Analysis of Influencing Factors of Postgraduate Dissertation Quality Based on Interpretative Structural Modeling

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Abstract: Dissertation quality is one of the most important indicators of the quality of postgraduate education. Cultivating and improving dissertation quality involves all aspects of the postgraduate education system and constitutes a complex systematic project. Based on literature research and expert consultation, the relevant factors affecting the quality of doctoral dissertations are sorted out and summarized. An explanatory structural model reflecting the interrelationships among these factors is constructed. The direct, secondary, deep-level, and fundamental influences of postgraduate dissertation quality are identified. Based on the results of the above analyses, strategies to improve the quality of doctoral dissertations are discussed from three aspects: improving the quality of postgraduate student sources, strictly controlling the "first gate" of supervisors, and increasing the investment of postgraduate cultivation funds, to provide references for the further improvement of the quality of postgraduate education.

Keywords: dissertation quality; influencing factors; interpretive structural modeling

1. Introduction

Postgraduate education shoulders the important mission of high-level talent training, innovation, and creativity and is the cornerstone of national development and social progress. In the past ten years, China's postgraduate education scale has achieved breakthrough growth. How to promote postgraduate education from big to strong and ensure and improve the quality of postgraduate education has become a hot topic. After the 18th Party Congress, the state has put forward a series of plans and initiatives to develop postgraduate education in the coming period to further strengthen the supervision of the quality of postgraduate education.

Postgraduate training is a comprehensive and systematic project of cultivating people with moral integrity, in which the quality of the postgraduate dissertation is the core and key element to measure the level of this project. Dissertation quality reflects the research ability and academic group of postgraduates and is the most important indicator of the training level of postgraduates[1]. To answer the question of how to improve postgraduate dissertations, it is first necessary to find out what factors affect the quality of doctoral dissertations. What is the logical relationship between the elements? Only then can we take targeted measures to ensure and improve the quality of postgraduate dissertations and enhance the quality of postgraduate training and education in China?

2. Overview of factors affecting the quality of postgraduate dissertations

Factors affecting the quality of postgraduate dissertations are manifold. Some scholars believe that the quality of doctoral dissertations is affected by both the personal quality of postgraduates and external objective factors. Yao Xiuying[1] summarized the factors affecting the quality of postgraduate dissertations and divided them into two categories: external factors and internal factors. External factors mainly include six aspects, such as the clarity of cultivation objectives, research conditions, and financial input, research atmosphere, the role of supervisors, dissertation quality monitoring system and dissertation writing time, etc.; internal factors mainly include postgraduates' personal academic foundation, learning style, academic awareness, and innovative spirit. In addition, some scholars have also explored the factors affecting the quality of postgraduate dissertations through empirical studies. For example, Zhang Xiaomin[2] proposed that course study, scientific research, supervisor guidance, and conditional support influence the quality of engineering doctoral dissertations based on the satisfaction

survey of postgraduate students. Through the statistical analysis of the peer evaluation results of doctoral dissertations from 2013 to 2919, Dong Zongwang[3] concluded that the level of supervisory team, discipline strength and student quality are the key factors affecting the quality of dissertations. Zhu Runxiang[4], Hou Yuehui, and other scholars[5] have emphasized the importance of the topic selection of a dissertation, which is considered a key factor affecting the improvement of dissertation quality. Kong Lingyi[6] combined and summarized 21 influencing factors of doctoral dissertation quality and further pointed out that the five key factors affecting the quality of a dissertation include institutional strength, doctoral supervisor selection system, doctoral student admissions policy, the investment of funds in postgraduate training, and human resource management ability.

