

Research on the Cultivation Mode of Systemic Ability for Engineering Management Students under the Engineering Education Model

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Abstract

Under the professional demands of society for engineering management talents and the background of professional accreditation of engineering education, the systematic capabilities that students majoring in engineering management need to possess were analyzed. Aiming at the problems existing in the cultivation process of systematic capabilities of students majoring in engineering management and guided by the standards of professional accreditation of engineering education, a talent cultivation system centered on the cultivation of systematic capabilities of students majoring in engineering management was constructed. This includes clarifying the training goals of systematic capabilities, constructing the curriculum system of systematic capabilities, reforming teaching methods and means, strengthening practical teaching links, and enhancing the construction of the teaching staff, etc. It provides a reference for improving the quality of systematic ability cultivation of students majoring in engineering management.

Keywords

Engineering education, engineering management major, system capability, cultivation mode.

1. Introduction

With the rapid development of the global economy and the accelerated advancement of urbanization, the field of engineering construction has witnessed unprecedented opportunities and challenges. As a comprehensive discipline, engineering management plays a crucial role in the engineering industry. It integrates engineering technology with management science, aiming to ensure the successful completion of engineering projects within the stipulated time, cost, quality, and safety standards, and to maximize the economic and social benefits of the projects.

Engineering management students shoulder the responsibility of promoting the development of the engineering industry. Cultivating their systematic capabilities is of vital importance for meeting industry demands and advancing the professional field. From the perspective of industry needs, today's engineering industry is characterized by large-scale projects, increased technical complexity, and higher levels of internationalization. Take some large-scale infrastructure projects as examples, such as the Hong Kong-Zhuhai-Macao Bridge and the high-speed railway network construction. These projects not only involve complex engineering technical issues but also require efficient management to deal with various risks and challenges. Against this backdrop, the industry has put forward higher requirements for the systematic capabilities of engineering management professionals. From the perspective of professional development, cultivating students' systematic capabilities is the key to the continuous progress of the engineering management discipline. The cultivation of systematic capabilities helps to

improve the curriculum system and teaching methods of the engineering management discipline and promote its healthy development.

Although certain research achievements have been made in engineering education models and the cultivation of engineering management students' capabilities both domestically and internationally, there are still some deficiencies. On the one hand, the constituent elements of the systematic capabilities of engineering management students have not yet been clearly and uniformly defined, leading to a lack of precision and consistency in the formulation of training objectives and programs. On the other hand, in the implementation of training models, issues such as how to effectively integrate teaching resources, coordinate the interests of various stakeholders, and establish a scientific and reasonable evaluation system to measure training effectiveness still need further in-depth research. Moreover, with the rapid development of the engineering industry and the continuous emergence of new technologies, such as artificial intelligence, big data, and the Internet of Things, new requirements have been put forward for the capabilities of engineering management students. However, existing research still lags behind in terms of how to cultivate students' abilities to adapt to the development of new technologies. This paper is based on the above research status and aims to deeply explore the composition of the systematic capabilities of engineering management students in the engineering education model, analyze the problems existing in the current training process, and construct a scientific and effective training model to fill the gap in existing research and provide theoretical support and practical guidance for the cultivation of the systematic capabilities of engineering management students.

2. The Composition of Systematic Capabilities for Students Majoring in Engineering Management

2.1. Engineering and Technical capabilities

Engineering and technical ability is the cornerstone for students majoring in engineering management to carry out their work. Students need to have a solid grasp of the basic knowledge such as engineering mechanics, engineering drawing, engineering materials and engineering structures. Take engineering drawing as an example. By drawing precise architectural drawings, students can transform their design concepts into visual engineering expressions, providing accurate guidance for the construction process.

