



Research on the Capacity Building of Supervisors for Cultivating Innovative Talents

--Analysis of Policy Texts Based on 65 "Double First-class" Universities

Yuan Zhang^{1,*}, Xiaoshen Cai^{2,a}

¹School of Marxism, Dalian University of Technology, Dalian, China

²School of public administration and policy, Dalian University of Technology, Dalian, China

*Corresponding author Email: qqquanz@163.com, acxshen99@163.com

Abstract. The team of high-quality supervisors plays a crucial role in advancing the integration of educational science and technology talents. Through LDA topic modeling and grounded theory programming coding of the central policy, the theoretical analysis framework of supervisor capacity building for innovative talent cultivating is constructed, which includes five dimensions: training system, construction content, construction form, assessment management, and construction guarantee. Through the use of Nvivo12, 96 policy documents from 65 "double first-class" universities spanning from 2018 to 2023 have been coded and quantified. The analysis reveals several significant challenges in the current capacity-building of supervisors, including a lack of individualized development concept, insufficient attention being devoted to the module on innovation capability, lack of practicality, underutilization of the positive incentive effect, and a lack of intelligence in training technical support. Addressing these challenges requires improving the personalized training system for supervisors, and establishing a collaborative training support service involving government, industry, universities, and research institutions. Furthermore, a scientific evaluation index system should be implemented, and the utilization of digital intelligence technology should be optimized to enhance the supervisors' training ecosystem.

Keywords: Innovative talents; Supervisor capability; LDA; Grounded theory; Supervisor training

1 Introduction

As high-level innovative talents, supervisors in colleges and universities not only make innovative contributions to the economy and society through scientific research activities but also shoulder the mission and heavy responsibility of cultivating national high-level innovative talents. However, there are still some practical difficulties, such as the lack of awareness of educating people and cultivating top-notch innovative talents, and

the lack of strong support for the cultivation of students' innovative ability by the overall level of supervisors.

In recent years, scholars have carried out a series of discussions around the connotation of supervisor ability[1], the development path of supervisor ability[2], and the influence of supervisor ability on postgraduate innovation ability[3], which provided theoretical reference and empirical evidence for this study. However, the existing research needs to be further deepened: First, the theoretical support for the ability composition and ability building of supervisors facing the cultivation of innovative talents needs to be enriched. Second, there is a lack of investigation on the current situation of the ability building of supervisors in colleges and universities facing the cultivation of innovative talents.

Therefore, it is imperative to establish a framework for enhancing supervisors' capabilities in cultivating innovative talents, find out the gap between the current supervisor capacity-building status and the construction goal, and put forward countermeasures for supervisor capacity building for innovative talent training.

2 Literature review

2.1 The Concept of Innovative Talents

Based on existing research, scholars generally believe that individuals who possess innovative consciousness, innovative thinking, innovative abilities, and innovative output can make valuable creative contributions to society [4-5]. This paper argues that innovative talents are individuals who, guided by an innovative spirit, exhibit both innovative consciousness and practical abilities, are adaptable to the demands of the latest scientific and technological revolution and industrial transformation, and can contribute to the self-sufficiency of national science and technology as well as the high-quality development of society.

2.2 Supervisor Competency in Fostering the Development of Innovative Talent

Moral Literacy

By practicing the scientific spirit and innovative spirit of seeking truth from facts and studying hard in the process of teacher-student communication and scientific research guidance, the supervisor's moral behavior consciously and unconsciously acts as an example to gain students' respect, which has a subtle influence on the spiritual order of graduate students [6], and can directly promote the innovative ability of doctoral students [7].

Innovation Capability

The innovative capability of university teachers is primarily demonstrated in the areas of teaching and scientific research. Teaching innovation capability encompasses the creativity that university teachers develop over time through their teaching activities.

The teaching behavior of teachers themselves plays a crucial role in fostering students' creativity. Creating a classroom environment that encourages autonomy, promotes divergent thinking, and instills confidence in students can enhance the development of their creativity [8]. On the other hand, the innovative capability in scientific research consists of academic and technological innovation, necessitating teachers to possess proactive innovative thinking [9].

Guidance Ability

A significant portion of the skills required in the task domain and creative thinking needed by innovative individuals are often hidden and internalized within them. The transfer of this tacit knowledge necessitates intensive and meticulous information sharing, as well as a high level of intimacy and dedication [10-11]. Supervisors possess the ability to impart innovative tacit knowledge through close personal mentorship. Many complexities and advancements in creativity arise in lasting, willing, reliable, and negotiated collaborations. The stronger the guidance, and the more harmonious the mentor-student relationship, the more advantageous it is in enhancing the innovative capacity of graduate students [12].