Dissertation quality is an important embodiment of the quality of postgraduate training, and the systematic sorting out of the factors affecting the quality of postgraduate training provides a powerful supplement and validation for the in-depth study of the factors affecting the quality of the dissertation. Wu Bin and other scholars[7] classified the factors affecting the quality of postgraduate education and divided them into two levels: external control factors and internal control factors. The external control factors mainly include the social development situation, national education strategy, and basic education resources of universities; the internal control factors cover the postgraduate education training system and the assessment of postgraduate education quality. Xiong Baolin[8] also believes that the factors affecting the quality of postgraduate training include subjective and objective factors, of which the emotional factors mainly refer to the quality and effort of postgraduates themselves; the objective factors refer to the cultivation conditions, teaching, and management, cultivation programs and the final cultivation results. Other scholars[9] start from the relevant subjects of postgraduate training, pointing out that the three types of issues, namely, students, supervisors, and training units, are important factors affecting the quality of postgraduate training, among which the student factors mainly include postgraduates' motivation to study, personal quality, scientific research ability, and family environment, etc.; supervisors factors specifically refer to the teacher's morality and ethical style, guiding knowledge, overseas background, and financial support, etc.; and the factors of training units relate to the enrolment selection system, the cultivation process and the degree awarding standards, etc. From the perspective of supervisors, Zhou Wenwen and others[10] summarized the factors affecting the quality of postgraduate training as supervisors' growth mechanism and positional power, supervisors' title, supervisory style, and mentoring-learning relationships. Other scholars[11][12] have consistently emphasized that factors such as student sources, scientific research, and supervisors are important factors affecting the quality of postgraduate training.

In summary, scholars have conducted rich studies on the quality of postgraduate dissertations and the influencing factors on the quality of graduate training. However, these studies mainly focus on the simple enumeration and qualitative description of the influencing factors and relatively few in-depth discussions on the interrelationships among the elements. This paper intends to construct an explanatory structural model to clarify the structural relationship among the factors affecting the quality of postgraduate dissertations, aiming to provide useful ideas, references, and suggestions for improving the quality of doctoral dissertations.

3. ISM Modeling of Factors Influencing the Quality of Graduate Student Dissertations

3.1. Introduction to Interpretive Structural Modeling

Interpretive Structural Modeling (ISM) is a method of modeling the structure of a system, developed by Prof. John Warfield in 1973 to study the structural relationships of complex socio-economic systems and to decompose the complex, disordered relationships between system units into clear, multilevel, hierarchical structural forms at multiple levels. The basic steps of constructing a hierarchical structural model of influencing factors using the Interpretive Structural Modeling approach are: □Compare the direct causal relationships between factors two by two, determine the logical connection between influencing factors, and form an adjacency matrix. The adjacency matrix reflects the relationship between the elements reached simultaneously, i.e., a direct relationship. □The reachability matrix of the adjacency matrix is computed by Boolean algebra operations. The reachable matrix reflects the relationship between elements reached at any time (including its reaches), i.e., direct + indirect relationship. □Perform hierarchical decomposition of the reachable matrix, determine the aspects of each level, and establish the structural model.

3.2. Identification of influencing factors

Factors influencing the quality of postgraduate dissertations are identified and recognized through literature research and expert consultation. In the stage of literature research, firstly, all the influencing factors of postgraduate dissertation quality involved in each relevant literature are listed; secondly, the listed influencing factors are de-emphasized, and similar influencing factors are placed and merged and categorized, with at least 2 pieces of literature supporting each element. The above steps identified the indicators of the influencing factors on the quality of postgraduate dissertations. In the stage of expert consultation, the importance of the influential factors of postgraduate dissertation quality identified in the literature is first judged. In contrast, the elements are beneficially supplemented and adjusted by combining the experts' suggestions. Through the above two stages of research, the finalized indicators of factors affecting the quality of postgraduate dissertations in this study are shown in Table 1.

