Adult and Higher Education (2022)
Clausius Scientific Press, Canada

DOI: 10.23977/aduhe.2022.041303
ISSN 2523-5826 Vol. 4 Num. 13

Research on the Core Competence Model of Engineering and Technical Personnel

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Keywords: Competence model, technical personnel, core competence, capability evaluation

Abstract: The establishment of index system and the determination of index weight are the key steps in the construction of talent core competence model. According to the national standard of talent training and the international evaluation standard of engineers, this paper determines the indexes of the core competence model of engineering and technical talents. The weight of each ability index is determined through investigation and demonstration. It lays a foundation for the construction of the core competence index model of applied technical talents and the application of capability evaluation.

1. Introduction

In the process of building the index model of applied technical talents' core competence, how to scientifically determine the index weight and carry out dimensionless treatment of the index is an important problem to be solved urgently. In recent years, various researches and explorations have been carried out at home and abroad focusing on the construction of core competence index system for application-oriented technical talents. For example, the evaluation index system of college students' core competence is established from the perspective of enterprise recruitment needs [1], the core competence index system is based on the working process [2], competency evaluation criteria based on grade point average and engineering modified problem solving scale [3], and according to the relationship between career goal and ability demand to determine the goal of talent training [4]. According to the existing research situation, the core competence index models of applied technical talents highlight the evaluation of comprehensive competence, but need to be improved in the aspects of indicator demonstration, weight determination and system typicality [5].

Collecting the data of each index in the evaluation index system and making a comprehensive evaluation is a mainstream idea to carry out the evaluation of talents' core competence at present. At present, there are many methods of comprehensive evaluation, such as professional evaluation method, comparative average method, Delphi method, principal component analysis, analytic hierarchy process, joint application of analytic hierarchy process and Delphi method, network analytic hierarchy process and so on [6-10]. As long as the weights of each index in the capability model are determined, the quantitative value weighting function method can make the evaluation process more clear at a glance, and better play the guiding role of indicators. Therefore, according to the basic principle of quantitative value weighted function method, this paper establishes the index system of applied technical talents core competence model, and determines the weights of all levels of indicators, thus building a complete applied technical talents core competence model.

2. Framework of capability

2.1. Source of capability indicators

To build the core competence evaluation criteria system of application-oriented technical talents, it is first necessary to establish the second-level indicators and third-level indicators corresponding to the core competencies, and then determine the weight of the indicators at all levels. Core competencies are indispensable competencies for all people in their careers and lifelong learning, not only for one professional position, but also for other competencies. Core competencies should run through the cultivation of engineering talents from beginning to end, which is a sustainable ability and can support them to maximize their abilities in their careers or positions. The National Skills Promotion Strategy divides the core competencies into eight core competencies, called the "8 core competencies", including: communication with people, digital applications, information processing, cooperation with people, problem solving, self-learning, innovation, foreign language applications, etc.

The American Accreditation Commission for Engineering and Technology Education proposes the competency standards for graduates, and there are 12 requirements for the basic abilities and qualities that engineering talents should have. include Engineering knowledge, Problem analysis, Design and develop solutions, Investigative research, Use of modern tools, Engineers and society, Environment and sustainability, Ethics, Individuals and teams, Communication, Project management and finance and Lifelong Learning. In June 2016, China officially joined the Washington Agreement, and after passing the certification, the degrees of our graduates were recognized by other organizations of the Washington Agreement, which improved the international influence of China's engineering education. The general standards for engineering accreditation issued by the China Engineering Education Professional Accreditation Association are basically completely consistent with the standards proposed by the American Engineering and Technology Education Accreditation Commission. The core competency framework also provides a basic paradigm for the professional construction of application-oriented technical talent training.

2.2. Capability code

By analyzing and summarizing the latest research and application results of the core competencies of talents at home and abroad, combined with the reality of applied technology talent education, the analysis ability, research ability, design ability, professional quality and teamwork ability are taken as the five first-level indicators of the core competence of applied technical talents, and these 5 first-level indicators take into account the 8 core competencies in the National Skills Revitalization Strategy and the 12 graduate competency standards proposed by the American Engineering and Technology Education Accreditation Commission. On the basis of determining the first-level indicators of the core competencies of applied technical talents, from the perspective of the mainstream requirements and changing trends of society and enterprises for the core competencies of applied technical talents, 20 second-level indicators and 82 third-level indicators of the core competencies of applied technical talents are constructed, and the names of the first-level and second-level indicators and their meanings are shown in Table 1.