3 Research Design

3.1 Data Sources

Using search terms such as "supervisor training," "supervisor," and "supervisor capacity building," the relevant policy documents published by the Ministry of Education and the official website of "double first-class" universities were collected, and the time limit was 2018-2023. Finally, 26 central policy documents and 96 effective policy documents from 65 universities were screened out.

3.2 Research Methods

LDA

Latent Dirichlet Allocation (LDA) is a document topic generation model based on Bayesian distribution, which includes three layers of structure: words, topics, and documents. The joint probability distribution formula of the LDA model is as follows:

$$P(\theta, z, w|\alpha, \beta) = P(\theta|\alpha) \prod_{n=1}^N P(z_n|\theta) P(w|z_n, \beta) \quad (1)$$

For the n th word in the document, the topic is first extracted from the topic distribution of the document and then extracted from the word item distribution corresponding to the topic, and the random process is repeated continuously until the whole traversal of the document is realized, where z represents the topic, w is the words in the document, α is the topic probability distribution parameter, β is the word item distribution probability parameter, θ is the topic distribution of each article, and N represents the number of all words in the document.

Grounded Theory

Grounded theory is a qualitative research method based on inductive logic, which can find and construct theories from original data, and constantly verify and improve them through comparison, coding, and sampling. Although the LDA topic model can identify hot topics, it can only refine topic words according to the set k value, and cannot trace the topic source. Through the programmed coding process of grounded theory, not only the identification and classification of subject words and sub-topics can be realized, but also the hot topics can be traced back to the original policy, which makes up for the deficiency of the LDA topic model.

3.3 Analytical Framework

Topic Clustering

Firstly, we use R language and R studio programming tools to preprocess word segmentation and build the LDA topic model for 26 supervisor capacity-building policy texts issued by the central government. Refer to the confusion score to determine the number of topics. The lower the confusion score, the more accurate the topic model can describe the content of the new document. The calculation formula for the confusion score is as follows:

$$P = \exp\left(-\frac{\sum_{d=1}^M \log P(w_d)}{\sum_{d=1}^M N_d}\right) \tag{2}$$

M represents the number of documents, N_d represents the number of words in each document d , w_d represents the words in document d , and $p(w_d)$ is the probability of word w_d in a document.

The calculation results show that when the number of topics is 20, the perplexity score is at the lowest inflection point, so the number of topics is 20(see Figure 1), and as shown in Table 1, similar topics are merged and clustered into five dimensions.

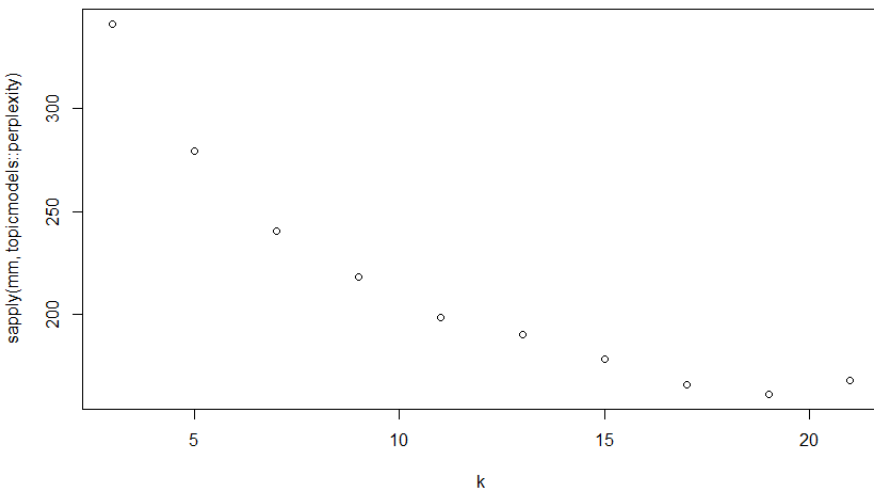


Fig. 1. Perplexity result

Table 1. LDA topic clustering results

Dimension	Initial topic
Construction type	T1 University teachers, T15 Classified management
Construction content	T12 Teacher's morality construction, T18 Duty standard, T19 Professional ability, T3 Postgraduate training, T6 Cultural education, T4 Practical teaching, T5 Teaching tasks
Construction form	T10 Typical demonstration, T16 Communication practice
Assessment management	T2 Assessment standard, T11 Quality evaluation, T14 Incentive mechanism
Construction guarantee	T7 Policy support, T8 Main responsibility, T9 System, T13 Culture shaping, T17 Digital resources, T20 Mechanism innovation

Element Extraction

Through Nvivo qualitative analysis software, the policy texts issued by the central government are deeply interpreted, and the core concepts and categories involved in the process of supervisor capacity building are extracted, which complement each other with LDA topic clustering results. As shown in Table 2, an analysis framework for supervisor capacity building for the cultivation of innovative talents has been constructed.