2.2. Engineering Management Capability

Engineering management capability focuses on the overall control of engineering construction projects. Students need to master professional knowledge such as project management, quality management, schedule management, cost management, and safety management. In a large-scale commercial complex construction project, engineering managers used schedule management knowledge to compile scientific Gantt charts, rationally arrange various construction procedures and time nodes, ensuring the project was completed on time. Additionally, by establishing a complete safety management system, no major safety accidents occurred during the entire project construction period, effectively ensuring the smooth progress of the project and highlighting the key role of engineering management capability in project management.

2.3. Engineering economic capability

Engineering economic capability is crucial for the economic benefit assessment and decision-making of engineering construction projects. Students need to master knowledge such as engineering economics and engineering cost management. During the project investment decision-making stage, by applying engineering economic analysis methods, the costs, benefits,

risks, etc. of the project are comprehensively evaluated to determine the feasibility of the project.

2.4. Engineering legal capability

Engineering legal capability is an important support for ensuring the legal and compliant operation of engineering construction projects. Students need to master knowledge such as engineering laws and regulations and contract management. During the process of signing engineering contracts, managers familiar with relevant legal knowledge can accurately identify risk points in the contract terms, avoiding disputes and losses caused by contract loopholes. During the project implementation process, when engineering disputes arise, they can solve problems properly through negotiation, mediation or arbitration based on relevant laws and regulations and contract terms.

2.5. System thinking capability

System thinking capability requires students to start from the whole and conduct comprehensive analysis and overall management of engineering construction projects. For example, in urban rail transit construction projects, it involves multiple subsystems such as civil construction, mechanical and electrical equipment installation, and communication and signal systems. Engineering managers with strong system thinking capabilities can view these subsystems as an organic whole, comprehensively consider the interrelationships and influences among the subsystems, conduct systematic planning and coordination, optimize project design and construction plans, and improve the overall benefits of the project.

2.6. Innovation capability

Innovation capability is the driving force for the development of the engineering construction field. In engineering construction projects, students with innovation capabilities can break through traditional thinking patterns and propose innovative solutions and management methods. For example, in the innovation of engineering management models, some students draw on Internet thinking and propose the "smart construction site" management model, which introduces Internet of Things and big data technologies to achieve real-time monitoring and intelligent management of personnel, equipment, and materials on the construction site, effectively improving project management levels[2].

2.7. Practical capability

Practical capability is the key to transforming theoretical knowledge into practical work results. Through participating in engineering internships, course designs, and graduation projects, students can operate and manage in actual engineering environments. Students can discover and solve problems in practice, further deepening their understanding and mastery of theoretical knowledge[1]. The improvement of practical capability also helps students better adapt to job positions and shorten the transition time from students to professionals.

2.8. Teamwork capability

Engineering construction projects usually require the collaborative efforts of multiple professionals and departments, so teamwork capability is indispensable. For example, in large-scale water conservancy engineering construction projects, it involves multiple professional teams such as water conservancy, geology, and electrical. Engineering managers with good teamwork capabilities can effectively communicate and collaborate with team members from different professional backgrounds. By clarifying the responsibilities and divisions of each team, establishing effective communication mechanisms, and regularly organizing coordination meetings, they can promptly resolve conflicts and problems among teams to ensure the smooth progress of the project.

2.9. Communication capability

Communication capability is the bridge for effective communication between engineering managers and all parties. In engineering construction projects, communication and coordination with the owner, design units, construction units, and supervision units are necessary. Managers with good communication capabilities can accurately understand the needs and intentions of all parties and clearly express their own views and ideas. In project change communication, they can effectively explain the reasons and necessity of the changes to the owner, seeking the owner's understanding and support; at the same time, they can communicate with the construction units to ensure the smooth implementation of the change plans.

2.10. Learning capability

In the context of the rapid development of the engineering construction field, learning capability is the key for students to continuously grow and adapt to industry changes. Students need to have the ability to learn independently and throughout their lives, constantly updating their knowledge and skills[3]. With the wide application of new technologies and new processes such as BIM technology and prefabricated buildings in the engineering field, students with strong learning abilities can quickly master these new knowledge and skills and apply them to actual work.

