Research on Adaptive Reconstruction of Vocational Undergraduate Talent Cultivation Models under the Background of Enterprise Digitalization

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Abstract: *With the progress of digitalisation in recent years, both the structure of the organisation of production and the demand for post-competencies have changed rapidly; thus, there is now a systemic mismatch in the traditional model for cultivating vocational undergraduate talents in terms of task ecological migration and dynamic capability generation. Based on the above research, the goal of training has changed from learning specific contents to learning how to apply them, and the focus of training has moved from task execution to handling all kinds of circumstances. Therefore, a modular integrated curriculum system and a virtual reality integrated teaching structure will be constructed based on the above. Multi-agent collaborative calibration rules, digital twin-driven matching strategies and a competency map-oriented progressive evaluation mechanism to build a closed-loop operation regulation system are also put forward in this paper. The aim of this model is to enhance the speed of response and improve the adaptability of the cultivation system to changes in the company due to digitalisation.*

Keywords: *Enterprise Digital Transformation, Undergraduate Education in Vocational Colleges, Talent Cultivation Model, Adaptive Reconstruction, Competency Map, Virtual Reality Applications*

Introduction

With the digitalisation of enterprises and the spread of cloud computing, Internet of Things, edge computing, etc., production systems are no longer hierarchical but have formed a network of dynamic cooperation; thus, the distribution of tasks, the exchange of information and the operation of technical activity units have changed. Traditional discrete functions of operation, debugging and maintenance will be centralised under the support of intelligent equipment, and as more intelligent jobs are added, so too will be the demand for system perception and abnormal response capabilities. Therefore, there is a mismatch between the current model of vocational college student training and the demands of digital jobs in terms of skill structure and the depth of competence. The old model of closed-loop deterministic tasks can no longer meet the demand for building dynamic capabilities because of the short iteration cycle of enterprise technical systems. Therefore, we need to identify the actual manifestations of imbalance in the vocational undergraduate talent cultivation model in the digital era, explore why there has been an adjustment and renovation of training goals, curriculum system and teaching structure, and establish corresponding operational regulation mechanisms. With the dual revolution of knowledge and ability, this paper will examine the flexible organisational logic of the modular integrated curriculum system and the restructuring plan for the virtual-reality integrated teaching structure in light of work-field iteration. The following are the proposed regulatory mechanisms: multi-agent collaborative calibration and digital twin-driven matching and competency map-oriented progressive evaluation; the aim is to provide a theoretical basis for the systematic optimisation of the vocational undergraduate talent cultivation system.

1. Manifestations of Imbalance in Vocational Undergraduate Talent Cultivation Models in the Era of Enterprise Digitalization

1.1 Reshaping Effects of Digital Technology Integration on Forms of Production Organisation

As a result of the digitalisation of the company, many old production organisation models have been broken down and reformed by new technologies. With the development of cloud computing, Internet of

Things and edge computing technologies, the structure of enterprise production systems has changed from hierarchical and linear to networked, decentralized, dynamic and collaborative. Task assignment has changed from fixed job duties to the temporary formation of project-based and modular teams, and now the distribution method for information is a multi-source real-time sharing network; it is no longer the old vertical chain of command. It will change both the scale of time and the area distribution of skill demand directly, and the technical activity units for vocational undergraduate talents will no longer be fixed[1].

Digitalisation of the production organisation has created new divisions of labour and problems of role overlap. In the past, the functions of operation, debugging, maintenance and preliminary analysis for discrete functions have generally been centralised under the support of intelligent equipment and digital twin platforms, and a single point has been responsible for many such tasks at the same time, such as monitoring equipment, analysing data and making local decisions. The links among all the parts of a company are no longer simple causes and effects but probabilistic correlations, so professionals have begun to pay more attention to system awareness and response in the event of an abnormality. If the model for cultivating vocational undergraduate talent continues to be based on fixed job descriptions and competencies, it will be difficult to deal with the problem of ecological migration caused by organisational changes mentioned above.

1.2 Misalignment Dimensions between the Supply of Vocational Undergraduate Talent and Digital Job Demands

The form of skills for digital jobs is changing, and now candidates need to be able to understand algorithms, operate digital interfaces and jointly debug multiple systems. Among the list of digital technical positions in companies, there has been a gradual rise in the demand for recognition of the underlying logic, data feature extraction and proficiency in human-computer interaction interfaces. At the same time, the current curriculum system and competency evaluation indicators for vocational undergraduate programs are also out of date; they mainly focus on mechatronic integration and single-equipment operation, so there is a considerable competency gap among graduates in digital job adaptability tests. They do not agree, and many problems have occurred in the process as a result.

