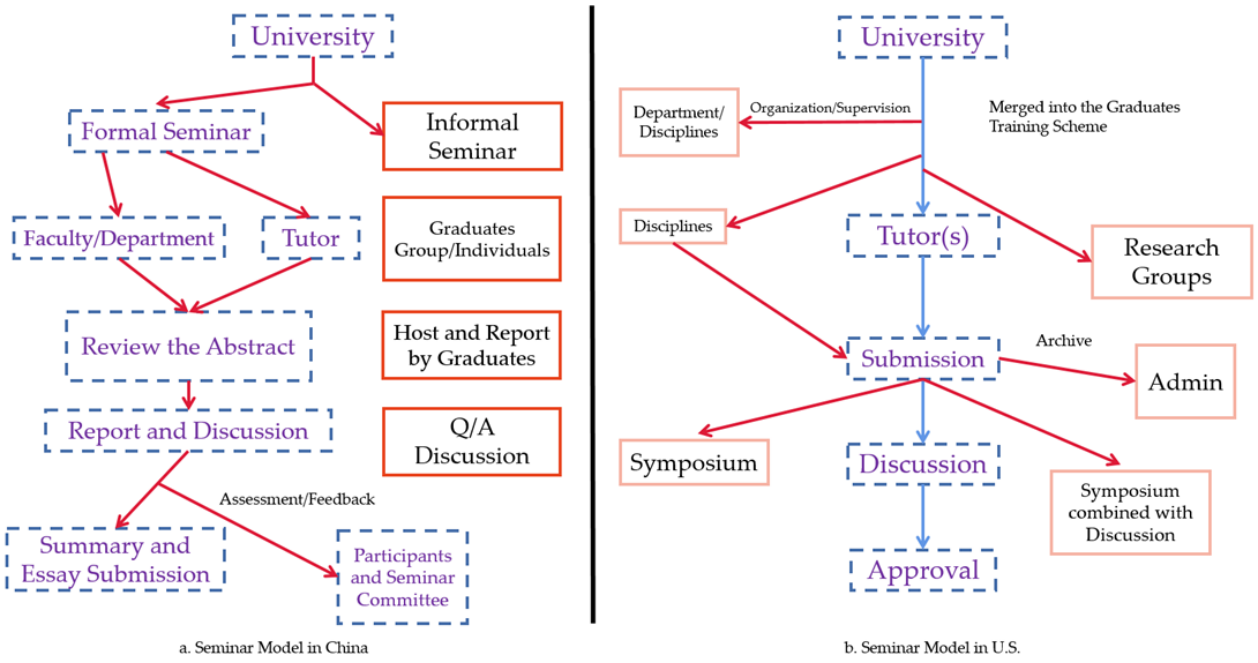

Figure 7. Seminar model in Chinese and U.S. universities

However, the current state of question awareness among China's postgraduates is unsatisfactory. Firstly, postgraduates struggle to identify questions during classroom learning, reading, practical operations, and academic writing. Secondly, they face difficulties in raising questions: teachers often fail to pose challenging questions to their students, and students, in turn, hesitate to ask questions to their teachers. Thirdly, students find it challenging to articulate and express their questions clearly. Fourthly, they struggle to address questions effectively, devise solutions, implement them, and evaluate or test the validity of their solutions.

3.6. Scientific research practice

Introducing competition mechanisms and establishing an appraisal system for theses, which commend noteworthy achievements and critique shortcomings to encourage graduate students to pursue bold innovations, should be prioritized. Additionally, implementing a mid-term screening system focusing on postgraduates' research abilities is essential. Only students demonstrating satisfactory performance should proceed with their thesis writing; those failing short should discontinue their studies and be granted certificates of completion or study.

Serious issues regarding thesis and scholarly paper evaluation have been identified. Firstly, during static evaluation, theses are often near completion, making it challenging to address quality issues at the final stage [23]. Secondly, the intervention of a dynamic evaluation system occurs relatively late. Many colleges and universities conduct mid-term defenses in the fourth semester, by which time numerous graduate experiments may not have been completed, and high-quality theses may not have been accepted. Consequently, students' actual abilities cannot be accurately evaluated.

Special attention should be devoted to developing postgraduates' general abilities and professional competencies. Local colleges and universities can provide targeted training based on students' knowledge and the specific characteristics of their fields, enhancing postgraduates' suitability for various roles. Colleges and universities in economically developed areas can delve into the employment characteristics of local enterprises and institutions, understanding diverse employment requirements, and actively expanding channels for

employment and cooperation.

3.7. Hardware conditions

The training environment fails to adapt to the demands of the times and meet the needs of teachers and students. Local colleges and universities primarily rely on funds from local government grants, which are relatively low in the education sector. Research conditions, including experimental instruments and equipment, library resources, and databases, fail to meet the requirements for cultivating high-quality graduate students, consequently limiting their ability to enhance the quality of scholarly papers and theses [24].

Administrators should intensify efforts to develop scientific research platforms and resources to enhance the training and improvement of scientific research abilities. Local colleges and universities need to allocate funds from educational foundations and invest in assets to procure experimental instruments and equipment, thereby improving the research environment. This investment will enable postgraduate students to engage in theoretical and technical innovation and technical identification comprehensively and systematically [25]. As a result, the quality of education for graduate students in local colleges and universities can be significantly enhanced.

3.8. Fostering of practical ability

Constructing school-enterprise practice bases and promoting school-enterprise joint training should be the primary focus for cultivating graduates' practical abilities. Through collaborative efforts between schools and enterprises in developing scientific research achievements, enterprises can enhance their absorptive capacity, improve innovation performance, and maintain long-term competitive advantages. Graduate students can simultaneously strengthen their theoretical research and technological development during practical experiences. Moreover, this collaboration deepens the trust between enterprises and universities, enabling universities to access more research topics.

Institutions of higher learning should enhance cooperation with joint postgraduate education bases, encouraging students to engage in research projects at research institutes and enterprises equipped with advanced experimental facilities and mature scientific research conditions. This expansion of the training space for graduate research capabilities will facilitate the cultivation and enhancement of postgraduates' scientific research abilities and overall quality.

4. Conclusions

Since 1980, graduate education in China has undergone significant development, coinciding with the era of mass higher education, which has provided access to advanced levels of education for an increasing number of students. However, this rapid development has led to a concerning phenomenon characterized by irreconcilable contradictions between quantity and quality. Consequently, several unresolved issues persist in postgraduate education in China compared to other countries.

As education reform continues to deepen and evolve, numerous challenges have surfaced at the postgraduate education stage, primarily in the following areas: the lack of a systematic and scientific postgraduate training model; the absence of a conducive research atmosphere and robust systems in some local institutions; inadequate conditions for scientific research; and the absence of construction of school-enterprise practice bases and school-enterprise-research institute joint training programs. These issues have resulted in several challenges, including a limited range of postgraduate training objectives, simplistic postgraduate course offerings, insufficient diversity in tutor team composition, and a lack of research and innovation abilities among

graduate students.

Disclosure statement

The author declares no conflict of interest.

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