3. Problems in the Cultivation of Systemic Abilities of Engineering Management Students

3.1. Unreasonable Curriculum System

The professional course setting lacks systematicness and the course content is outdated. Currently, the course settings of some universities' engineering management majors are scattered and lack organic connections, making it difficult for students to build a systematic knowledge structure. Although courses in multiple fields such as engineering technology, management, economics, and law are involved in the curriculum system, there is often an ineffective integration and connection among these courses. Students have difficulty integrating knowledge from different fields during the learning process and cannot apply what they have learned to solve complex engineering management problems.

With the rapid development of the engineering industry, new technologies and new concepts are constantly emerging. However, the course content of some universities' engineering management majors has not been updated in a timely manner and is out of touch with the industry's cutting-edge developments. Some courses still focus on traditional engineering management methods and technologies, with little introduction and application of emerging technologies and concepts such as BIM technology, prefabricated buildings, and green buildings. During the learning process, students cannot be exposed to the latest industry trends and actual problems, making it difficult for them to adapt to the changes and development of the industry.

3.2. Monotonous Teaching Methods

Teaching is mainly theoretical, with poor interaction.

In the traditional teaching of engineering management, the teaching method is often teacher-centered, focusing on the imparting of theoretical knowledge. Teachers dominate the classroom, teaching through blackboard writing and PPTs, while students mainly listen passively and take notes. This passive learning method is not conducive to students' in-depth understanding and mastery of knowledge, nor can it cultivate students' autonomous learning ability and innovative thinking ability.

In the current teaching of engineering management, the lack of interaction between teachers and students and among students is quite common. In classroom teaching, the interaction between teachers and students mainly takes the form of teachers asking questions and students answering them. Teachers rarely pay attention to students' interests and needs, and students lack opportunities to actively ask questions and express their own views. This one-way teaching mode makes the classroom atmosphere dull and restricts students' thinking, preventing them from fully exerting their initiative. There is also a lack of interaction among students. Although some teachers attempt to adopt group cooperative learning, due to the lack of effective organization and guidance, group cooperation often remains superficial, and students lack substantive communication and collaboration.

3.3. Weakness in Practical Teaching

Inadequate construction of practical bases, insufficient practical teaching guidance, and an incomplete practical assessment and evaluation system.

Currently, some universities have an insufficient number of practical bases, failing to establish a sufficient number of practical bases, resulting in a lack of practical resources per student. At the same time, many enterprises, considering production schedules and the protection of commercial secrets, only provide students with simple visits and short-term internships, preventing students from truly participating in the core links of engineering projects.

Some universities are facing problems such as an insufficient number of practical teaching instructors and limited guidance capabilities. Some instructors, although having solid theoretical knowledge, have been away from engineering practice for a long time and have insufficient understanding of practical engineering operation and management issues, making it difficult for them to provide effective practical guidance to students.

The practical assessment and evaluation system is an important basis for measuring students' practical abilities and achievements. However, some universities currently have problems such as a single assessment and evaluation method and unclear standards. The assessment mainly relies on written forms such as internship reports and practical assignments, lacking assessment of the practical process and actual operational abilities of students. Due to the lack of clear evaluation criteria, teachers may be influenced by personal subjective factors during the evaluation process, leading to biased evaluations of students. This results in students' dissatisfaction with the evaluation results, which in turn affects their learning enthusiasm and confidence.

3.4. Insufficient Construction of the Teaching Staff

Teachers lack practical experience, have a single professional background, and the mechanism for teacher training and development is not well established.

In the teaching of the engineering management major, some teachers have long been focused on theoretical teaching and lack working experience in the actual engineering field. This makes it difficult for them to closely integrate abstract theoretical knowledge with specific engineering practice in the teaching process. As a result, students have difficulty truly understanding the application of knowledge in actual engineering and cannot connect what they have learned with actual engineering.