Table 1 Names of primary and secondary indicators and their meanings

Tier 1 indicators		Secondary indicator points	
Name	Meaning	Name	Meaning
Analytical skills	Be able to comprehensively use the mastery of mathematics and natural science, engineering foundation, professional basic knowledge and engineering technology and methods to express complex engineering problems in the field of engineering, establish mathematical or physical models, and analyze the advantages, disadvantages, rationality and feasibility of models or solutions through literature research to obtain effective conclusions.	Problem breakdown	Be able to use professional knowledge to abstract and summarize the essence of typical engineering problems, and identify the key links and parameters of complex engineering problems.
		Question expression	Be able to establish mathematical or physical models of the system and ensure that the models meet the actual needs of simulation and engineering calculations.
		Problem analysis	Be able to solve the model of the system, analyze the pros/cons, rationality and feasibility of the model or solution to obtain effective conclusions.
Design capabilities	Be able to design solutions to complex engineering problems in the field of engineering, design electronic systems and information systems that meet specific needs, test the rationality of design through practice, master innovative methods, reflect innovative awareness, and comprehensively consider social, health, safety, legal, environmental and other factors.	Indicator analysis	According to the actual needs of the project, the user requirements and overall design requirements of complex engineering problems can be determined, the performance indicators of the system are given, and feasible design methods to meet the design goals are proposed.
		System design	Be able to follow the design principles, methods and technical routes of engineering, follow technical standards and specifications, consider the correlation and influence between functional modules or subsystems, design a system that meets specific functional requirements, and reflect the sense of innovation in the design.
		Consider non-technical influences	Be able to consider social, health, safety, legal, cultural and environmental influences in the design. Through comprehensive evaluation, the design scheme and process flow are compared, optimized and feasibility.
Research capabilities	Be able to use engineering knowledge and technical means to study complex engineering problems, including designing and implementing experiments, analyzing and interpreting experimental results, and obtaining reasonable and effective conclusions through information synthesis to improve the solution of complex engineering problems.	Design experimental protocols	Be able to select, design experimental protocols, and carry out experimental verification. On this basis, according to specific needs, engineering scientific principles and technical methods can be used to select research routes and design feasible experimental schemes for complex engineering systems.
		Experimental implementation	According to the experimental plan, correctly select experimental devices, equipment, development/simulation platforms, build experimental systems to carry out experiments, and correctly collect, analyze, process, transmit, store, and visualize data.
		Practical analysis	Be able to sort out experimental data, explain and process problems or phenomena in the experimental process, analyze experimental results, draw reasonable and effective conclusions, and improve the solution of complex engineering problems.

Professionalism	Have humanities and social science literacy, establish socialist core values, consciously abide by engineering professional ethics and norms in engineering practice, and fulfill social responsibilities. Understand engineering-related industrial policies, industry standards and laws and regulations, be able to correctly analyze and evaluate the social, health, safety, legal and cultural impacts of complex engineering problem solutions and engineering practices, and understand the responsibilities to be assumed. Be able to pay attention to, understand and evaluate the impact of engineering practices on the environment and social sustainable development of complex engineering problems, and assume corresponding responsibilities.	Analyze engineering ethics	Familiar with design specifications, technical standards, intellectual property rights, industrial policies and laws and regulations related to engineering practice, correctly analyze the impact of engineering practice on society, health, safety, law and culture, and know the social responsibility to be undertaken.
		Evaluate engineering ethics	Be able to objectively evaluate the social, health, safety, legal and cultural impacts of complex engineering problem solutions and engineering practices on the implementation of the project, and understand the responsibilities to be borne based on the practical application background of the project.
		Understand engineering and the environment	Understand the concept and connotation of scientific outlook on development, environmental protection and social sustainable development, have environmental and sustainable development awareness, and be familiar with relevant laws and regulations on environmental protection and national energy development strategy.
		Practice Engineering and Environment	In engineering practice, it can consider the constraints of environment and sustainable development, correctly evaluate the impact of environmental and sustainable development caused by engineering practice, and assume corresponding responsibilities.
		Have the right values	Have humanistic knowledge, critical thinking ability, handling ability and scientific spirit, establish the core socialist values, understand the national conditions, and adapt to social development.
		Comply with professional ethics	Be able to abide by engineering ethics and norms in engineering practice, and have legal awareness; Understand and fulfill social responsibilities for public safety, health, well-being, and environmental protection.
Teamwork skills	Possess a sense of teamwork and collaborative spirit, and be able to assume the roles of individual, team member and leader in a multidisciplinary team. Be able to communicate effectively with peers and the public on complex engineering issues, including writing reports and design manuscripts, making statements, clearly expressing or responding to instructions; And have a certain international perspective, able to communicate and exchange in a cross-cultural context.	Task execution	Understand the relationship between individuals and teams in a multidisciplinary context, understand the responsibilities and connotations of different roles in the team, be able to assume the responsibilities of different roles in the team, and complete the tasks assigned by the team to individuals.
		collaboration	Be able to collaborate with team members in different disciplines to complete engineering tasks, be able to assume the role of leader, integrate the opinions of team members, and make reasonable decisions.
		expression	Be able to write reports, design manuscripts, make statements or respond to instructions, and effectively communicate and exchange with peers and the public on professional issues through oral, manuscripts, charts, etc.
		International outlook	Understand international trends and research hotspots in the field of engineering, and track the cutting-edge technologies of the profession. Master at least one foreign language, be able to read foreign language materials related to engineering sciences, be able to understand and respect the differences and diversity of different cultures, use technical language in a cross-cultural context on professional issues, and communicate and exchange technical solutions, technical reports, etc.

