Model and Design of Teaching Management Oriented to Outstanding Civil Engineer’s Training in Local Colleges and Universities Based on Internet-plus

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Abstract: In the progress of higher education’s reformation, the Plan for Educating and Training Outstanding Engineers (PETOE) is an important scheme that can train engineering talents in the domain of engineering education, which is deeply affecting colleges and universities’ teaching activities including the way and depth for teaching problems. Taking higher education of civil engineering as an example in the background of “Internet + Architecture”, firstly this paper analyses some problems that encountered during the implementation of PETOE in local colleges and universities, and proposes the school-enterprise’s distributed and collaborative teaching strategy oriented to outstanding civil engineer’s training. Then it builds the network management model for teaching services oriented to outstanding civil engineer’s training. Finally, the paper designs and implements this kind of network management system for teaching services. As enterprise participation is the key to the success of PETOE, and school-enterprise cooperation is the assurance of training qualified outstanding engineers, PETOE needs to participant enterprises to supply more teaching resources, which can satisfy the local colleges and universities’ demands of teaching data from the real engineering environment. In the process of teaching services management, the active and customized services to teaching data can also be reflected in the kind of network management system for teaching services.

1. Introduction
In order to improve the quality of talent training in the Chinese engineering education, and meet the demands for the professionals involved in the traditional industries and the strategic emerging industries, the Ministry of Education has launched a reform project of PETOE (hereinafter referred to as “excellence plan”) in the engineering field of colleges and universities. From the perspective of talent training, the main goal of excellence plan is to take the effective implementation by colleges and universities as a breakthrough, which will deepen the reform and innovation of Chinese engineering education comprehensively, and strive to build the systems of modern higher engineering education with international advanced level and Chinese characteristics, which can promote China from a large engineering education country to a strong engineering education country.

For colleges and universities participating in excellence plan, the graduate students, whether trained by the relevant departments, who can meet the professional talent requirements of industrial...
enterprises, and become a qualified excellent engineer, its key lies in the participating students’ training quality, which is also the roots of whether the top design of excellence plan can be achieved successfully. For this purpose, the quality assurance of outstanding engineers training must be attached great importance to by colleges and universities participating in excellence plan, and should be started from the beginning of applying for excellence plan, so as to ensure the final realization of the established target of excellence plan[1].

2. Competitive environment and urgent problems of the local colleges and universities

Under the new normal of China’s higher education reform, taking Taishan University as an example, it has determined the training target of applied senior professional talents to meet the needs of economic and social development, which is combined with the local colleges and universities’ development history, running conditions, traditional advantages, and regional economic and social development. As a local university newly assigned to the provincial management, Taishan University is facing both good development opportunities and unprecedented difficulties and challenges in the current education domain, especially for the comprehensive reform of China’s higher education. The first is the severe challenge brought by the market-centered allocation of resources. In the process of educational market competition, Taishan University is still in a weak position. Just belonging to provincial management, it is necessary to participate in the fierce competition from the educational market and teaching resources. The second is the huge impacts of the government on the optimization and adjustment of the educational structure, these significant effects, especially to the disadvantage of the transformation and development of local undergraduate education, are manifested in the following aspects [2]:

① Supporting excellent universities, special universities, and stronger universities;
② Focusing on the construction of some large-scale universities, and supporting the featured universities to take the lead in transformation;
③ Supporting higher vocational colleges and private education, including giving priority to policies, funds and the others.

Similar to Taishan University, the local undergraduate public colleges and universities, which are mainly based on undergraduate education and supplemented by junior college’s education, also occupy a certain amount in China's colleges and universities, and cultivate a large number of engineering-applied undergraduate talents, so as to serve the local regional economic and social development [3]. Taishan University is a full-time general undergraduate school established with Taian Teachers College as the main body and approved by the Ministry of Education in March 2002. As it has a deeper background of serving the local normal education from 1958 years, its teaching resources, whether they are software or hardware, account for a large proportion of the educational resources of the whole school. While the engineering education background is relatively lacking for applied undergraduate talent training oriented to engineering majors, and engineering teaching resources and practice training sites are also very weak from industrial enterprises. As a result, school resources and corporate resources cannot be classified and bridged together; school teachers and corporate tutors also cannot be docked with each other. This will ultimately make it difficult for students to effectively integrate theoretical knowledge with actual engineering, which is also impossible to experience the knowledge and technology that is derived from the background of real engineering applications.

