

Construction of Evaluation Index System of University Students' Innovation Ability Based on Social Network Analysis

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Abstract—University students can drive the country's technological progress with their innovative ability. However, in reality, most researches have not gone in-depth into the study of the components of university students' innovation ability or the evaluation index system. This paper, on the basis of the quantitative analysis on literature, works out initially the innovation ability evaluation index system of university students. Then, data collected from the questionnaire and social network analysis tool are adopted to select appropriate indexes. With the introversion centrality the screening criterion, it builds the innovation ability evaluation index system of university students. The system consists of six primary indicators and 36 secondary indicators, which provides reference and guidance for evaluating university students' innovation ability.

Keywords—university students; innovation ability; evaluation index system; social network analysis

I. INTRODUCTION

University students are the main force for innovation, which drives the country's technological advance. It is the priority of higher education to cultivate students' innovative spirit and capability. A scientific innovation ability evaluation system of university students is not only helpful for colleges and universities to open innovative courses and arrange corresponding innovative practices, effectively improve the innovation education in colleges and universities, but also helpful for university students to get an objective understanding of their own innovation ability, so as to make efforts as is needed. Through literature review, this paper summarizes carries out statistical analysis of the factors influencing students' innovative ability, establishes an evaluation index system of university students' innovation ability, and then uses questionnaire survey data and social network analysis tools to build an evaluation index system of university students' innovation ability based on the principle of internal centrality, providing reference and guidance for the evaluation of university students' innovation ability.

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II. LITERATURE REVIEW

A. The innovative ability of university students

Amabile [1] believes that innovation ability consists of innovation motivation, innovation knowledge and innovation skills. Qian Zhaochu [2] considers that university students' innovative ability includes four aspects, that is, thinking innovation ability, lifelong learning ability, self-management ability and innovative practical ability. Zhang Yuanyuan [3] found that the innovation ability of university students depends on five aspects, namely, innovation consciousness, innovation spirit, innovative thinking, knowledge structure and practical ability. Lu Jingdan et al. [4] built a measurement model of university students' innovation ability based on SEM, and believed that the innovation ability contains innovation consciousness and innovation skill. Innovation consciousness consists of observation, imagination and inquiry ability while innovative skills involve information processing and hands-on operation skills.

B. Factors influencing university students' innovation ability

On the basis of literature review, Cui Hongqiao et al. [5] made a qualitative and quantitative study of the factors affecting the cultivation of university students' innovative ability, and concluded that the factors such as innovative incentive mechanism, innovative practical training and social atmosphere will have an impact on the cultivation of the innovative ability. Based on the influencing factors model of university students' innovative thinking ability, Li Cunjin et al. [6], through quantitative analysis, concluded that university students' innovative thinking ability is relatively low, which is influenced by their own dimension, education system dimension and family education dimension. Cui Huibin [7] made a quantitative analysis of the relationship between information literacy and university students' innovation and entrepreneurship ability. Combining with structural equation model analysis, he concluded that information literacy has a significant impact on university students' innovation ability, and put forward corresponding measures and suggestions.

C. Evaluation of university students' innovative ability

Fudan et al. [8] qualitatively analyzed the innovative ability of university students by questionnaire survey and experts grading method, and evaluated the innovative ability of university students by extension comprehensive evaluation

method. The results showed that the evaluation of the innovative ability of university students by extension comprehensive evaluation is more objective and scientific. Li Yanpo et al. [9] summarized the evaluation indexes of innovation ability of university students at home and abroad, and combined with the characteristics of higher vocational colleges in China, put forward the related evaluation index system in Chinese higher vocational colleges, and used the fuzzy comprehensive evaluation to assess the innovation ability of university students. Gu Jun [10] used the questionnaire survey and expert scoring method to construct the evaluation index of university students' innovative ability, and preliminary applied the index system combined with fuzzy comprehensive evaluation.

Through the literature, it is found that the influencing factors involved in the evaluation index system of university students' innovation ability are not comprehensive enough. Therefore, based on the literature analysis, this paper intends to use the social network analysis method to construct a systematic and scientific evaluation index system of university students' innovation ability.

III. CONSTRUCTION OF EVALUATION INDEX SYSTEM OF UNIVERSITY STUDENTS' INNOVATION ABILITY

Based on the analysis and extraction of relevant research literature, this paper summarizes the factors affecting university students' innovative ability and builds the evaluation index system of university students' innovative ability for the first time. Then, the relationship matrix between samples and indicators is obtained by using questionnaire data, and the selection of indicators is completed by using social network analysis tools.

A. Initial construction of the evaluation index system of university students' innovation ability

303 journals in this paper are all collected from CNKI by typing in keywords like "University Students' Innovative Ability", "University Students' Innovative Ability Assessment", "Innovative Evaluation Index", "Influencing Factors of Innovative Ability" and setting the retrieval period from July 2009 to July 2019. Based on the contents of the indicators built by domestic and foreign scholars, this paper interprets, analyses, codes, collates and synthesizes the factors affecting university students' innovative ability, deletes indicators whose frequency are less than five times, and summarizes the secondary indicators as shown in table 1.

