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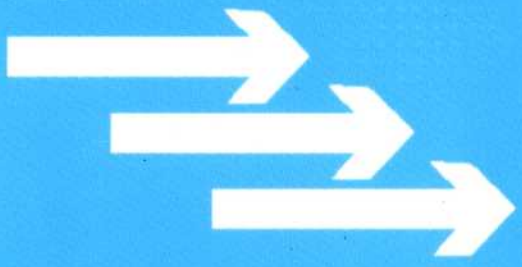

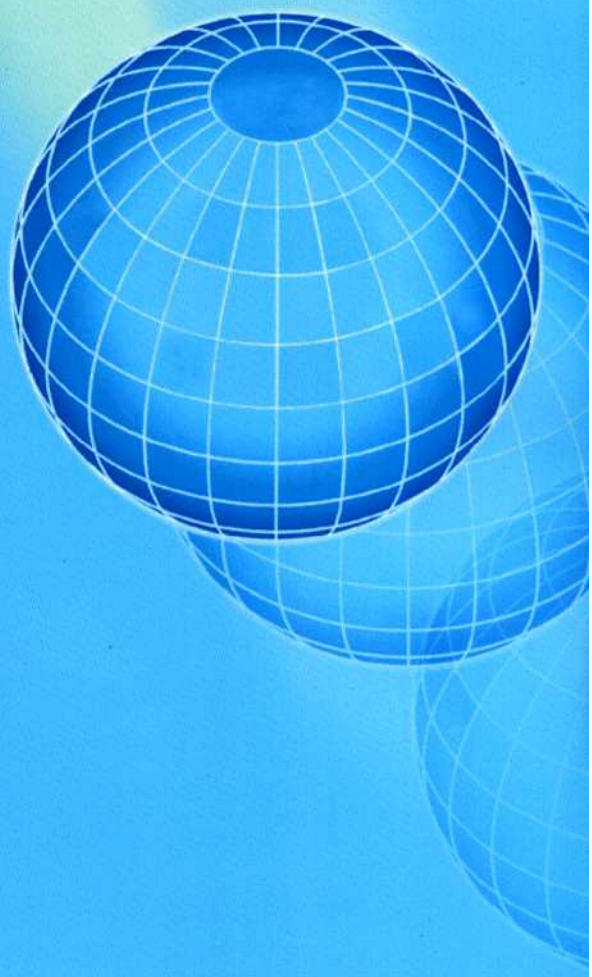

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GRAY CORRELATION ANALYSIS ON INFLUENCING FACTORS OF POSTGRADUATES' INNOVATIVE CAPACITY

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ABSTRACT

Cultivation of innovative spirit and capacity is the core of postgraduate education, serving also as the requirement of its development and nature. With the help of grey correlation analysis, this paper analyzes the correlative degrees of influencing factors in postgraduate education. Data collected indicate evidently that innovative capacity of postgraduates are closely related to factors like creativity of the supervisor, discipline construction, social demand for professional personnel, thesis writing and social practice skills, with correlative degrees being 0.881, 0.869, 0.829, 0.805 and 0.799 respectively. In contrast, factors like enrolling system and examinees' intelligence show much less relevance with correlative degree being below 0.4.

Keywords: *Postgraduates(P), Innovation Capacity(IC), Influencing Factor(IF), Grey Correlation Analysis(GCA)*

1. INTRODUCTION

Ever since 2010, full-time postgraduate education falls into two categories: academic master degree and professional master degree. Similar to traditional training target, academic master degree aims to cultivate teaching and scientific research personnel whereas education for professional master degree intends not only to help students lay a solid theoretical foundation but also to cultivate practical and professional personnel that are highly demanded in the market. Judging from the competitive job market nowadays, the key to improving the embarrassing situation for postgraduates who are unfit for higher posts but unwilling to take the lower ones and to realizing their value lies in the cultivation of their innovative capacity, thus making it the core of postgraduate education and embodiment of its requirement and nature. In recent years, the analysis of associated influencing factors and scientific evaluation methods has become an urgent concern for scholars[1-2], for they are crucial in improving innovative ability of postgraduate and employment rate. Grey correlation analysis proposed by Professor Deng julong, provides a quantitative method as well as a comparative way to show the trend of continuous development of a system. Its basic idea is to measure correlation degree and the numerical relations between subsystems, by examining the degree of similarity or dissimilarity between certain geometrical figures and correlation between curves representing the reference number sequence and several comparative number sequence[3].Grey correlation analysis is employed in this paper in order to show correlative degrees of various influencing factors of postgraduate students' innovative ability, thus paving the way for evaluation of their creativity.