3. School-Enterprise's collaborative teaching management strategy

Despite the above-mentioned problems of competition in the educational resources, it is irreversible that the local colleges and universities face the society to obtain high-quality teaching resources. In the process of cultivating civil engineering technical talents, the participation of civil engineering enterprises should be taken as the precondition for the implementation of excellence plan, which is also the key to the successful realization of outstanding engineer training goals. In fact, excellence plan regards industrial enterprises as the main body of training outstanding engineers together with colleges and universities, and requires them to conduct comprehensive, systematic and close
cooperation in the entire process of training outstanding engineers [4]. Therefore, from the perspective of the current problems faced by excellence plan and the training quality of outstanding engineers, it is necessary to study how to effectively promote the training of outstanding engineers jointly by industrial enterprises and local universities, so as to promote excellence plan to a better and more sustainable development.

Excellence plan actively advocates the “3+1” cultivation model of school-enterprise cooperation at the undergraduate level, namely three-year on-campus education and one-year on-enterprise learning. On the basis of striving for more cooperative enterprises to provide the real engineering training for students, colleges and universities must pay more attention to the main stage of students’ on-campus learning in the first three years of the “3+1” model, vigorously reform the teaching methods for the training of outstanding engineers, and strengthen the infiltration link of engineering elements in the course of explanation. So that students can immediately experience the classroom environment integrated with the real engineering background.

Since the construction process of civil engineering has distinct technical and economic characteristics, such as large project entity, strong comprehensive business, multiple condition variability, strong production fluidity, and long construction period. On the premise of increasing enrollment scale, decreasing operational funds, lacking real engineering teachers, and aggravating teaching tasks, let existing civil engineering teachers in local colleges and universities go to enterprises for short-term study or training, it will not achieve significant efficiencies in order to increase practical experience and engineering elements in the course of teaching. Moreover, it also will not reach the targets that the teaching content’s advantages, such as the depth, breadth and integration, should be reflected effectively. As school teachers and corporate tutors have their own resource advantages in engineering theory and engineering practice, in the progress of offering the courses for outstanding engineers, it is necessary to make full use of school-enterprise cooperative platform supplied to school teachers, and let corporate tutors provide the course’s preparative materials from the enterprises’ VR and AR resources or problem-solving solutions from the real engineering environment, which are based on the school teachers’ course teaching combined with engineering elements as far as possible. With the help of the professional clusters, technology-applied universities (colleges) alliances formed in the future, and the platform of educational groups that are set up by social industrial enterprises and universities (colleges), the data resources for course teaching will be rapidly increased to broaden the channels for obtaining the data information, which can expand the scope of the data services and promote a virtuous circle of teaching data shared between colleges and universities.

As the above-mentioned cooperative mode of industrial enterprises’ teaching participation and school-enterprise cooperation is less expensive, flexible and feasible, it is acceptable for enterprises and their own corporate tutors in the current stage of excellence planning, which can be adapted to the cross-regional and fluid construction management characteristics of the civil engineering industry. According to such distributed collaborative teaching strategies, the teaching contents of relevant professional courses are formed, and the professional knowledge is imparted by taking the specific practical problems of engineering technology and product design as the main-line or link, so that students participating in excellence planning can complete the improvement of their learning ability in the progress of concrete engineering thinking, which can gradually train them to own the modern engineer’s basic qualities of engineering practice, innovation, self-learning, self-improvement, and so on[5-7]. At the same time, the “3+1” cultivation model of undergraduate education is also helpful to achieve the docking and integration between students and corporate tutors in the last-year phase of the students’ corporate learning.