With the rise of the demand for abilities now, the growth speed of tacit knowledge transfer for digital jobs has exceeded that of explicit operational skills. In the digital era of enterprises, it is necessary to collect rule sets from all parts of the knowledge to solve semi-structured problems and then build cross-process and cross-equipment problem representations. The current model for training students at vocational colleges is relatively deterministic and standardised in terms of the foundation for abilities, and the need for judgment in the non-deterministic environment of digital jobs has not been systematically incorporated into the training programmes. A lack of organisation for knowledge in supply and demand can be seen in the slow response and uniform strategy of graduates to unexpected abnormal operating conditions[2].

1.3 Adaptation Lag of Traditional Cultivation Models in the Development of Dynamic Capabilities

The original mode of cultivation is based on the closed-loop of deterministic tasks, that is, clear input, standardised processing and standardised output. There are serious defects in the logic mentioned above due to changes in the environment of enterprise digitalisation; that is to say, many digital tasks have the characteristics of incomplete input conditions, irregular processing rules, and multi-dimensional output evaluation. The skill structure of the traditional model will have many repeated operations in a stable technical system and is not suitable for various technical ecosystems. If the iteration cycle of the enterprise's technical system is short, generally only one or two years, then the update speed of the course content and equipment platform in the cultivation model will not keep up with it, and thus there will be a problem of capability generation lag.

The generation of dynamic capabilities is affected by the time lag of learning situations and work situations. Most of the technical problems in the traditional training mode and the on-campus practical training sessions are relatively simple, do not have many external factors, and are at a much lower level of complexity and uncertainty compared with those in real digital production environments. The behaviour patterns and cognitive schemas that learners have developed in the simplified tasks cannot be directly applied to real-world digital environments because of noisy data and occasional equipment failures, etc. With the development of society and the increase in demand for digital jobs, the composition of competencies required in low-complexity training has been changing, and as a result, the lifespan of these positions has also been shortening. Therefore, there is a problem with the system of generating dynamic capabilities in the cultivation model.

2. Identification of Elements and Reconstruction of Relationships for Adaptive Reconstruction of Vocational Undergraduate Talent Cultivation Models

2.1 The Dual Shift in Knowledge and Competency of Training Objectives Driven by Digitalisation

With the new demand for digital technology systems, enterprises at all levels have developed a new knowledge structure, and now procedural knowledge is more in demand than substantive knowledge. The original goal of undergraduate vocational education is to have students learn the theoretical knowledge of equipment principles, process parameters, material properties, etc.; these are relatively fixed and can be documented. Procedural knowledge in a digital production environment refers to the logic of data flow, rules for interaction in cyber-physical systems, interpretation of algorithm output, etc.; however, the latter type of knowledge is more time-sensitive and context-dependent, so it needs to be continuously updated in light of changes in operation over time. The modification to the knowledge dimension of training objectives is that data perception, information screening and digital model invocation have been added to the main knowledge areas, forming an ordered ratio of substantive knowledge to procedural knowledge, and the proportion of procedural knowledge increases with the degree of digitalisation of the position[3].

Training goals in the area of competence now include the ability to adapt to various situations. Digital Positions require practitioners to be able to make judgments and respond to all sorts of changes in their environment, such as equipment conditions, production schedules, quality feedback, etc.; they should not just follow preset rules. The sub-competencies of the components for recognising abnormal patterns, decision-making under resource constraints and analysing data from all kinds of equipment should be added to the training goals. Changes in both the quantity and quality of knowledge and skills provide a good basis for adaptive reconstruction, and specific goals will be set for the next adjustment of the curriculum system and teaching structure.

2.2 Flexible Organisational Logic of the Modular Integrated Curriculum System

The Flexible Organisational Logic of the Modular Curriculum System is based on the separability and recombination of knowledge units. Many independent modules have been developed for the vocational undergraduate courses in all areas of technology, and each module is linked to a specific competency unit in the digital age, such as sensor data collection, digital twin model verification and construction of edge computing devices. Modules have horizontal connections and vertical progress according to the preset interface rules, and they contain the three kinds of metadata: prerequisite knowledge tags, output competency signatures, and compatibility version numbers. According to the competency map of the job they hope to obtain, learners can select some modules to build different learning paths, and the combination plan will be automatically verified for interface compatibility. The organisation logic above does not follow the fixed order of the traditional academic year and is more responsive to changes in local conditions and the company's need for updates. Only the corresponding module needs to be changed, and the whole system does not need to be recompiled.