2. ALGORITHM OF GREY CORRELATION ANALYSIS

Grey correlation analysis quantifies the dynamic correlation degree of the trend of a system and its influencing factors; it is suitable for dynamic analysis[4]. Concrete steps of implementation are as follows:

2.1 Define reference number sequence reflecting system behavior and comparing number sequence affecting system behavior

Select reference number sequence reflecting system behavior, i.e. to choose the optimal value of one among all influencing factors as the ideal sample logo or reference number sequence, and then select the optimal value of influencing factors as comparing number sequence.

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2.2 Turn the reference and comparing number sequence into dimensionless for better comparison of various factors

$$xi(k) = \frac{xi(k)}{xi(m)}, k = 1,2,3\ldots n; i = 0,1,23\ldots m$$

2.3 Calculate grey correlation coefficient of reference and comparing number sequence ξ, and find out the maximum and minimum in the grey relational coefficient. Correlation coefficient of x0(k) and xi(k):

$$\zeta i(k) = \frac{\min\limits_i \min\limits_k |y(k) - xi(k)| + \rho \max\limits_i \max\limits_k |y(k) - xi(k)|}{|y(k) - xi(k)| + \rho \max\limits_i \max\limits_k |y(k) - xi(k)|}$$

Assuming $\Delta_i(k) = |y(k) - x_i(k)|$, then

$$\xi_i(k) = \frac{\min\limits_i \min\limits_k \Delta_i(k) + \rho \max\limits_i \max\limits_k \Delta_i(k)}{\Delta_i(k) + \rho \max\limits_i \max\limits_k \Delta_i(k)}$$

ρ is named as distinguishing coefficient, the range of values allowed for ρ is from 0 to 1. Usually ρ = 0.5.

2.4 Grey correlation degree (r) calculation

$$ri = \frac{1}{n}\sum_{k=1}^{n} \zeta i(k), k = 1,2,3\ldots n$$

3. GRAY CORRELATION ANALYSIS ON INNOVATIVE CAPACITY OF POSTGRADUATES

3.1. Influencing Factors Determination

As research varies in content and emphasis, components of innovation also vary greatly. Generally speaking, there are Three-component Claim, Four-component Claim, Five-component Claim and Multi-component claim[4-5]. Multi-component claim believes that innovative capacity, as advanced manifestation of intelligence, is composed of acute observation, focused attention, good memory, rich imagination, critical judgment and innovative thinking (including metacognition, practical abilities, etc) which are all components of intelligence. Assessment of postgraduates' innovation in this paper involves examination of their ability to construct knowledge, analyze, solve problems and to break new ground. Based on literature review, we decide on the following associated influencing factors(Table 1).

Table 1. Influencing Factors Of Innovative Capacity Of Postgraduates

First grade indexes	Second grade indexes	Meaning
Creative thinking of students	Intelligence factor	Profound reflection, acute perception, rich imagination and ability to gain knowledge
	Non-intelligence factor	High expectation, courage to conquer difficulties, strong will power to persevere
	Psychologic factor	Strong passion to create, desire to explore, thirst for knowledge, curiosity, enterprise and confidence
Creative concept of education	Discipline construction	Discipline construction is the prerequisite to cultivation of creative thinking. The development of disciplines into national or provincial key disciplines provides postgraduates with advanced subjects and research topics.
	Training plan Curriculum	Revising the training plan, optimizing the course structure, emphasizing the training of method employment and ability, promoting teaching reform, including influencing factors like teaching, research practice and dissertation writing and so on
	Thesis writing	
	Social practice	Broadening students' horizon by on-the-job-placement, social practice during summer vocation, social investigation, etc.
	Teaching mode	Self study, seminar, research, SSR teaching mode, monographic study and case study centered on problems and organized for research subjects
	Quality monitoring and Evaluation system	Establishment of dynamic innovation evaluation system. In addition to thesis oral defense, we should attach greater importance to evaluation system, which leads to a comprehensive evaluation system of teaching quality and functioning also as part of it, gives