4. Management model for the courses’ teaching services

In the current“Internet +”environment, the internet will no longer play the role of information infrastructure only, and more importantly, it will become an innovative element of improving the management, production and operation mode of economic and social entities, so as to accelerate the
deep integration of the internet and economic society, and promote the innovation and development of economic and social entities [8]. For the trend of “Internet +” reform and innovation, it has brought the profound response and interaction in the field of higher architectural education in China. In particular, the third China Higher Architecture Education Summit in 2016 raised the theme of “Internet + Architecture” in higher architectural education under the new normal, with a view to further promoting colleges and universities’ educational reform in the professional field of civil engineering[9]. The concept of educational reform and innovation based on “Internet + Architecture” accords closely with the interactive requirements of university-enterprise's deep cooperation, which can realize the distributed collaborative teaching management strategy oriented to the school-enterprise’s joint training, so that corporate tutors can join in the teaching action, provide the course’s preparative materials or problem-solving solutions from the real engineering environment, and deepen the research-based teaching reforms and innovations based on problems, cases and projects.

In the field of computer network management, the services-oriented network management is a network management system that takes network service as the object to be managed. By providing a method for the client to simulate the user’s requesting service, it can test the network service, detect and analyze the running status of the service, so as to monitor the operating and changing rules of network services. Active computation, as an intelligent network architecture’s computing form that allows users to program network intermediate nodes, can provide related services and node resources needed for active network code’s running. At the same time, it also can actively provide management services for users. Supported by the active computing technology, this paper builds a network management model of teaching services oriented to outstanding civil engineer’s training from the service-oriented perspective. It makes the course’s teaching mode have the characteristics of active and customized services, which is oriented towards teaching service users by the distributed collaboration. Management model of the course’s teaching services is shown in Figure 1:

Under the above management model of teaching services, the network teaching applications, which are based on the course’s teaching system supported by the network teaching platform, include the following three components.

①School teacher’s teaching activities, such as teaching design, teaching organization, teaching implementation, homework assignment, answering questions, homework correction, classroom discussion, extracurricular guidance and teaching evaluation, etc.

②Student’s learning activities, such as listening to class, studying course content, doing homework, participating in a discussion and taking an exam, and so on.

③Corporate tutor’s teaching participation activities for excellent engineer’s training courses.

At the same time, the above-mentioned activities are regarded as the network services. In this way, the service is defined as an end-user-oriented application supported by a group of network layer functions, the school teachers, participating students, and corporate tutors involved in the network teaching are regarded as the services’ users, which can extend the service and application range of the network teaching services. In the progress of the teaching service management, according to the teaching activities’ contents of the colleges and universities’ professional courses participating in the excellent plan, service layers are divided up into some functional modules including the above-mentioned network services.
Figure 1. Management model of the course’s teaching services.

According to the distributed collaborative working mechanism, the codes of teaching service management are distributedly saved in the Active Code Server (ACS), and the codes contain some customized functions, which can realize the corresponding services including the teaching service information’s timely retrieval and the teaching activities’ change, addition and deletion on the basis of the user’s request. In the course of teaching service management, according to the user’s instructions, it is generally restricted to school teacher’s authority and corporate tutor’s limited authority. The client’s ANN (Active Network Node) can directly load the local ANC (Active Network Code) to realize the function of changing, adding, and deleting the teaching services, so that the corporate tutors’ teaching participation can be joined correspondingly in order to realize the distributed collaborative teaching cooperation between school teachers and corporate tutors; If not, it will preferentially choose the default download location from the nearest neighboring node; or else according to the code pointer encapsulated in the active packet, it will call and execute the corresponding ANC from ACS again, which can complete the teaching service management after loading. In fact, with the in-depth application of advanced technologies such as machine learning, artificial intelligence, cloud computing, and big data, more advanced intelligent nodes can be added to the computing nodes and services configured for intelligent networks, so as to further improve the running quality of the above working mechanism for the course teaching services’ management.

If ANN does not find ANC of the corresponding service management, it will report the unresolved teaching service as a new service to the server’s ANN, and request the management code oriented to the new teaching service. After the new ANC, received by the client’s ANN, was executed and solved, it would be stored in the local ACS as a historical record. With the deepening of corporate participation intensity, the increase of distributed cooperation nodes and the expansion of collaborative training channels, the teaching function modules in the service layer can also increase the teaching management services such as curriculum design and graduation design, which can realize the following functions.

① Overcoming the current bottleneck problems existed in the school-enterprise’s cooperation of training outstanding engineers.

② Adapting to industrial cooperation characteristics of civil engineering production management, such as cross-region, fluidity, complexity, and so on.