Table 1 Influential Factors Related to the Quality of Postgraduate Dissertations

Dimension	Specific Factor	Variable	Literature Support (partial)
Postgraduate Factors	Individual Academic Basis	S_1	YAO Xiu-Ying[1], KONG Ling-Yi[6],SHAO Yong-Bin[13]
	Academic Motivation	S_2	YAO Xiu-Ying[1],YU Jian-Guang[11]
	Research Training	S_3	Kong, Lingyi[6], SHAO Yong-Bin[13]
	Research Capacity	S_4	YAO Xiu-Ying[1], HE Tian-Xu[9], SHAO Yong-Bin[13]
	Quality of Student Supply	S_5	Kong, Lingyi[6], Zhao, Jun[14],Choi, Soon-gil[15]
	Thesis Selection	S_6	ZHU Runxiang[4],KONG Lingyi[6],XIAO Xiangjie[16]
Supervisor Factors	Supervisor's Business Quality	S_7	Dong Zongwang[3], Kong Lingyi[6]
	Mentoring Input	S_8	ZHANG Xiaomin[2], KONG Lingyi[6], WU Dan[17]
Training Unit Factors	Level of Disciplinary Development	S_9	DONG Zongwang[3], WU Bin[7], XIAO Huayin[18]
	Financial Investment	S_{10}	YAO Xiu-Ying [1], KONG Ling-Yi[6]
	Academic Atmosphere	S_{11}	KONG Lingyi[6], YU Jian-Guang[11], XIAO Huayin[18]
	Thesis Quality Control System	S_{12}	YAO Xiu-Ying[1],HOU Yue-Hui[5]
	Course Teaching	S_{13}	ZHANG Xiaomin[2], XIONG Baolin[8], SHAO Yongbin[13]
	Quality of the Training Process	S_{14}	KONG Lingyi[6], HE Tianxu[9], WU Dan[17]

Interpretation of the above variables, detailing the specific connotations of each variable, will help to explore in depth the role of each variable in enhancing the quality of postgraduate dissertations. The clear explanations are shown in Table 2.

Table 2 Explanation of variables influencing the quality of postgraduate dissertations

Specific Factor	Variable	Variable Explanation
Individual Academic Basis	S_1	The theoretical basis, rational thinking and speculative spirit, acute perspective and innovative consciousness that postgraduate have[1].
Academic Motivation	S_2	It can be expressed in the courage to question, independent exploration, good innovation of academic consciousness, etc..
Research Training	S_3	Postgraduates receive research-related training and practical activities, such as laboratory practice, academic conference participation, research project participation, and academic paper writing.
Research Capacity	S_4	The ability to independently design and conduct scientific research, such as research design and implementation, academic writing, and presentation skills, developed at the graduate level.
Quality of Student Supply	S_5	It refers to the overall level and quality of students entering graduate school.
Thesis Selection	S_6	A high-quality topic selection is usually characterized by strong relevance and research significance, a high degree of cutting-edge innovation, etc.
Supervisor's Business Quality	S_7	The professional level and ability of a supervisor in guiding postgraduates, conducting scientific research and teaching.
Mentoring Input	S_8	The amount of time, effort and resources invested by the supervisor in the dissertation supervision process.
Level of Disciplinary Development	S_9	The research level, technical level, and overall performance of academic and practical achievements achieved in a certain subject area over a certain period of time.
Financial Investment	S_{10}	The financial investment provided by the university to support postgraduate training covers a wide range of areas, such as scholarships, funding for research projects, laboratory equipment, and library resources.
Academic Atmosphere	S_{11}	An academic culture and climate developed in the educational environment of the school.
Thesis Quality Control System	S_{12}	It is usually reflected in the monitoring and managing of the dissertation opening report, midterm examination, blind examination, pre-defense, and sampling.
Course Teaching	S_{13}	It generally includes the curriculum, teaching methods and teaching content, etc. [2].
Quality of the Training Process	S_{14}	The quality of the nurturing environment, teaching management, supervisory guidance, and research support provided by the university throughout the postgraduate study and research phases.

3.3. Construction of an Interpretive Structural Modeling

3.3.1. Create adjacency and reachability matrices

Firstly, the initial relationship matrix of the factors is formed based on literature research. Then, the opinions are solicited from the experts in the field. After the experts' views are analyzed, sorted out, and summarized, the final judgment results are formed and processed as follows: if S_i (row factor) has a direct influence on S_j (column factor), the corresponding position is filled with 1; if S_i does not have a direct impact on S_j, the corresponding function is filled with 0; if S_i and S_j influence each other, the party with the largest influence is determined to be the influencing relationship, to form the adjacency matrix A.