The whole shape of the curriculum is also to integrate theoretical learning and practical training at the same time. The whole structure is not only a list of foundations but also covers teaching the principles of digital technology in the operation of the corresponding equipment and system debugging sessions to provide reference points for abstract concepts in concrete technical work. Review nodes for explicit knowledge and competency checkpoints have been added to the curriculum modules, and various combinations of modules can still form an organised cognitive schema. The foundation for the flexible organisation mentioned above is to change the concept of discipline into a way of cultivating abilities in curriculum planning, thereby improving the responsiveness of the vocational undergraduate curriculum system to changes in enterprise digitalisation.

2.3 Reorganizing the Structure of Virtual-Reality Integrated Teaching Based on Work-field Iteration

Reform of the virtual reality integrated teaching model will increase the number of physical exercise equipment and digital simulation platforms. All the operations of the equipment, collection of sensor signals and response of actuators in actual operation are synchronously mapped to the digital world to create a mirror-training environment. Wiring and calibration are carried out in the physical world, and then learners can observe how changes in parameters affect changes in the system at the digital level. At the same time, one can also change the parameters in the digital environment and then apply them to the actual equipment. To reduce material waste and improve the safety of training, a two-way mapping method will be used; at the same time, the same work scenario can be organised in different ways to expand the scope of training.

The working-area iteration logic should be based on the general digital task unit and not on the type of equipment. All task units in enterprise production are closed-loop systems; for example, after changing a batch recipe, the threshold of a sensor also needs to be reset, and such a closed-loop has four stages: perception, decision-making, execution and verification. At different times in the course of teaching, students will experience the three successive stages of physical simulation, semi-physical simulation and quasi-production environment; at each stage, the constraints and uncertainties of the tasks will gradually increase, and the quasi-production environment will be based on desensitised real enterprise working condition data. Automatically save the modified information in the fields according to the order of operation and decision paths of the learners on the digital platform, build individual capability development profiles, and store the distribution of error patterns and correction times for each field. The goal of the reform in teaching structure here is to replace the gradient of equipment complexity with the gradient of work-field complexity as the main way of organising teaching, so that vocational undergraduate talents can achieve cognitive pre-adaptation to multi-level uncertain environments before entering real digital workplaces and develop cross-field strategic transfer ability[4].

3. Operating Regulations for Vocational Undergraduate Talent Cultivation in the Adaptive Reconstruction Model

3.1 Multi-agent Collaborative Dynamic Calibration Rules for Cultivation Programs

Based on the collection and organisation of quantitative data for all the above reasons, dynamic calibration rules for cultivation programs have been developed. All the different agents, such as the technical departments of enterprises, teaching administration offices of vocational colleges and industry skill certification bodies, have different constraints and demand directions. Periodically, the technical department of the company will release the frequency distribution of competencies for digital positions and a list of typical task changes; the teaching administration office will inform relevant parties about the current distribution of curriculum modules and credit-hour capacity constraints, and skill certification institutions will periodically update the list of professional competency level standards. The above signals are sent to the calibration hub via the fixed interface protocol, and then a quantitative description of the difference between the current cultivation plan and digital job demands is obtained.

Dynamic calibration has two kinds of execution modes, and it can be either fixed or triggered by an event. According to the above data, the weights of the modules, the class-hour ratios and prerequisite relationships in the cultivation plan will be changed at different times. The extent of the revision will be limited by the level of ability, the job retention rate of graduates from the previous cycle, and so on. At the same time, event-driven triggering can be employed to start key links in the iterative process of enterprise digital technology, such as the commissioning of new equipment or the complete replacement of old control systems, and then local emergency calibration will be carried out in the areas affected by the competency map. After the calibration hub generates the adjustment recommendations, they should be in line with the curriculum system, and it needs to be ensured that the newly added modules do not have logical conflicts or competency gaps with the existing modules; this check process includes closed-loop detection of prerequisite relationships and verification of class hour load balancing. A set of rules will be added to increase the flexibility of the cultivation plan, and instead of fixed paper documents, there will be a system that can be continuously updated by multiple agents according to changes in digital technology and avoid the structural chaos caused by frequent modifications[5].