③ Bridging and docking with each other between the local colleges and universities’ teaching resources and the industrial enterprises’ engineering resources.
5. Design and implementation of management system for the course teaching services

In the design of the course teaching services’ management system oriented to outstanding civil engineers, the Java application of the service layer’s ANN1 corresponds to the Java class “ActiveApplication.manage”, which is used to manage the service layer; the Java application of the network layer’s ANN2 corresponds to the Java class “ActiveApplication.Node”, which is used to manage the network layer; at the same time, the download function of active code is configured for the network layer’s ANN2, which corresponds to the Java class “ActiveLoad.Node”. For this purpose, this example mainly configures three Java classes in software system design, namely ActiveNetworkNode1 class, ActiveNetworkNode2 class and ActiveLoad class. Furthermore, the specific management functions and communication locations of these Java classes are shown in Table 1 below.

| Java Class          | Management Function                                      | Communication Location          |
|---------------------|----------------------------------------------------------|---------------------------------|
| ANN1 class          | Representative element for service layer’s management     | Service layer                   |
| ANN2 class          | Representative element for network layer’s management     | Network layer                   |
| Active Load class   | Download ANC from local ACS or adjacent ANN               | Network layer                   |

5.1. Network management interface of the course teaching services

Taking the course of Civil Engineering Construction Organization as an example, the management interface for the course teaching services oriented to outstanding civil engineer’s training is shown in Figure 2.

Figure 2. Network management interface of the course teaching services.

5.2. Running example based on school-enterprise’s distributed collaborative teaching management
Taking the principle of flow construction in the course of Civil Engineering Construction Organization as an example, in the past, when the school teacher explained how to determine the value of flow pace of different rhythm flow construction, the textbook only gives the following formulas:

\[
k_{i,i+1} = t_i \quad (t_i \leq t_{i+1})
\]

\[
k_{i,i+1} = m t_i - (m-1) t_{i+1} \quad (t_i > t_{i+1})
\]

In the above formulas, the description of the calculation parameters is as follows:

1. "m" represents the number of construction sections;
2. "\(t_i\)" refers to flow beat of the \(i\)-th construction process;
3. "\(i\)" stands for the \(i\)-th construction process or any one construction process;
4. "\(k_{i,i+1}\)" refers to flow pace between any two adjacent construction processes.

When the school teacher teaches these knowledge points in classroom, how to make the abstract calculation formula for students to understand and accept, based on the visual classroom experience, is a teaching difficulty that the school teacher should pay attention to in the process of classroom teaching, because if students cannot fully understand the formula, it will affect the correct calculation about the other time parameters, and result in errors in the drawing of the entire schedule of different rhythm flow construction.

At this point, the teaching mode can give full play to the resource advantages of the corporate tutors, including engineering experience, professional knowledge and guiding ability. From the perspective of the real sequence of construction process, the corporate tutor can provide the specific teaching materials based on engineering background, participate in the teaching process of the school curriculum, and give the teaching data that are both professional and visual, which are directed against the internal defectiveness originated from the school teachers’ teaching contents and the external closure oriented to the students’ learning environment. Management mode of the course teaching services, based on the school-enterprise’s distributed collaborative teaching strategy, can make the school-enterprise teachers modify and improve the teaching courseware together. About the different rhythm flow pace, the explaining contents for classroom teaching are as follows:

\[
k_{i,i+1} = t_i \quad (t_i \leq t_{i+1})
\]

Enterprise explaining: For any two adjacent construction processes, such an assignment can ensure that the end time of the previous construction process on the same construction section will be prior to or equal to the start time of the latter construction process on the corresponding construction section, so as to meet the sequence requirements of any two adjacent construction processes; or considering that the duration of the \(i+1\)-th construction process is longer than the \(i\)-th construction process, it is hoped that the latter construction process can enter the corresponding construction section earlier to carry out the work from the perspective of reducing the value of project duration and keeping the continuous construction. In this way, the small value between \(t_i\) and \(t_{i+1}\) is assigned to \(k_{i,i+1}\). The construction schedule under such condition is shown in Figure 3.