Currently, some teachers in the engineering management major have a relatively single professional background, mainly concentrated in a certain field such as engineering technology or management, lacking a cross-disciplinary knowledge structure. This makes it difficult for teachers to integrate knowledge from multiple disciplines in the teaching process and unable to comprehensively impart the comprehensive knowledge required by the engineering management major to students.

Some universities do not attach sufficient importance to the training and development of engineering management teachers and lack a complete mechanism for teacher training and development. Teachers lack opportunities and platforms to update their knowledge and improve their teaching abilities, resulting in an outdated knowledge structure and outdated teaching methods, which cannot meet the rapid development needs of the engineering industry. At the same time, schools lack effective support for the improvement of teachers' teaching abilities, such as the allocation of teaching resources and the conduct of teaching research. This makes it difficult for teachers to apply advanced teaching technologies and methods in the teaching process.

4. Construction of a Systemic Ability Cultivation Model for Engineering Management Students under the Engineering Education Model

4.1. Formulation of Training Objectives Based on the OBE Concept

Firstly, the training objectives should be clearly defined. According to the engineering education professional certification standards and industry demands, student-centered, outcome-oriented, and continuous improvement training objectives are important guidelines for the development of the engineering management major. Through methods such as questionnaires and student symposiums, understand students' interests, career plans, and learning needs, and provide personalized training plans and guidance for students. In terms of course setting, increase the proportion of elective courses, allowing students to choose courses based on their interests and career goals, broadening their knowledge and horizons.

Secondly, through in-depth research on industry demands, communicate and exchange with industry enterprises such as construction companies, real estate development companies, and engineering consulting institutions to understand the knowledge, skills, and quality requirements for engineering management talents in the industry. When formulating training objectives, convert these requirements into specific outcome indicators for targeted training.

Finally, collect opinions and suggestions on training objectives through methods such as graduate follow-up surveys, employer feedback, and teacher teaching evaluations, and continuously improve. Based on the evaluation results, promptly adjust and improve the training objectives to better meet industry demands and the actual situation of student development. For example, with the wide application of new technologies such as BIM and green buildings in the engineering industry, promptly incorporate related knowledge and skills into the training objectives, adjust the course settings and teaching contents, and ensure that students master the latest technologies and concepts in the industry.

4.2. Optimization of the Curriculum System

4.2.1. Construction of a Modular Curriculum System

Constructing a modular curriculum system based on the knowledge domains and ability requirements of the engineering management major is a key measure to cultivate students' systemic abilities. The engineering management course covers four major curriculum system modules in total, see Fig. 1.