$$A = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (1)$$

Matlab software uses Boolean algebra operations on the above adjacency matrix to obtain the reachability matrix M. The reachability matrix reflects any sub-reach relationship (including self-reach) between elements, i.e., direct + indirect relationship.

$$M = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad (2)$$

3.3.2. Hierarchical analysis of influencing factors

Table 3 Levels at which each factor influencing postgraduate dissertation quality

SI	$R(S_i)$	$A(S_i)$	$C(S_i)$	level
S_1	1,4,6,8	1,2,3,5,7	1	2
S_2	1,2,4,6,8	2,5,7	2	3
S_3	1,3,4,6,8	3,5,7	3	3
S_4	4	1,2,3,4,5,7	4	1
S_5	1,2,3,4,5,6,8	5	5	4
S_6	6	1,2,3,5,6,7	6	1
S_7	1,2,3,4,6,7,8	7	7	4
S_8	8	1,2,3,5,7,8,9,10,11	8	1
S_9	8,9,11,12,13,14	9,10	9	3
S_{10}	8,9,10,11,12,13,14	10	10	4
S_{11}	8,11	9,10,11	11	2
S_{12}	12,14	9,10,12	12	2
S_{13}	13,14	9,10,13	13	2
S_{14}	14	9,10,12,13,14	14	1

According to the reachability matrix M, find the reachable set $R(S_i)$, the prior set $A(S_i)$ and the common set $C(S_i)$, where the reachable set $R(S_i)$ denotes the group consisting of the elements reachable

by S_i, i.e., the columns in row i of 1; the prior set $A(S_i)$ represents the set consisting of the elements reachable by S_i, i.e., the rows in row i of 1; and the common set $C(S_i)$ denotes the common part of the reachable set and the prior group of S_i. When $R(S_i) = C(S_i)$, $R(S_i)$ is the first layer of elements; remove the rows and columns in the reachable matrix where the first layer of features are located, and then repeat the steps from the remaining matrix to get the next layer of elements. And so on to get the levels of all the factors (as shown in Table 3).

3.3.3. Interpretive Structural Modeling analysis

Based on the above hierarchical division of influencing factors, a structural model of influencing factors on the quality of postgraduate dissertations is derived, as shown in Figure 1.