TABLE I. EVALUATION INDEX SYSTEM OF UNIVERSITY STUDENTS' INNOVATION ABILITY (INITIAL)

Indexes	Connotation of index	Indexes	Connotation of index
Innovative consciousness	Motivation to create new things or ideas	Awareness of adventure	Interest in exploring new things
Entrepreneurship competition award	Innovative practical achievements	Publish of academic papers	Innovative achievements
Intuitive thinking	Thinking pattern of understanding the essence of things	Critical thinking	Quality of questioning authority
Basic knowledge	Foundation of innovation	Relevant knowledge	Information or skills related to innovation
Knowledge integration ability	Knowledge transfer and connectivity	Knowledge renewal ability	Updating and iteration of knowledge system
Social practice	Holiday or off-campus internship	Research on scientific projects	Innovative achievements
Exploratory consciousness	Interest in the unknown	Strive hard and make progress	Positive performance
Quality of graduation design	Ability to apply professional knowledge	Application for patent	Innovative achievements
Divergent thinking	Thoughts that do not conform to convention and seek innovation	Overcome difficulties	Ability to solve difficult problems
Professional knowledge	Stable and systematic knowledge	Digital model competition	Innovative achievements
Knowledge acquisition ability	Ability to acquire and master new knowledge	Information retrieval ability	Ability to collect and integrate information
Experimental practical ability	Hands-on and problem-solving skills	Internship experience	Learning experience from practice
Questioning spirit	Doubt about existing things	Analytical and comprehensive ability	Connection and distinction between things
Quality of course design	Ability to apply professional knowledge	Student work	Team work experience
Logical thinking	Law of understanding and reflecting things	Ability to discover and solve problem	Ability to discover and solve problems
Innovative knowledge	Innovative technologies, methods and practices	Academic conference	Acquisition of professional knowledge and information
Knowledge acceptance ability	Acquisition, absorption and utilization of knowledge	Professional interest	A need for something
Market research capability	Ability to collect and analyze market conditions	Moral character	Ideological criteria for measuring the legitimacy of behavior
Self-confidence	Degree of trust in one's ability	Firm will	Degree of firmness to achieve a certain goal
Skill training	Ways to acquire innovative skills	Knowledge transfer ability	Use of existing knowledge to solve new problems

B. Selection of evaluation index of university students' innovation ability

1) Social network analysis

A social network represents a form of social organization in which points and points are interconnected in some way. The points usually refer to individuals or organizations, and their connection means different social relationships. Individuals or organizations form a relatively stable relationship system based on a certain connection. The social network analysis was originally proposed by the famous British anthropologist Professor Brown in the 1930s to study the behavior of members of the bounded group. Chinese scholar Wang Yifei et al. [11] used the social network analysis method to construct the measurement index system of enterprise technology innovation capability, which enriched the application scope of social network analysis methods.

The primary condition of borrowing social network analysis is to clarify the internal associations of each unit, which is the premise of social network analysis. The correlation of social network analysis is oriented, that is, it can not only reflect whether any two units are related, but also mirror the direction of association between them. By establishing the relationship among all units in the network, the association form between them is built to reflect its relationship network. After building the network, it is necessary to calculate the importance of each node (that is, each cell) in the network, namely, the introversion centrality of the network. Introversion centrality of network is mainly used to reflect the status and rights of nodes, which can be classified into three sub-categories: degree centrality, intermediate centrality and proximity centrality. Among them, degree centrality is mainly

used to measure the importance of network nodes. The higher its value is, the bigger its impact is.

2) Selection of index

This paper selected the senior students from Sun Yat-sen University, South China Normal University, Southern University of Science and Technology, and Shenzhen University as the subjects of the survey. 400 questionnaires were distributed and 380 valid questionnaires were collected, with an effective recovery rate of 95%.

The samples and primary and secondary index are regarded as network nodes. The relationship between samples and indicators is defined as the connection line or edge of the network. The importance of indicators is quantified by social network analysis, and the results are visually displayed. Introversion centrality is used as the selection criterion of the index, and the degree centrality of each index is calculated to measure its importance, so as to complete the selection of the evaluation index system of university students' innovation ability.

Based on the results of the questionnaire, the matrix relationship of "sample: secondary index" is constructed respectively, as shown in table 2. Among them, every row in the matrix is composed of sample survey data, and the secondary index is the initial construction of the index system. The 0-1 value reflects whether the sample approves of this index as a factor affecting university students' innovative ability. One represents full approval, and zero shows total disapproval. The basic attribute values of the secondary indicators are calculated by using the social network analysis software Ucinet.