Table 2. Analysis framework

Dimension	Revised topic	Category
Training system	Pre-job training	Newly hired supervisor
	Thematic training	On-the-job supervisor
	Individualized learning	Different disciplines supervisor, Different stages supervisor, Different types supervisor
Construction content	Moral literacy module	Scientific spirit, Professional ethic, Duties of a supervisor Educational ideas and guiding methods
	Guidance ability module	Psychological knowledge, Guidance relationship
	Innovation capability module	Teaching method, Scientific research method,

		Interdisciplinary and academic frontier
Construction form	Theoretical learning	Keynote speech
	Practical learning	Industry practice, Exchange and discussion, Typical demonstration, Visiting study, Academic vacation
Assessment management	Assessment standard	Process assessment, Effect evaluation
	Incentive measures	Constraint mechanism, Incentive mechanism
Construction guarantee	Organizational guarantee	University, government, society
	Funding guarantee	Special funds, establishment funds
	Technical support	Digital resource library, Online learning platform

4 Results

Based on the analysis framework, this paper examines the policy texts of 65 "double first-class" universities, comparing them with relevant theories of innovative talent training and the policy requirements of the central government to identify practical problems in supervisor capacity building for cultivating innovative talents.

4.1 Lack of Individualized Development Concept

Table 3. Coding statistics of training system dimension

Elements		Reference points	Percentage
Pre-job training	Newly hired supervisor	21	39.62%
Thematic training	On-the-job supervisor	17	32.08%
Individualized learning	Different disciplines supervisor	10	18.87%
	Different stages supervisor	3	5.66%
	Different types supervisor	2	3.77%
Total		53	100%

Due to the training characteristics and needs of innovative talents, the ability development of postgraduate supervisors also presents diversified and personalized characteristics. However, Table 3 shows that colleges and universities pay insufficient

attention to personalized learning of supervisors, with 18.87% of reference points emphasizing discipline characteristics, 5.66% emphasizing targeted training for different levels such as youth and backbone supervisors, and the lowest proportion emphasizing training for different types such as professional degree supervisors, only 3.77%.

4.2 Insufficient Attention has been Devoted to the Module on Innovation Capability

Table 4. Coding statistics of construction content dimension

Elements	Reference points	Percentage
Moral literacy module	119	50.21%
	Scientific spirit	58
	Professional ethic	42
	Duties of a supervisor	19
Guidance ability module	96	40.51%
	Educational ideas and guiding methods	49
	Psychological knowledge	33
	Guidance relationship	14
Innovation capability module	22	9.28%
	Teaching method	12
	Scientific research method	8
	Interdisciplinary and academic frontier	2
Total	237	

Major original innovations often arise from interdisciplinary fields, and interdisciplinary integration is not only a crucial element for major innovations but also a significant platform for nurturing innovative talents [13]. However, it can be observed from Table 4 that the innovation capability module in the institutional documents of universities only accounts for 9.28%, which is much lower than the moral literacy module (50.21%) and the guidance ability module (40.51%). Surveys indicate that 68.3% of teachers cannot effectively integrate new technologies with their respective majors, while 72.6% of teachers exhibit a strong willingness to integrate disciplines [14]. This discrepancy may result in limitations in supervisors' knowledge scope, academic vision, and interdisciplinary cultural identity, thus hindering their motivation for original innovation. Without a solid interdisciplinary cultural identity and the necessary methods and skills for interdisciplinary education, supervisors may struggle to achieve outstanding results in interdisciplinary postgraduate training.

4.3 Lack of Practicality

Table 5. Coding statistics of construction form dimension

Elements	Reference points	Percentage
Industry practice	17	16.35%
Exchange and discussion	39	37.50%
Typical demonstration	5	4.81%
Visiting study	8	7.69%
Keynote speech	34	32.69%
Academic vacation	1	0.96%
Total	104	100.00%

Table 5 shows that current colleges and universities do not adequately focus on the overall practice of supervisors, with "industry practice" accounting for only 16.35%. Additionally, there is a lack of creation of a practical training environment for supervisors. According to relevant notification documents from colleges and universities, most training is conducted in academic lecture halls on campus, with training sessions lasting only 1-2 days. These short-term, concentrated training sessions do not facilitate the shaping and interaction of practical situations, nor do they allow for sufficient time for practical reflection and application for supervisors. Industry practice is essential for the development of supervisors' professional autonomy. The overall lack of industry practice hinders the practical ability of most young teachers, exacerbating the issue of limited supervisor training autonomy and ultimately weakening the overall postgraduate practical ability training [15].