3. Confirm of indexes proportion

After determining the indicators of ability at all levels, it is necessary to further characterize the ability in quantitative form and determine the core competence level of applied technical talents. It is necessary to scientifically define the weight of each indicator. Expert consultation and statistical methods are used to determine the weight of each level of core competencies. This consulting activity selected 9 experts, divided into three categories: enterprise technical experts, enterprise management experts and educators. The research group has carried out three rounds of index weight consultation and completed the determination of the weight of the secondary index and the tertiary index. In order to ensure the independence and objectivity of the selection of expert opinions and ensure the scientific weight, each expert gets a consultation questionnaire and submits the answers independently, and maintains the stability of the consultation environment. The weights of secondary and tertiary codes are obtained, as shown in Table 2.

Table 2: Coding weight of applied talents ability

ability	Secondary encoding	Three-level coding	Weight
Analytical skills	Problem breakdown	The ability to use professional knowledge to abstract and summarize the essence of typical engineering problems	0.4
		The ability to identify key links in complex engineering problems according to the essence of typical engineering problems	0.3
		The ability to design key parameters of complex engineering problems based on the nature of typical engineering problems	0.3
	Question expression	Ability to establish systematic mathematical models	0.3
		Ability to establish physical models of systems	0.3
		The ability to debug system models to simulate real-world engineering	0.2
		The ability to debug system models to meet the actual needs of engineering calculations	0.2
	Problem analysis	The ability to solve the model of the system	0.3
		The ability to analyze the strengths and weaknesses of the model	0.1
		The ability to analyze the strengths and weaknesses of a solution	0.1
		The ability to analyze the rationality of a solution	0.1
		The ability to analyze the feasibility of a solution	0.1
		The ability to draw valid conclusions based on the results of the above analysis	0.3
Design capabilities	Indicator analysis	The ability to determine the user needs of complex engineering problems according to the actual needs of the project	0.2
		The ability to determine the overall design requirements of complex engineering problems according to the actual needs of the project	0.2
		The ability to give system performance indicators according to user needs and overall design requirements	0.3
		The ability to propose feasible design methods that meet design objectives based on system performance metrics	0.3
	Consider non-technical influences	The ability to integrate health and safety considerations into design	0.1
		The ability to integrate the impact of social and environmental factors in design	0.1
		Ability to integrate legal and cultural influences in design	0.1
		The ability to compare and optimize design solutions based on comprehensive evaluation results	0.2

