Research on the Innovative Path of Industry-Education Integration in Engineering Industry Colleges under the Background of New Engineering

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Abstract: *With the construction of the New Engineering, the demand for engineering talents has risen, and now people are required to have all-round engineering skills and system-oriented thinking. As the first institutions for industry-education integration, engineering industry colleges have been in urgent need of reforming the structure of their education. First, this paper will break down the mechanism of industry-education integration, identify the heterogeneous elements and their relational network topology in the academic cultivation system and the industrial technology system of engineering industry colleges, and analyze the fracture points of the traditional linear series connection model; it turns out that these fracture points are mainly at the level of knowledge transfer and capability transformation. Based on the above, this paper puts forward an improved logic for the education path, builds a curriculum system with embedded design based on the full cycle of engineering projects, creates a flexible transformation mechanism for teaching organisation driven by the dual subjects of the university and the enterprise, and develops a collaborative education model that links knowledge flow with technological iteration. A multi-node feedback regulation system will be used to respond quickly to changes in the operating environment of the path; a dynamic mapping model of the engineering capability map and cultivation process has been built to increase the specificity of capabilities, and a hierarchical migration strategy based on the concept of ecological niches will be employed for continuous development of the path. The system for building and continuously improving the new construction and development path of industry-education integration in engineering industry colleges is organised in this paper.*

Keywords: *New Engineering, Engineering Industry Colleges, Industry-Education Integration, Education Path, Capability Map, Ecological Niche*

Introduction

With the new construction boom, engineering education has been required to update its knowledge system in a timely manner and to shorten the iteration cycle of industrial technology. The old way of organising teaching according to the logic of disciplines can no longer help students learn how to solve difficult engineering problems. As the special education units that link the academic cultivation system with the industrial-technology system, the effectiveness of engineering industry colleges in the process of industry-education integration education will directly affect the level of capability matching for engineering talents. Most of the current industry-education integration is still in its early stages. There has been little cooperation between universities and enterprises in the areas of curriculum co-creation, project-based training and capability assessment; thus, there are problems of fragmented knowledge transfer and slow development of capabilities. Therefore, it is necessary to carry out an organised review and innovative design of the industry-education integration education path in engineering industry colleges. The reasons for this study can be found in two places: first, there is a demand from new engineering for the reconstruction of the capability structure of engineering talents, and second, there are problems of link fragmentation and slow response in the traditional path of industry-education integration. Based on the mechanisms studied so far, dynamically deconstruct them at all three levels, then design a set of adaptive and iterative innovative solutions to promote the development path of industry-education integrated education, and thus this paper will provide theoretical support and an operational basis for improving the educational effectiveness of engineering industry colleges.

1. Deconstruction and Reconstruction of the Industry-Education Integration Education Mechanism in Industry Colleges

1.1 Element Identification and Relationship Network of Industry-Education Integration in Engineering Industry Colleges

The Structure of the Mechanism for Industry-Education Integration in Engineering Industry Colleges has many links. The first few are the engineering knowledge system, industrial technology standards, engineering training equipment, university-enterprise joint-track teaching staff and project-based learning tasks. The first two are the system of academic cultivation and the system of industrial technology. The two systems have different purposes, use resources in different ways, are judged by different standards, and are thus often not closely related. Determine the function of each part and assign weights to them in the educational stage to build a foundation for building the network of industry-education cooperation[1].

The Structure of the relationship network will determine how well information and tasks are distributed among the components. Students, university teachers, enterprise engineers, course modules, engineering projects and training platforms are all considered to be nodes in terms of network nodes. Nodes make up a network, and the edges are curriculum co-creation, technological problem-solving, joint supervision, etc. The link between the technology node of the enterprise and the course content node in this network will directly affect the transmission accuracy of engineering capabilities, and management nodes, such as the teaching guidance institution of the industry college, will be responsible for ensuring the stability of the network. According to the connection and central position of the nodes, some are relatively important and others are weak links in the network for the purpose of path reconstruction.

1.2 Limitations and Fracture Point Analysis of the Traditional Industry-Education Integration Education Path

The traditional model of industry-education integration education is mainly a linear series connection model, and it has been developed in the order of "basic courses, professional courses, enterprise internships and graduation projects". In this case, there will be no closed-loop feedback mechanism among all the links, and the update speed of the course content will be slower than that in industrial technology; thus, when students reach the stage of enterprise internship, there will be a structural mismatch between their knowledge and skills. Along the traditional path, engineering industry colleges generally only have contact between the university and enterprises in the form of internships and employment; their participation in the front-end links of curriculum design, project training and capability assessment is shallow, and thus they form functional islands in the education chain[2].