As can be seen from Figure 1, the model is a four-layer hierarchical structural model, and the higher the layer, the deeper the influence of the factors at that level on the quality of postgraduate dissertations. The first level consists of four elements, including the quality of topic selection, the quality of the training process, the research ability and supervisory input, which together constitute the direct influences on the quality of postgraduate dissertations; the second level consists of four factors, including the dissertation quality control system, individual academic foundation, academic atmosphere and course teaching, which together constitute the sub-influences on the quality of postgraduate dissertations, which indirectly affect the quality of doctoral dissertations through the influence on the direct factors; the third level consists of three elements, including research training, academic discipline construction level and academic motivation, which have a deeper influence on the quality of postgraduate dissertations; the fourth level consists of three factors, including the quality of student source, the quality of supervisor's business and the financial investment, which are the fundamental factors affecting the quality of postgraduate dissertations.
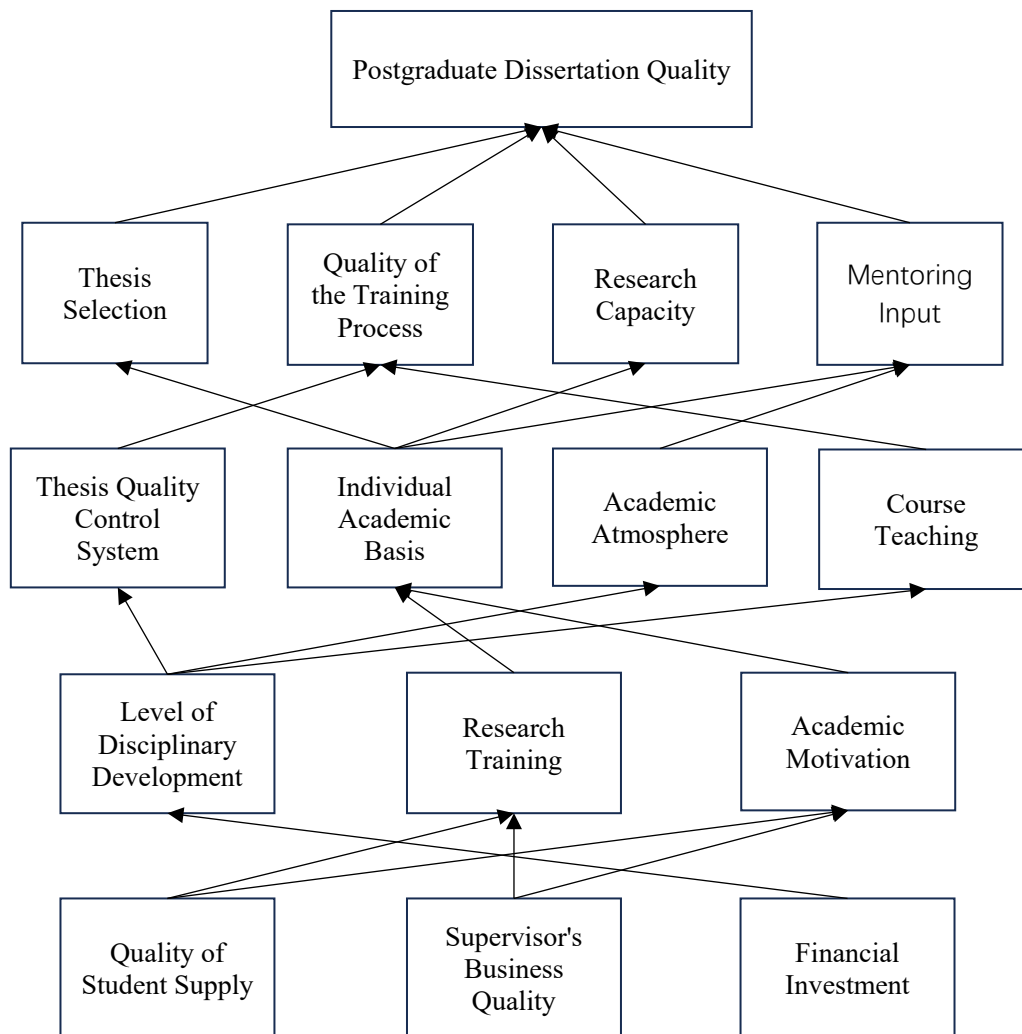

Fig. 1 ISM of factors influencing the quality of postgraduate dissertations

4. Suggestions for Improving the Quality of Postgraduate Dissertations

4.1. Multi-pronged measures to improve the quality of postgraduate students

For a college or university, improving the quality of postgraduate sources is a systematic work that must work together from many aspects and links. Firstly, we can focus on the school's student source, combine the enrollment plan of each discipline of the school, explore the construction of the whole chain of talents training system of this master's and doctoral degrees, and establish a system for cultivating the excellent student sources in the school. Secondly, we can actively strive for deserving students in various ways. Schools can consider holding "summer camp", "autumn camp" and other activities, through the selection of outstanding campers, to attract outstanding students outside the school in advance. At the same time, the university actively strives for excellent students from inside and outside the university to ensure the quality of postgraduate sources. Thirdly, we should innovate the mechanism of postgraduate admission and reasonably allocate the proportion of doctoral students' scores in the preliminary examination and reexamination. Based on the traditional "preliminary examination + retest" or "application - assessment" enrollment method, colleges can innovate postgraduate admission mechanisms, such as increasing the material review link in the process of master's degree enrollment and incorporating the candidates' previous undergraduate academic achievements, awards, internships, and practices, etc. into the scope of assessment, to comprehensively measure the quality of the postgraduate, merit-based admission. At the same time, we consider appropriately increasing the proportion of postgraduate review results, improving the content and form of review, and focusing on examining candidates' scientific research potential and professional quality.