TABLE II. BASIC ATTRIBUTE VALUES OF SECONDARY EVALUATION INDEX OF UNIVERSITY STUDENTS' INNOVATION ABILITY

Secondary index	Degree	NrmDegree	Share	Secondary index	Degree	NrmDegree	Share
Innovative consciousness	61.000	67.155	0.056	Knowledge transfer ability	20.00	34.459	0.019
Exploratory consciousness	57.000	63.879	0.055	Knowledge acceptance ability	20.00	34.459	0.019
Questioning spirit	55.000	61.547	0.052	Knowledge renewal ability	20.000	34.459	0.019
Awareness of adventure	51.000	59.235	0.048	Social practice	19.000	32.855	0.017
Strive hard and make progress	49.000	58.435	0.047	Experimental practical ability	19.000	32.855	0.017
Overcome difficulties	47.000	57.921	0.045	Market research ability	18.000	31.522	0.016
Entrepreneurship competition award	43.000	56.678	0.042	Research on scientific research projects	18.000	31.522	0.016
Quality of graduation design	41.000	56.452	0.039	Internship experience	16.000	26.588	0.014
Quality of course design	39.000	54.375	0.037	Student work	14.000	25.456	0.013
Publish of academic papers	37.000	53.587	0.036	Academic conference	13.000	24.543	0.012
Application for patent	36.000	53.114	0.035	Professional interest group	13.000	23.455	0.012
Digital model competition	35.000	52.456	0.031	Skill training	12.000	21.571	0.017
Intuitive thinking	33.000	50.458	0.031	Information retrieval ability	11.000	20.241	0.009
Divergent thinking	32.000	49.872	0.028	Analytical and comprehensive ability	10.000	18.253	1.000
Logical thinking	31.000	48.259	0.027	Mean	17.892	24.571	0.017
Critical thinking	29.000	47.256	0.026	Std Dev	17.325	11.241	0.009
Basic knowledge	28.000	44.396	0.025	Sum	1004.000	1638.209	1.000
Professional knowledge	26.000	41.346	0.024	Variance	73.168	152.129	0.000
Innovative knowledge	26.000	41.346	0.024	SSQ	2649.000	49761.276	0.031
Relevant knowledge	23.000	39.355	0.023	MCSSQ	4831.598	12899.535	0.006
Knowledge integration ability	23.000	39.355	0.023	Euc Norm	151.339	264.834	0.156
Knowledge acquisition ability	21.000	37.346	0.021	Minimum	10.000	18.253	1.000
				Maximum	61.000	67.155	0.056
Network Centralization=51.62% Heterogeneity=1.93%. Normalized=0.49%							

According to table 2, the centrality of index network reaches 51.62%. From innovation awareness to research

projects, its introversion centrality index ranges from 61 to 18, exceeding the average of 17.892; the lowest centrality of

standardization is 31.522, which has high acceptability. However, the introversion centrality of internship experience, student work and other indicators are lower than the average value of the overall network of 17.892, so the 7 indicators are discarded, and the remaining 36 secondary indicators are used as secondary indicators for the evaluation of university students' innovation ability.

According to the two-level index system, this paper classifies the similar indicators of semantic expression into one group through induction and analysis, and extracts the first-

level indicators of this paper, which are: (1) personal traits, that is, needed characteristics of individual innovation of university students; (2) innovation transfer ability, namely, individual innovation achievements; (3) thinking ability, that is, innovative thinking of university students; (4) ability of knowledge reserve, namely, knowledge and skills that university students use to innovate; (5) learning ability, that is, renewal and iteration of university students' knowledge; (6) practical ability, namely, practical experience of university students' innovation. See table 3 for details.

TABLE III. EVALUATION INDEX SYSTEM OF UNIVERSITY STUDENTS' INNOVATION ABILITY

Primary indicator	Secondary indicator	Primary indicator	Secondary indicator
Personal qualities	Innovative consciousness	Innovation transfer ability	Entrepreneurship competition award
	Exploratory consciousness		Quality of graduation design
	Questioning spirit		Quality of course design
	Awareness of adventure		Publish of academic papers
	Strive hard and make progress		Application for patent
	Overcome difficulties		Digital model competition
Knowledge reserve capacity	Basic knowledge	Learning ability	Knowledge integration ability
	Professional knowledge		Knowledge transfer ability
	Innovative knowledge		Knowledge acceptance ability
	Relevant knowledge		Knowledge renewal ability
Thinking ability	Intuitive thinking	Practical ability	Social practice
	Divergent thinking		Experimental practical ability
	Logical thinking		Market research ability
	Critical thinking		Research on scientific research projects

IV. CONCLUSIONS

This paper makes a quantitative analysis of domestic research literature on university students' innovative ability, and constructs an evaluation index system of it based on questionnaire survey and social network analysis. The study draws the following conclusions:

(1) By sorting out and summarizing the relevant literature on university students' innovative ability, the influencing factors of which are preliminarily extracted. Combined with questionnaire survey data and social network analysis tools, the introversion centrality is used as the screening criterion, and the secondary indicators of university students' innovation ability evaluation are determined. Through further refining, the second-level indicators, the first-level indicators for evaluating the ability are summarized. The index system consists of six first-level indicators and 36 second-level indicators.

(2) On the basis of literature analysis, it is partly systematic and scientific of the evaluation index system of university students' innovation ability built by questionnaire survey and social network analysis, which can reflect the research viewpoints of most domestic scholars and truly mirror the main factors affecting the innovation ability. Furthermore, it is relatively convincing to effectively evaluate university students' innovative ability.

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