Further analysis of the fracture points in the path shows that the two main levels are knowledge transfer and capability transformation. A fracture in knowledge transfer can be observed from the considerable differences in the complexity, constraints and openness of the problem situations used in on-campus theoretical teaching and the actual technical problems at engineering sites; it is difficult for students to map symbolic knowledge to practical engineering decisions. A fracture in capability transformation can be seen in the lack of alignment between project training and industrial standards; for instance, little attention has been paid to cost control, reliability and technical economy in the design of students' courses. The fracture points mentioned above will result in the decline of industry-education integration to a form of formal cooperation and thus weaken the educational effect of engineering industry colleges.

1.3 The Reshaping Logic of the Education Path Driven by New Engineering

In the new engineering era, the main demand for training engineering talents is no longer a single technical skill but all-around engineering ability and system thinking. Therefore, the education path of industry colleges should be changed from a linear series connection structure to a multilateral coupling structure. The first goal of the restructuring logic is to rebuild the demand-transmission mechanism; that is, the micro-units of the industrial technology capability model are broken down so that they can be included in courses and projects, and dynamic organisation among knowledge units and skill units is achieved through modular design. Based on the above, the path of education will no longer be fixed; instead, it will build a personalised progress map according to learning conditions and project difficulties, and students can go back and forth between theoretical study and engineering practice at different times.

The other change in the restructuring plan is that the assessment system will be based on a general map of abilities, not continuous accumulation. In the past, only the links were evaluated individually and there was no central collection; now, a single engineering ability development portfolio has been established to collect data on students' performance in courses, simulations and training, engineering projects, technical problem-solving, etc., and provide dynamic feedback according to how well the capability indicators meet the demands of industrial work. Therefore, the problems mentioned above can be solved; industry-education cooperation will be more data-driven and less experience-based, and an iterative path for building education in industry colleges will be established[3].

2. Multidimensional Architecture Design of Path Innovation

2.1 Embedded Design of the Curriculum System Based on the Full Cycle of Engineering Projects

All the stages in the life cycle of an engineering project are as follows: demand analysis, scheme design, detailed design, test and verification, construction, operation and maintenance. All of the above are particular combinations of engineering knowledge and skills. The Design embeds the above stages in the organisational logic of course modules so that the curriculum system is no longer a fixed list of subjects but a set of knowledge units organised dynamically according to the timeline of project development. Courses in the project initiation stage are Requirements Engineering and System Modelling; those in the design and verification stages are Computational Simulation and Reliability Analysis; and the courses for the operation and maintenance stage are Fault Diagnosis and Efficiency Optimisation. Based on the actual input and output at each stage of the project, interfaces and prerequisite dependencies among the course modules will be set up to avoid knowledge redundancy and articulation gaps caused by the disciplinary boundaries of the traditional curriculum system.

The Design of the embedded part should also be in line with the progress of the project. On the one hand, as the project advances, the corresponding course modules will be released, and students will be able to learn the relevant theories in time. At the same time, the technical methods taught in the courses will also be continuously refined through practice to form a closed-loop system of teaching and learning. In addition to the above, the curriculum system should be organised as a pluggable micro-course unit that is in line with the main technical activities at different times in the project, such as parameter identification, error analysis and robust design. These micro-units do not have to be associated with specific semesters and can be organised flexibly according to the progress of the project; therefore, the curriculum system will be process-oriented rather than fixed-structure.

2.2 The Flexible Transition Mechanism of Teaching Organisation Driven by the Dual Subjects of University and Enterprise

The main reason for the dual-subject drive by the university and the enterprise is to break away from the fixed structure of a single teaching institution and create an organisational form that can be flexibly changed among the university-led mode, the enterprise-led mode and the collaborative governance mode. The teaching organisation will be based on the disciplinary knowledge system under the leadership of the university, and the order of courses will be in line with the law of cognitive development. In the enterprise-led model, the teaching organisation will adhere to the schedule of the engineering project delivery plan and carry out learning activities according to the work breakdown structure. Based on the model of collaborative governance, the teaching organisation will be jointly led by a joint teaching guidance unit of the university and the enterprise, and teaching tasks will be distributed dynamically according to the level of capability achievement and resource availability. Loose change should have had an already set list of change-triggering conditions at the organisation level. For example, if the course content does not meet the requirements of the industrial technology standard, it will automatically switch to enterprise-led revision of the content[4].