4.2. Strictly control the first gate of supervisors and establish the concept of lifelong learning for supervisors

The supervisor not only plays a primary role in the process of writing postgraduate dissertations, but also is the main responsible for and implementers of the whole stage of postgraduate training. The professional level of supervisors indirectly affects the quality of supervision of postgraduates' dissertations. First of all, the "entry gate" of supervisors should be strictly controlled to ensure that their selection is reflected in their supervisory ability. The supervisor is a specific division of duties, so it is necessary to abandon the fixed qualification system and the lifelong system, realize the virtuous cycle of "up and down, selecting the best," and select a supervisor who is academically proficient, scientifically skilled, and with strong teaching ability—secondly, focusing on the continuous improvement of supervisors' ability and establishing the concept of lifelong learning for supervisors. Those who educate people should educate themselves first. The training of postgraduate supervisors should not only stop at the pre-service training for newly elected supervisors. Still, it should also pay attention to the capacity improvement of in-service supervisors and organize more of them to participate in all kinds of postgraduate supervisors' capacity enhancement training programs organized by domestic and foreign high-level universities or other institutions. At the same time, experienced tutors and older tutors should be included in the training program and provided with training content that meets their needs to enhance the pertinence of the supervisor training and effectively improve the supervisors' personal level and ability to guide postgraduate.

4.3. Increase the investment in postgraduate training funds, injecting "cardiotonic agent" for scientific research and innovation

Improving the training funds for postgraduates is not only an important means to stimulate postgraduates' scientific research creation and strengthen their motivation, but also a basic guarantee work to ensure that postgraduates complete the dissertation writing. First, it is necessary to create a favorable research environment and research conditions for postgraduate students. Adequate research equipment and experimental facilities are crucial for postgraduates in the field of natural sciences when writing their dissertations. It is not only the basis for ensuring the smooth progress of postgraduate dissertations but also an important element for guaranteeing the quality of their dissertations[1]. For graduate students in the social sciences, field research, picking activities, and so on need certain financial support; otherwise, it will inevitably affect the innovation enthusiasm of postgraduates—secondly, a sound postgraduate scholarship system. Most colleges and universities currently rely on state funding for postgraduates, "three aids and one assistant," post-funding comprehensive quality awards, and other ways. However, with the establishment of new situations, new requirements, and new goals for the reform of postgraduate education, the guarantee and incentive effect of these scholarship systems have not been

fully realized, and it isn't easy to meet the needs of the continuous development of postgraduate education. Therefore, the university can rely on the state's financial allocation and explore diversified channels such as self-financing and social donations. Consideration can be given to establishing a funding method of school funding and faculty (supervisor) funding to increase the investment in postgraduate research funding.

5. Conclusion

The results of the study show that the factors affecting the quality of postgraduate dissertation can be categorized into four levels. In the level of direct influencing factors, there are two factors related to the individual postgraduate, namely, the quality of dissertation topic selection and the research ability of postgraduate. Meanwhile, the supervisor's supervisory input also has a direct impact on the quality of postgraduate dissertation. In addition, the quality of postgraduate training is also directly related to the level of postgraduate dissertation. These factors together constitute the key factors that have a direct impact on the quality of postgraduate dissertation. At the level of secondary influencing factors, the strength of individual academic foundation, the soundness of the monitoring system of training units, the strength of academic atmosphere and the quality of course teaching all jointly shape the development track of postgraduate academic level and dissertation quality. At the level of deep-level influencing factors, the level of research training and academic motivation of postgraduates, as well as the level of disciplinary development of the training unit, jointly shape the depth and breadth of postgraduates' academic research and dissertation writing. The optimization and enhancement of these deep-level factors will affect the quality of postgraduate dissertation at the fundamental level. At the level of fundamental influencing factors, the quality of postgraduates' source is directly related to their potential and performance in academic research, the academic level of supervisors determines the level of guidance in the postgraduate research process, and sufficient funding provides adequate research resources and support for postgraduates, which profoundly affect the overall level of quality of postgraduate dissertation.

However, the Interpretive Structural Modeling of the factors influencing the quality of postgraduate dissertation constructed in this study relies on the experience and advice of experts, and the influencing relationships and effects among the factors have not yet been empirically tested, which is an issue that will be explored in depth in the subsequent part of this study.

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