![Figure 3. Construction schedule](image-url)
Enterprise explaining: When organizing flow construction, it is necessary to ensure that the last construction section of the i-th construction process is finished before the last construction section of the i+1-th construction process is assigned to start work, which can conform to the objective sequence requirements of any two adjacent construction processes; or considering that the duration of the i+1-th construction process is shorter than the i-th construction process, it is hoped that the i+1-th construction process cannot earlier enter the corresponding construction section to carry out the work. According to the above analyses and Figure 4, the difference, between the previous construction process’s total duration and the latter construction process’s duration of the first m-1 construction sections, is assigned to $k_{i,i+1}$.

\[ k_{i,i+1} = m_t - (m-1)t_{i+1} \quad (t_i > t_{i+1}) \]  

(2)

In this way, before the previous construction process has not yet completed enough construction section tasks, it is avoided that the latter construction process will enter the same construction section in advance to carry out the work, which will lead to the congestion and confusion in the construction operation surface of the project site, and reduce the construction efficiency of the professional flow operation. Furthermore, such assignment can avoid technical logic errors that the latter adjacent construction process had completed the same construction section task before the previous construction process has not completed the corresponding construction section task.

5.3. Running effects based on the school-enterprise’s distributed collaborative teaching management

Taking the civil engineering students from 2012 and 2015 grade as study objects, the teaching mode’s running effects to the course of Civil Engineering Construction Organization are as follows:

(1) Under the traditional teaching mode with the school teachers as the teaching activity center, the results of 2012 grade students’ course test are sampled as shown in Figure 5.

(2) Taking the students as the main body of the course teaching activities, under the course teaching services’ management mode based on the distributed collaborative working between school teachers and corporate tutors, the results of 2015 grade students’ course test are sampled as shown in Figure 6.
(3) Sample data analyses between traditional passive teaching mode and school-enterprise’s distributed collaborative teaching mode:

From the sample data of the examination results of the above two classes, the 2015 grade civil engineering class is superior to the 2012 grade civil engineering class in terms of both the number of outstanding students and the number of good and middling students, which reflects that the learning situation of the whole student group has shown the positive development trend. The growth trend of the students’ professional ability is not only a one-way change of students’ achievement scores, but also a student-centered way to organize the teaching process and contents in the classroom, so that students can actively absorb the new knowledge, and understand the engineering background and practical connotation of new knowledge, which can help students break through the key points and difficulties of the teaching knowledge.

In the process of teaching professional courses, the students’ partial or whole specific performance should be connected with the interaction and communication between teachers and students, and the problem-solving ideas or schemes, which stems from the real engineering background, should be selected to make the explanation of the abstract professional knowledge into a knowledge breakthrough that students can vividly and easily integrate. In this way, the school-enterprise’s distributed collaborative teaching mode also can let students actively experience and perceive the building process of the continued change and innovation of ontology cognition and knowledge structure, which will effectively promote the real learning experience between textbook knowledge and engineering practice. At the same time, the teaching mode is consistent with the research-based teaching method implemented by colleges and universities’ excellence plan, that is, problem-based inquiry learning, case-based discussion learning and project-based participatory learning. Such mode can enable students to complete acquisition and application of professional knowledge, and achieve cultivation and improvement of engineering capability, so that it will efficiently realize the target requirements and quality standards for outstanding engineer’s training in local colleges and universities.

6. Conclusion

In the implementation of PETOE for civil engineers, including the local colleges and universities, the teaching mode can not only configure and integrate the teaching resources and contents in order to carry out the research-based learning for the professional courses with strong engineering skills, but also design and build the knowledge modules of the courses for training outstanding engineers, so as to fully excavate the excellence contribution for the teaching data from school teachers and corporate tutors. In this way, the classroom teaching process and cluster teaching mode can be shaped nicely, which reflects the students’ main body development, highlights the real engineering background, and realizes the joint training between schools and enterprises. Furthermore, according to the distributed cooperative working mechanism and the active customized management method, this mode also can reflect the value-added application of such teaching data supplied by the school-enterprise’s
cooperative group, become a powerful integration point for the school-enterprise’s deep cooperation, and form a practical way to effectively reduce the cost of cooperation and improve the quality of cooperative training, so as to meet the two-way requirements of local universities and enterprises participated in the joint training of outstanding engineers, which is included in the applied talents training of civil engineering oriented to the current large number of undergraduate students.

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