The operation of the Transition Mechanism is based on a configurable resource pool and a role authority and responsibility mapping table in the teaching organisation. Resources include university teachers, enterprise engineers, training facilities, software tools, project data, etc. All the materials have been sorted according to teaching scenarios and can be arranged in many different ways. As shown in the Role, Authority and Responsibility Mapping Table, the university teaching node and the enterprise technology node have different levels of decision-making power, implementation obligations and evaluation responsibilities in different situations. Change the mode of organisation and then use the mapping table to automatically update the approval path, task division and quality gate parameters. According to the type of course, the stage of the project and the ability of the students, a flexible transition mode can be selected so that teaching is not interrupted and problems of resource waste or teaching mismatch caused by fixed modes are avoided.

2.3 Construction of a Collaborative Education Model Based on Knowledge Flow and Technological Iteration

Collaborative education is a type of educational model that promotes cooperation among universities and enterprises in the cultivation of talent; joint training plans are developed, teaching activities are organised, educational resources are provided, etc., to meet the talent supply demands of the industry. The Design Goal of this model is to turn the technological iteration pulses in the industry into updates for teaching materials at the university level. The first part of this model is the knowledge conversion gateway; it will collect problem reports, record changes and new technology verification data from the technical department of the company, organise them and create teachable knowledge units. For example, the problem of tolerance accumulation that a company has in the trial production of a new product can be generalised into a teaching case on geometric dimensioning and tolerance analysis, along with original data, constraint conditions and failure mode analysis. The above is to make the tacit knowledge explicit and, at the same time, retain the engineering authenticity of the technical problem.

The other necessary link in the construction of the model is the establishment of a bidirectional iteration channel; that is to say, industrial technology can be introduced to the teaching side unilaterally, and optimisation plans developed by the teaching side can also be fed back for iteration in industrial technology. In some cases, the alternative technical path, parameter optimisation method or test improvement plan put forward by students in their course projects or graduation designs can be added to the company's technical change process after being reviewed by the joint university-enterprise technical committee and confirmed as effective. A technology readiness assessment module should be added to this channel to classify the technical achievements of all sources into various levels, and only schemes that meet a certain level will be allowed to enter the industrial application link. With the integration of the flow of knowledge and technological iteration, collaborative education is no longer about the one-way transmission of knowledge; rather, it has become an innovative New Engineering education model with feedback amplification.

3. Operational Guarantee and Dynamic Optimisation of Path Innovation

3.1 Multi-node Feedback Regulation System for the Industry-Education Integration Education Path

All the course modules, project nodes, ability assessment points and university-enterprise cooperation sites in the education path are collection nodes for feedback in the multi-node feedback regulation system, and a closed-loop regulation network has been established to cover all stages of cultivation. All nodes have a uniform data collection module to record all kinds of data on students' learning behaviour, quality of task completion, efficiency of university-enterprise cooperation, etc. For example, the course module node will collect knowledge mastery and study time; the project node will store the technical solution review score and iteration frequency; and the university-enterprise interaction node will log the technology demand response latency and knowledge conversion success rate. Normalisation processing is used to collect all the data from the various parts of the path via the path regulation engine, and then a quantitative description of the current path operation status is obtained[5].

The regulation engine has an internal deviation detection algorithm, and at a certain time, it will be compared with the baseline curve of the desired path to determine whether the deviation exceeds the threshold. Based on the type of deviation, various degrees of regulation can be employed; intra-node regulation is achieved by adjusting the distribution of teaching resources or the difficulty of tasks within a single node, and inter-node regulation can be carried out by modifying the connection weights of neighbouring nodes or reordering the sequence of nodes. The regulated path status will be returned to the data collection stage and then a loop will start. The Design of this system will no longer be evaluated by the overall score at the end of the year or semester; instead, we will make timely corrections to prevent any problems during the development period.