		The ability to compare and optimize the process flow according to the comprehensive evaluation results	0.2
		The ability to demonstrate the feasibility of design schemes and processes based on the results of comparison	0.3
Research capabilities	Design experimental protocols	Ability to select and design experimental protocols	0.3
		The ability to conduct experimental validation	0.3
		The ability to choose a research route based on specific needs	0.2
		The ability to design feasible experimental protocols using engineering scientific principles and technical methods	0.2
	Experimental implementation	The ability to correctly select experimental devices, equipment, and development/simulation platforms according to the experimental protocol	0.2
		Build an experimental system to carry out experiments	0.2
		The ability to collect data correctly	0.1
		The ability to analyze data correctly	0.1
		The ability to transmit data correctly	0.1
		The ability to store data correctly	0.1
		The ability to visualize data correctly	0.1
		The ability to handle data correctly	0.1
	Practical analysis	The ability to organize experimental data	0.1
		Ability to interpret and deal with problems that arise during experiments	0.2
		Ability to analyze experimental results	0.3
		The ability to draw reasonable and valid conclusions based on the results of the analysis	0.2
		The ability to refine solutions to complex engineering problems	0.2
Professionalism	Analyze engineering ethics	Knowledge of design codes, technical standards, intellectual property rights, industrial policies and laws and regulations related to engineering practice	0.2
		The ability to properly analyze the social and cultural impact of engineering practices	0.3
		The ability to properly analyze the health and safety impacts of engineering practices	0.3
		Know your social responsibilities	0.2
	Evaluate engineering ethics	The ability to objectively evaluate the social and cultural impact of solutions to complex engineering problems based on the practical application background of engineering projects	0.2
		The ability to objectively evaluate the health and safety implications of solutions to complex engineering problems based on the practical application background of engineering projects	0.2
		The ability to objectively evaluate the social and cultural implications of complex engineering practices based on the practical application context of engineering projects	0.2
		The ability to objectively evaluate the health and safety implications of complex engineering practices based on the practical application background of engineering projects	0.2
		Ability to objectively assess the impact of social, health, safety, legal and cultural factors on project implementation	0.2
	Understand engineering and the	Understand the concept and connotation of scientific outlook on development, environmental protection and sustainable social development	0.2

	environment	Be environmentally and sustainability-conscious	0.2
		Familiar with relevant laws and regulations on environmental protection	0.2
		Familiar with the national energy development strategy	0.2
	Practice Engineering and Environment	The ability to consider environmental constraints in engineering practice	0.2
		The ability to consider sustainability constraints in engineering practice	0.2
		The ability to properly evaluate the environmental impact of engineering practices	0.2
		The ability to properly evaluate the sustainability impact of engineering practices	0.4
	Have the right values	Humanistic knowledge	0.1
		Critical thinking	0.1
		Ability to do things	0.1
		Scientific spirit	0.2
		Understand the national situation	0.1
		Establish socialist core values	0.1
		Ability to adapt to social development	0.3
	Comply with professional ethics	Be able to comply with engineering ethics and norms in engineering practice	0.2
		Be legally aware	0.2
		Understand social responsibility for public safety, health and well-being	0.3
		Understand the social responsibility of environmental protection	0.3
Teamwork skills	Task execution	Understand the relationship between individuals and teams in a multidisciplinary context	0.2
		Understand the responsibilities and connotations of different roles in the team	0.2
		Ability to complete tasks assigned to individuals by the team	0.3
		Ability to take on different roles in the team	0.3
	Team collaboration	Ability to collaborate on engineering tasks with team members from different disciplinary backgrounds	0.5
		The ability to make sound decisions based on the opinions of team members	0.5
	expression	Ability to write reports	0.3
		Design manuscript skills	0.2
		Presentation of speaking ability	0.2
		The ability to effectively communicate and exchange with peers and the public on professional issues by oral, manuscript, chart, etc	0.3
	International outlook	The ability to communicate and exchange internationally on technical solutions, technical reports, etc	0.2
		The ability to track the cutting-edge technology of your expertise	0.2
		Foreign language skills	0.3
		Ability to read foreign language materials related to engineering sciences	0.3

4. Conclusion

As an important part of higher education, the education of technical talents not only imparts knowledge, but also undertakes the important mission of inheriting spiritual civilization and social values. The weight distribution of each level of the ability index system reflects the structure and characteristics of the current social demand for the ability of all kinds of applied technology talents and provides a basis for the quantitative evaluation of the core competence of applied technology talents.

Acknowledgements

Jilin Province Education Science "13th Five-Year Plan" 2020 project "Research on the Construction of Applied Technology Colleges Talent Training Quality Evaluation Model" (GH20272).

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