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		Timely feedback and control.
Supervisors	The selection and appraisal of supervisors	Regulating selection of research subjects, thesis proposal, research conduction, supervision and oral defense. Observing the requirements of innovation and practically improving postgraduates' scientific research ability, creativity and innovative spirit.
	Innovative capacity of supervisors	
	Laboratory construction	Constructing laboratories and training base as a forum centering on major scientific research projects in order to cultivate students' innovation
	Academic atmosphere	Carrying out academic exchanges and a variety of academic activities, like lectures made by renowned experts at home and abroad. Participation in those domestic and international conferences not only enables students to know the frontier of the discipline, but also improves their professional skills and broadens their horizons.
Postgraduate enrolling system	Enrolling aim	As the core of enrolling system, it plays a guiding role in selection of students and implementation of enrollment. It is also closely related to the interest of the state, society, schools, families and individuals, manifesting general requirements on the quality and specification of students.
	Recruit and the register condition	It refers to those who conform to the register condition and their level of education, physical constitution, morality etc.
	Concrete measures for implementation (assessment and enrollment)	Concrete measures for implementation serve to ensure the purpose of enrollment. Admission conditions manifest the concept of talent.
Social environment	Macro social environment	State financial investment on postgraduate education, legal environment, social culture environment, political environment, economic environment, and technological environment
	Expectation of employment	Students' expectation of employment, salary and prospect of their job
	Social demand for professional personnel	

3.2. Data Analysis

By interviewing postgraduates from four postgraduate programs in Hebei normal university science & technology, this paper conducts an experiment on their views towards twenty influencing factors with the help of Likert's five point rating scale, naming great influence, strong influence, moderate influence, slight influence and no influence scored by 5, 4, 3, 2, 1 points respectively. Results are calculated from weighted averages of the scores graded by students from different majors. Y1 to Y4 represent vocational and technical education major, applied chemistry major, Pomology major, Plant Genetics and Breeding major respectively. Data analysis is indicated from table 2 to 5. Judging form table 5, we can tell that postgraduates' creativity is closely related to the innovative ability of their supervisors, discipline consternation, social demand for professional personnel, thesis writing and social practice skills, with correlation degree being 0.881, 0.869, 0.829, 0.805 and 0.799 respectively. Enrolling system and intelligence factors, on the other hand, show much less relevance with correlative degree being below 0.4.

Table 2. Source Data On Major Influencing Factors

Influencing factors	Y1	Y2	Y3	Y4
Intelligence factor	3.215	3.341	3.184	3.357
Non-Intelligence factor	3.59	3.27	3.44	3.27
Psychologic factor	4.463	4.359	4.688	4.135
Discipline construction	4.866	4.896	4.635	4.777
Training plan	3.966	3.854	3.478	3.954
Curriculum	4.126	4.555	4.323	4.398
Thesis writing	4.055	4.896	4.789	4.752
Social practice skills	4.661	4.562	4.782	4.635

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Teaching mode	4.788	3.654	3.87	4.125
Quality monitoring and evaluation system	4.120	3.569	3.666	3.451
The selection and appraisal of supervisors	3.589	3.457	3.265	3.412
Innovative capacity of supervisors	4.879	4.564	4.988	4.789
Laboratory construction	2.689	4.855	4.978	4.865
Academic atmosphere	4.336	4.654	4.447	4.569
Enrolling aim	2.335	2.654	3.125	2.894
Recruit and register condition	2.455	2.365	2.478	2.475
Concrete measures for implementation (assessment and enrollment)	2.987	3.012	3.145	3.120
Macro social environment	3.142	3.215	3.225	3.897
Expectation of employment	4.665	4.689	4.665	4.564
Social demand for professional personnel	4.789	4.888	4.612	4.567
Standard Value	5	5	5	5