3.2 Dynamic Mapping Model of the Engineering Capability Map and Cultivation Process

An organisation chart of engineering requirements can be used to organise all the necessary engineering specifications in a particular industry, as well as related capabilities, units and their interdependence. The four types of abilities are: technical operation ability, engineering analysis ability, system integration ability and technological innovation ability. Each dimension is further divided into observable units of ability, and for example, the unit of technical operating ability includes instrument operation, code writing, parameter tuning, etc. Prerequisites and successors are set up among the capability units to form a directed acyclic graph (DAG), and this graph shows the necessary order of learning and accumulation of skills in engineering capability building. The goal of the dynamic mapping model is to map the trajectory of students' learning activities in real time during the integration of industry and education onto this capability map and then obtain indicators such as the extent of coverage of individual and group capabilities, the depth of capability achievement, and deviations in the development path of capabilities.

The operation of the mapping model is based on a rule base for the association between capability indicators and the features of teaching activities. Set the weight and confidence for each rule of a particular type of teaching activity (e.g., finishing the design report by a certain time in an engineering project) in a given capability unit. When the behaviour data that the student obtains from the multi-node feedback regulation system meets the rule-trigger condition, then the model will automatically update the student's state value in the corresponding capability unit. Capability heatmaps show the accumulated state values to identify weak links in the capabilities and areas that need to be further developed in detail. In addition, there is an inverse map; that is, given a desired cross-section of the capability map, one can also find the corresponding combination of teaching activities and path sequences. A two-way mapping function can be employed to build a path for the target state and generate corresponding cultivation materials; thus, the engineering specificity of talent cultivation in industry colleges will be improved.

3.3 Continuous Evolution Strategy of the Path from the Perspective of the Industry College's Ecological Niche

According to the ecological niche theory, industry colleges are considered functional units in the regional engineering technology ecosystem, and the survival and development of the education path depend on resource exchange and functional complementarity with other ecological units (such as industrial enterprises, technical service institutions, professional certification organizations, etc.). The first idea of the Path Continuous Evolution Strategy is to build an ecological niche monitoring and migration system. Periodically collect the distribution density of the surrounding industrial technology communities, the spectrum of talent demand and path characteristics of similar educational institutions, etc., and then determine the current ecological niche coordinates of the college in this way. If the overlap in ecological niches is too large or the supply of technological resources is insufficient, it can be concluded that the current educational path will be homogeneous in competition and suffer from resource scarcity; therefore, the process of path evolution should be started.

The old programme has an old migration plan. The first level is intra-path parameter optimisation; that is, we modify the weights of the courses, node thresholds, feedback gain coefficients, etc., but do not change the topology of the path. The second is to change the structure of the path, that is, some nodes and edges in the topology of a path are added, deleted or modified. The third period will see a change in the direction of development; that is to say, the ecological niche will be different, and instead of all-round engineering positions, the focus will be on certain technical fields with profound new directions, such as intelligent control systems and high-end equipment integration. The three levels of strategy are arranged in increasing order of cost and risk, and the corresponding level is chosen based on how far it is from the ecological niche and what the forecast results of technological trends are. The development plan of this industry college will provide a good study environment for the students, and given the changes in the industrial technology environment, functional rigidity and value decay should be avoided.

Conclusion

The three stages of this study are the deconstruction of mechanisms, the design of architecture, and finally, the guarantee of operation; together they form a new path for industry-education integration in engineering industry colleges under the new engineering era. First, this paper lists all the components and links of industry-education integration, points out the problems in the old way, and puts forward a restructuring reason focused on rebuilding the demand-supply chain and improving the evaluation system. Second, in light of the entire life cycle of engineering projects, this paper develops an embedded curriculum system, sets up a flexible teaching organisation and transition mechanism based on the dual subjects of universities and enterprises, and builds a collaborative education model with feedback amplification to create a multi-dimensional architectural path innovation scheme. Finally, this paper introduces a multi-node feedback regulation system, a dynamic mapping model of the engineering capability map, and a hierarchical evolution strategy based on ecological niche monitoring for continuous optimisation of the path. First, some studies will be carried out to build an algorithm that can automatically build and update the capability map with fewer manual annotation rules. Second, we will study how to compare ecological niches and promote collaborative evolution among industry colleges in different areas to determine whether a hierarchical migration strategy can be applied to all kinds of technological communities. Finally, based on the above two, an information support platform will be built that can handle multi-node feedback and dynamic mapping to achieve the construction of digital twins and simulation deduction of the operation of the education path.

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