3.2 Digital Twin-driven Learning Progress and Resource Matching Strategy

Determine how much study is needed and what materials need to be obtained for the Digital Twin. Obtain the actual behaviour data of each student, such as the length of the operation sequence, error rate, number of retries and location of help-seeking nodes, map this data into the space of the digital twin and create an individualised capability evolution replica. Frame by frame, this copy is compared with the standard capability evolution curve to determine where and by how much it exceeds the threshold. There are probably many reasons for the deviation, such as cognitive overload or a lack of prerequisite knowledge, and thus the digital twin system will issue all kinds of resource scheduling commands.

According to the kind and size of the deviation, the resource-matching method will automatically construct a resource-combination plan. For the progress lag caused by deficiencies in prerequisite abilities, trace back to the unclosed competency nodes in the competency map and push the corresponding micro-module courses or virtual simulation training units; the push order should be in line with the topological sort of node dependency relationships. To reduce the load on the cognitive system, this way will decrease the number of learning tasks performed at one time, increase the time interval between modules, use simplified-difficulty alternative training versions to reduce the number of interfering factors, and keep the main operating logic unchanged. The range of resource allocation can be divided into promotions and reinforcements at different times in people's work, such as providing visual aids or shortening the time limit for some inspections. A digital twin-based matching strategy will not have the problem of resource misallocation in the traditional unified-progress instruction, and each student will be given materials that are suitable for their current stage and development path in learning. The accumulated data in the resource scheduling record can be used to increase the confidence interval of the standard curve step by step.

3.3 Progressive Evaluation and Feedback Path According to the Competency Map

Based on the foundation of the competency map, the requirements for digital positions have been broken down into many small, measurable and quantifiable competency indicators, and the links among these indicators have been specified. Each competency node is a particular technical operation or judgement behaviour, and the association edges show the dependence and hierarchy among these nodes. The construction of the competency map is based on the operation sequence analysis of enterprise digital tasks and expert cognitive task analysis, so the granularity of the nodes is in line with the precision of the actual action units at that position. Assessment will no longer be only at the end; instead, we will also know whether the student has met the requirements and how well they have performed at various times in the competency map.

Progressive evaluation has two ways of node unlocking and path accumulation. Learners need to pass the prerequisites in the competency map to unlock the next node; otherwise, they will have to be retested or retrained, and although the parameters of the retest version are the same as those in the original test, there will be some changes in the numerical values. The results of the evaluation will be in the form of vertical and horizontal feedback. Vertical feedback shows the learner's current position in the competency path and how far it is from the end nodes, in the form of progress bars and node-density heatmaps. Horizontal feedback is the difference between the actual operating characteristics of a learner at each node and the standard operating model, and deviation parameters are set, such as the percentage deviation of the torque value from the nominal value, step-skipping positions in the data-reading sequence, or the time by which the response latency exceeds the threshold. The feedback path goes back to the next training recommendation, and thus a loop of evaluation-positioning-correction-re-evaluation has been formed. At each cycle, record the deviation convergence curve to see how well it has been corrected. Gradual evaluation can make the progress of ability development more open and traceable, provide concrete data anchors for the operation of the regulation mechanism, and offer continuous calibration references in the development model of abilities in the digital twin system.

Conclusion

A Systematic Analysis of the Adaptive Reconstruction of Vocational Undergraduate Talent Cultivation Models in Light of Enterprise Digitalisation is Conducted at Three Levels: Identification of Manifestations of Imbalance, Identification of Elements and Reconstruction of Relationships, and Operation of Regulatory Mechanisms. Research has shown that the change in the form of production organisation due to digital technology has altered the scale and space of skill requirements, and it has also revealed the adaptation lag mechanism of traditional cultivation models in dynamic capability development. In terms of the Path of Reconstruction, this paper puts forward a double shift in the knowledge and competency goals of training, a flexible organisational logic for the modular integrated curriculum system, and a restructuring of the virtual-reality integrated teaching structure based on work-field iteration. To guarantee the good operation of the reconstructed model, this paper puts forward multi-agent collaborative dynamic calibration rules for cultivation programs, digital twin-driven learning progress and resource matching strategies, and a progressive evaluation and feedback path based on the competency map. The three parts are in a loop to achieve the goal, allocate resources and monitor the level of staff.

In the future, other ways will be found to construct competency maps for all kinds of digital posts, and the dynamic self-optimisation mechanism of the standard capability evolution curve in the digital twin system will also be studied. Another problem that needs to be solved is the transferability validation of the adaptive reconstruction model in different industries and academic fields.

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