Table 3. Dimensionless Table

Influencing factors	Y1	Y2	Y3	Y4
Intelligence factor	0.643	0.668	0.637	0.671
Non-Intelligence factor	0.718	0.654	0.688	0.654
Psychologic factor	0.893	0.872	0.938	0.827
Discipline construction	0.973	0.979	0.927	0.955
Training plan	0.793	0.771	0.696	0.791
Curriculum	0.825	0.911	0.865	0.880
Thesis writing	0.811	0.979	0.958	0.950
Social practice skills	0.932	0.912	0.956	0.927
Teaching mode	0.958	0.731	0.774	0.825
Quality monitoring and evaluation system	0.824	0.714	0.733	0.690
The selection and appraisal of supervisors	0.718	0.691	0.653	0.682
Innovative capacity of supervisors	0.976	0.913	0.998	0.958
Laboratory construction	0.538	0.971	0.996	0.973
Academic atmosphere	0.867	0.931	0.889	0.914
Enrolling aim	0.467	0.531	0.625	0.579
Recruit and register condition	0.491	0.473	0.496	0.495
Concrete measures for implementation (assessment and enrollment)	0.597	0.602	0.629	0.624
Macro social environment	0.628	0.643	0.645	0.779
Expectation of employment	0.933	0.938	0.933	0.913
Social demand for professional personnel	0.958	0.978	0.922	0.913
Standard Value	1.000	1.000	1.000	1.000

Table 4. Grey Correlation Coefficient

Influencing factors	Y1	Y2	Y3	Y4
Intelligence factor	0.427	0.445	0.423	0.448
Non-Intelligence factor	0.486	0.435	0.461	0.435
Psychologic factor	0.713	0.675	0.810	0.606
Discipline construction	0.909	0.928	0.785	0.857
Training plan	0.563	0.538	0.467	0.560
Curriculum	0.604	0.750	0.663	0.689
Thesis writing	0.585	0.928	0.863	0.843
Social practice skills	0.797	0.753	0.859	0.785
Teaching mode	0.863	0.497	0.541	0.604
Quality monitoring and evaluation system	0.602	0.482	0.500	0.462

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The selection and appraisal of supervisors	0.486	0.463	0.434	0.456
Innovative capacity of supervisors	0.917	0.753	0.991	0.863
Laboratory construction	0.366	0.902	0.984	0.908
Academic atmosphere	0.667	0.794	0.707	0.756
Enrolling aim	0.333	0.362	0.415	0.388
Recruit and register condition	0.344	0.336	0.346	0.345
Concrete measures for implementation (assessment and enrollment)	0.398	0.401	0.418	0.415
Macro social environment	0.418	0.427	0.429	0.547
Expectation of employment	0.799	0.811	0.799	0.753
Social demand for professional personnel	0.863	0.922	0.774	0.755

Table 5. Correlation Degree Of Influencing Factors And Their Ranking Order

Influencing factors	Correlation degree	Ranking
Intelligence factor	0.436	17
Non-Intelligence factor	0.454	16
Psychologic factor	0.701	9
Discipline construction	0.869	2
Training plan	0.532	11
Curriculum	0.676	10
Thesis writing	0.805	4
Social practice skills	0.799	5
Teaching mode	0.626	12
Quality monitoring and evaluation system	0.512	13
The selection and appraisal of supervisors	0.460	14
Innovative capacity of supervisors	0.881	1
Laboratory construction	0.790	7
Academic atmosphere	0.731	8
Enrolling aim	0.375	19
Recruit and register condition	0.343	20
Concrete measures for implementation (assessment and enrollment)	0.408	18
Macro social environment	0.455	15
Expectation of employment	0.791	6
Social demand for professional personnel	0.829	3