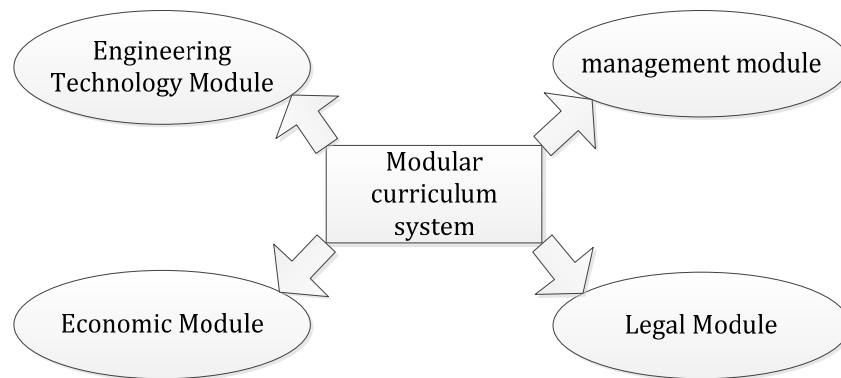


Figure 1. Curriculum system module

The engineering technology module includes courses such as engineering drawing, civil engineering materials, building mechanics, and architectural design; the management module includes courses such as management principles, project management, and financial management of engineering projects, which is one of the core modules of the engineering management major; the economic module includes courses such as engineering economics and cost management of engineering projects, which plays a crucial role in students' project cost control, investment decision-making, and benefit assessment; the legal module includes courses such as construction laws and engineering contract management, which plays an important role in regulating engineering construction behaviors and safeguarding the rights and interests of all parties. It is also necessary to pay attention to the mutual influence and penetration among the modules. The engineering technology module provides technical support for the management, economic, and legal modules; the management module guides the implementation and application of engineering technology; the economic module provides economic analysis and decision-making basis for engineering technology and management; the legal module ensures the legality and standardization of engineering technology, management, and economic activities. Through the collaborative effect of each module, students can build a complete engineering management knowledge system and improve their systemic abilities.

4.2.2. Update of Course Contents

Timely updating of course contents and integrating industry cutting-edge knowledge and new technologies is an inevitable requirement for closely aligning course contents with actual work demands. With the rapid development of the engineering industry, new technologies and new concepts are constantly emerging, such as BIM technology, prefabricated buildings, green buildings, and intelligent construction, which have a profound impact on engineering management. Teachers should also pay attention to the latest policies and regulations in the industry and incorporate them into the course contents. At the same time, as laws and regulations are revised, students should also promptly acquire relevant knowledge to avoid legal risks.

4.3. Innovation of Teaching Methods

4.3.1. Adoption of Project-Based Teaching

Using actual engineering projects as carriers and organizing students to conduct project-based learning is an effective way to cultivate the systemic abilities of engineering management students[4]. By participating in tasks at different stages of the project, students can master the entire process management of actual engineering projects, closely integrate the theoretical knowledge they have learned with practical operations, improve their practical application ability and problem-solving skills, and cultivate their professional qualities and sense of responsibility.

4.3.2. Introduce case-based teaching

During the case analysis and discussion process, teachers should guide students to apply the professional knowledge they have learned to conduct in-depth analysis and discussion of the problems in the cases. Encourage students to put forward their own insights and solutions and engage in group discussions and debates. During the discussion process, students can think about problems from different perspectives, broaden their thinking horizons, and cultivate their innovation and critical thinking abilities.

4.3.3. Promote group cooperative learning

In group cooperative learning, teachers should rationally group students based on their learning abilities, personality traits, and professional backgrounds to ensure that each group has complementary and diverse members. Generally, the number of students in each group can be controlled at around 3-5, which can not only ensure the efficiency of group discussions and collaborations but also provide each student with sufficient participation opportunities. In group cooperative learning, group members need to clearly define their respective responsibilities and divisions of labor, jointly formulate work plans and schedules, and complete learning tasks through communication and collaboration. Teachers should provide necessary guidance and support to students.

4.4. Strengthen the practical teaching link

4.4.1. Enhance the construction of practical bases

Establish in-depth cooperative relationships with enterprises to jointly build practical teaching bases. Try to choose large-scale construction enterprises with rich project experience and advanced management concepts. These enterprises have numerous projects of different types and scales, which can provide students with diverse practical scenarios. Universities can also establish cooperative relationships with multiple enterprises in different related fields to form a practical teaching base network, broadening students' practical directions and choices. Through the practical base network, students can choose different types of practical projects based on their interests and career plans, improving their comprehensive qualities and professional abilities.

4.4.2. Improve practical teaching guidance

Universities should rationally arrange the number of practical teaching guidance teachers based on the needs of practical teaching to ensure that each student can receive adequate guidance and attention. Practical teaching guidance teachers should have rich engineering practice experience and solid professional knowledge. Universities can improve teachers' practical abilities and professional levels by introducing professionals with enterprise work experience, encouraging teachers to participate in enterprise practice projects, and sending teachers to enterprises for on-the-job training. During students' internships, guidance teachers should regularly visit the internship sites for guidance and inspection, promptly understand students' internship situations, identify problems, and provide timely guidance and assistance.