4.4 The Positive Incentive Effect is not Fully Exerted

Table 6. Coding statistics of assessment management dimension

Elements		Reference points	Percentage
Assessment standard	Process assessment	37	78.72%
	Effect evaluation	10	21.28%
	Total	47	100.00%
Incentive measures	Constraint mechanism	49	81.67%
	Incentive mechanism	11	18.33%
	Total	60	100.00%

According to Table 6, the majority of assessments focus on the process rather than the outcome, potentially reducing capacity building to a mere formality. There is also a lack of positive feedback in the design of incentive measures, with constraint

mechanisms comprising 81.67% and incentives accounting for only 18.33%. This highlights a gap in the current assessment management concept of training authorities, as it fails to align with the growth patterns and unique characteristics of training innovative talents. Additionally, there is a notable absence of specific regulations governing the standards of training assessment management. This absence results in the haphazard and simplistic design and implementation of training assessment systems, leading to a lack of effective feedback for participating supervisors in long-term training projects. Ultimately, this hinders the ability to fully leverage the motivating potential of training assessment management.

4.5 Lack of Intelligence in Training Technical Support

Table 7. Coding statistics of construction guarantee dimension

Elements	Reference points	Percentage
Organizational guarantee	106	82.81%
Funding guarantee	16	12.50%
Technical support	6	4.69%
Total	128	100.00%

As depicted in Table 7, the utilization of intelligent technology in supervisor capacity building has not reached a level of institutionalization and widespread development. Only 4.69% of technical support is referenced in this regard. The integration of emerging technologies and supervisor capacity building remains inadequate, primarily focusing on training implementation. Intelligent support throughout the entire process of "needs analysis-content design-curriculum development-training implementation-training evaluation" has not been ensured.

5 Conclusions

Based on the LDA topic model and grounded theory programmed coding, this paper establishes a theoretical framework for the capacity building of graduate supervisors for cultivating innovative talents, which mainly includes five dimensions: training system, construction content, construction form, assessment management, and construction guarantee. This paper investigates the current policy documents on supervisor capacity building in double first-class universities from 2018 to 2023. The results of the study reveal several challenges faced by the capacity building of graduate supervisors for innovative talent training in China. These issues include a lack of individualized development concept, insufficient attention that has been devoted to the module on innovation capability, lack of practicality, the positive incentive effect is not fully exerted, and lack of intelligence in training technical support. The paper proposes relevant recommendations to address these issues.

Firstly, it suggests improving the personalized training system for supervisors by collecting and analyzing training needs for supervisors of different disciplines, levels, and types. Develop training content and design training methods based on the results of the needs analysis. Set up supervisor training files and provide customized training programs for different supervisors.

Secondly, it proposes building a collaborative training support service system. This system would establish an inter-departmental supervisor training organization encompassing universities, governments, scientific research institutions, enterprises, and other societal sectors. It aims to enhance the operating mechanism of supervisor collaborative training through resource sharing, training achievement transformation, and mutual benefit mechanisms.

Thirdly, it suggests establishing a scientific evaluation index system and improving the evaluation process and method based on the four levels of "reaction-learning-behavior-result". Ensure timely and accurate feedback of training effect, and provide a basis for subsequent improvement and optimization. In the design of incentive mechanisms, one hand enhances training incentives, strengthens the effective connection and penetration between restraint mechanisms and incentive mechanisms, and enhances the effect of policy implementation, while on the other hand, material and spiritual incentives are combined to design diversified incentives.

Lastly, it advocates for optimizing the supervisor training ecosystem by leveraging digital intelligence empowerment. Integrate smart technologies such as artificial intelligence, big data, and virtual simulation to enhance supervisor training techniques, catering to the diverse and individualized learning requirements of participating supervisors. Furthermore, utilize intelligent technologies to revamp the supervisor training system and modernize the delivery approach of such training. This encompasses the entire supervisor cycle from "selection and admission-pre-employment training-on-the-job training", including demand analysis, online learning, learning process monitoring, training evaluation, and more.

This paper's contribution lies in constructing an analytical framework for enhancing supervisor capacity building, covering five dimensions: training system, construction content, construction form, assessment management, and construction guarantee. This study offers valuable insights for advancing the integration of education, science and technology, talent development, and supervisor training in higher education institutions.

Acknowledgments

This research was supported by the Liaoning Province's 2023 Postgraduate Education and Teaching Reform Project titled "Research and Practice of Supervisor Training and Training System for Innovative Talents Training", the Dalian University of Technology's Postgraduate Education Reform Project under the title "Research on Full Coverage, Full Cycle, and All-round Supervisor Training System" (JG2021010) and the "Research on Team Building in supervisor Based on Multi-Dimensional Ability Training" (JG2022054).

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