4. DISCUSSION THE DETAILED ANALYSIS OF INFLUENCING FACTORS

4.1. Construction Of The Supervisor Team As The Base Of Cultivating Innovative Capacity Of Postgraduates

In China, there are many factors that may affect the cultivation of postgraduates' innovative ability, such as educational system, academic environment, traditional culture, value orientation, supervisor team and teaching mode. Among all those possible factors, supervisor team turns out to be the prime factor, for it is the supervisor who plays the guiding role in students' learning process by imparting knowledge, guiding their scientific research, and exploring academic issues with them[6]. At the same time, strategic thinking is organization architecture and using of the employees' individual intelligence[7]. Therefore, we cannot underrate the role played by a high level academic faculty team with reasonable age structure, high level educational background, well-structured professional titles and creative thinking. Such a team will definitely encourage and guide students to be creative in their bold exploration and improve their innovative ability which, with inspirations and new statistical methods, will in turn facilitates supervisors' own research projects and promotes scientific research at large[8]. Under the supervisor-responsibility system, the combination of individual and collective teaching gives full play to supervisors' expertise and makes close cooperation between supervisors with different knowledge structure possible, enabling students to form a complete knowledge structure and system for innovative ability.

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4.2 Discipline Construction As Strategic Infrastructure In The Development Of Higher Education

Discipline construction is the core of postgraduate education as well as the guarantee of its quality. Meanwhile, postgraduate education promotes discipline construction in turn and manifests its development. Innovation is crucial for the quality of postgraduates[9]. Therefore, discipline construction is closely related to postgraduate education; they complement and promote each other. Disciplines authorized to grant master degrees are likely to undertake major scientific research projects and thus can provide students with a broad field of research topics and platform for scientific study. In turn, postgraduate students, as a fresh force for research, promote the development of subjects with their research findings.

4.3 Thesis Writing As The Key To Cultivating Postgraduates' Innovative Spirit And Ability

Nathan M. Pusey, the 24th President of Harvard University, argues that creativity draws a clear distinction between first-class and third-rate talents. It is creative thinking that comes before creativity in all fields[10]. Therefore, supervisors should help students enrich their knowledge in research practice, improve their theoretical level and foster independent thinking. Meanwhile, supervisors should also encourage them to study assiduously, seek truth from facts and foster the pioneering spirit to innovate in scientific research. In the process of thesis writing, supervisors must carefully guide students to study the up-to-date literatures, new technology and algorithm[11-12],employ innovative and advanced methods. Research topics could either be frontier subject or interdisciplinary subject to fill the domestic research gap. Attention should also be given to updated writing methods, such as introduction of new statistical methods or reform of the traditional experimental procedures[13].

4.4 Social Demand For Professional Knowledge And Personnel As The Stimulant Of Cultivation Of Postgraduates' Innovation

In recent years, due to the declining employment rate among college graduates, many of them choose to apply for further education for better job opportunities. Therefore, the demands of enterprises, institutions, career stability and income have become prime concern of postgraduates [14]. In order to cultivate talents that are in short supply, universities should change the traditional training mode, establish the schools' principal status in the market and set up a flexible contact with employers for better understanding of their requests. Only in this way can we solve the problem of "labor shortage" as well as stimulate students' creativity when they are guaranteed of future employment and get the motivation to learn. E.R.Naganathan et al. [15] utilize artificial neural networks to obtain knowledge for the management of educational resources to predict student results and help postgraduates find suitable career.

4.5 Social Practice As A Platform For Cultivation Of Innovative Ability

Innovation involves the ability to construct knowledge, raise questions, solves problems and to break new ground. Nowadays, postgraduate students generally lack the ability to ask questions and to break new ground. Just imagine, if a student cannot even ask a single question, how can he be creative? Two major causes for the current status lie in students' misconception to wait for a ready answer and the fact that traditional teaching mode fails to provide the necessary condition for innovation. Therefore, we should advocate practical teaching to suit students' various needs and encourage independent learning. Methods to bring out students' initiative should also be employed, such as seminars, SSR and question-oriented teaching methods. We should also organize students by research topics and exercise monographic study and case study oriented toward problems. Bruner's discovery learning, Bernard's emphasis on effective learning methods, Bohr's belief, Wagenschein's case method all prove to be effective in postgraduate education[16]. Supervisors should provide different research topics for different students and allow them freedom to choose or offer them topics relevant to the supervisors' own research subjects. They can also explore new topics with employers. In a nutshell, personalized education, scientific research and assessment provide the only way to give full play to students' potential and improve their creativity.

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