4.4.3. Establish a diversified practical assessment and evaluation system

In practical assessment and evaluation, adopt diversified practical assessment and evaluation methods to comprehensively evaluate students' practical abilities, innovation abilities, and teamwork abilities. Emphasize the combination of process evaluation and result evaluation. In terms of evaluation content, it should cover students' various abilities. Teachers can objectively and fairly evaluate students' practical achievements based on pre-established evaluation standards. During the evaluation process, invite enterprise experts to participate in the evaluation, fully listen to their opinions and suggestions, and make the evaluation results more in line with actual work requirements.

4.5. Strengthen the construction of the teaching staff

4.5.1. Enhance teachers' practical abilities

Encouraging teachers to participate in engineering practice projects is an important way to enhance their practical abilities. Universities can introduce relevant policies to support teachers in participating in actual engineering projects of enterprises, allowing teachers to accumulate rich engineering experience in practice. To better support teachers' participation in engineering practice projects, universities can also establish a management platform for teachers' practice projects, providing services such as project information release, project application, and project tracking for teachers.

4.5.2. Optimize the Professional Structure of Teachers

Introducing teachers with diverse professional backgrounds is a key measure to optimize the structure of the teaching staff. This helps achieve the integration and cross-disciplinary teaching of multi-disciplinary knowledge, providing students with a more comprehensive and rich knowledge system. Teachers with different professional backgrounds can collaborate in the teaching process and conduct cross-disciplinary teaching. Through cross-disciplinary teaching, students can understand and master professional knowledge from multiple perspectives, broaden their thinking horizons, and improve their ability to comprehensively apply knowledge. Universities can also regularly organize cross-disciplinary exchange activities for teachers to promote knowledge sharing and cooperation among teachers, form teaching teams, and jointly carry out teaching reforms and research projects to enhance teaching quality and research levels.

4.5.3. Establish a Teacher Training and Development Mechanism

Universities should provide teachers with opportunities and platforms to participate in academic exchanges and teaching training both on and off campus, and formulate a complete teacher training plan. To motivate teachers to actively participate in training, universities can establish corresponding incentive mechanisms. Teachers who participate in training and achieve good results can be given certain rewards, such as bonuses and honorary certificates; teachers' training experiences and achievements can be used as important bases for title evaluation and performance assessment to encourage teachers to continuously improve their teaching levels and professional qualities. Fully mobilize teachers' enthusiasm for participating in training and development activities to promote their professional growth and development.

5. Conclusion

Under the engineering education model, constructing a scientific and reasonable system for cultivating the comprehensive abilities of engineering management students is of great significance for improving the quality of engineering management talent cultivation and meeting the demand for high-quality talents in the engineering construction field. This paper, guided by the engineering education professional certification standards, has constructed a talent cultivation system centered on the comprehensive ability cultivation of engineering management students, including the formulation of training objectives, optimization of the curriculum system, innovation of teaching methods, strengthening of practical teaching links, and strengthening of the construction of the teaching staff. The research results provide a reference for improving the quality of comprehensive ability cultivation of engineering management students and also offer a reference for the comprehensive ability cultivation of students in other engineering disciplines. With the rapid development of the engineering industry and the continuous emergence of new technologies, such as the wide application of artificial intelligence, big data, and the Internet of Things in the engineering field, the requirements for the abilities of engineering management students will continue to increase.

Future research will closely follow the development trends of the industry, deeply study the impact of new technologies on the comprehensive ability cultivation of engineering management students, and timely adjust and optimize the cultivation model to cultivate high-quality engineering management talents that meet the needs of the times.

Acknowledgements

Quality engineering project of Anhui Province, China: Exploration and Practice on the Cultivation of Systematic Competence for Engineering Management Students (2022jyxm662), Quality engineering project of School of Anhui Xinhua University, China: First-class offline course: Architectural Construction (2024xxkcx04).

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