THE PRACTICE OF TRAINING OUTSTANDING ENGINEERS BASED ON UNIVERSITY-ENTERPRISE COOPERATION PATTERN

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Abstract
The establishment of the excellent engineer training base in the university based on the university-enterprise cooperation pattern is an exploration and practice of the Outstanding Engineers Plans in China, termed as OEP. There are attempts at realizing effective docking between schools and IT enterprises. To this end, the university reforms the teaching content, teaching process and teaching mode, so as to cultivate students into qualified IT engineers or prospective project managers within four years in the campus. However, on the closely-related issue of how to take corrective actions to reconcile education behavior with the talent requirements from companies when considering OEP, research is still in its infancy. We propose a systematic talents cultivation proposal. Furthermore, referring to the AHP (Analytic Hierarchical Processes) method, we establish the evaluation index system and multi-level fuzzy evaluation model of teaching effect from the fuzzy description of non-dimensional evaluation indexes such as teacher evaluation, student evaluation and employer evaluation, so as to realize the multi-index evaluation of curriculum reform and teaching effect.

Key Words: Outstanding Engineers Plans, Analytic Hierarchical Processes, University-Enterprise Cooperation, Curriculum Reform.

1. Introduction
Our university is the first pilot unit of the National Outstanding Engineers Plans [1] (OEP) in China, and the computer science and technology specialty is a pilot one. Focusing on the goal of training outstanding engineers in the campus, we should establish a training base for cultivating outstanding engineers by employing the university-enterprise cooperation pattern. Based on the principle of win-win between universities and enterprises, the base takes the university as the main body, cooperates with software production and talents training enterprises to carry out university-enterprise cooperation procedures, introduces and effectively integrates various social resources and forces in accordance with the actual situation of talents cultivation in universities. Also, the base introduces enterprise management system, enterprise operation, enterprise project development management and personnel training pattern. Eventually, the base can effectively carry out talents training, software production, engineering education, science research and social service activities.

Since the Ministry of Education of China put forward the OEP, although there exists a large body of work in the area of OEP, surprisingly little has been done with interactive cultivation method for talents. The training pattern based on CDIO (Conceive, Design, Implement, Operate) provides a possible way [2] to cultivate talents. The learner-centered MOOC (Massive Open Online Courses) teaching mode borrows from the American engineering education mode [3]. Qiao and his colleagues studied major contents of specialty teaching project [4]. The importance of cooperation between universities and enterprises is pointed out in [5]. The focus of OEP is the exploration of cooperation mode between universities and enterprises. The university-enterprise cooperation training mechanism is necessary, which was elaborated in [6]. There have been past attempts at bridging the gap between universities and enterprises to cultivate outstanding engineers, such as [7-10]. Researchers also put forward practical problems and countermeasures in the implementation of the OEP in [11]. Yu Wang and others...
suggested a double track teaching method using lecture based learning and problem based learning in [12]. Teachers employed in JiangSu University in China analyzed the training standard of excellent engineers from the enterprise dimension taking NanJing Automobile Groups as an example [13]. However, on the closely-related issue of how to take corrective action to reconcile education behavior with the talent requirements from companies when considering OEP, research is still in its infancy.

Beginning in 2009, we investigated the demand for IT talents in many IT enterprises and the talent training pattern within IT enterprises. We also traced, investigated and studied the talent training pattern of IT training enterprises, studied their curriculum system, training path, teaching content, teaching mode, and so on. Also, we started to explore and practice the talent training mode in colleges and universities. We planned to transplant the talent cultivation work done by IT production and training enterprises into colleges and universities, explore and establish a set of application-oriented talent cultivation pattern, so that students could receive the engineering ability required by engineering position before graduation.

In the meantime, we hoped to explore a new training mode for cultivating outstanding engineers according to the actual situation of our university. Through the operation of the base, we could achieve strong cooperation, complementary advantages and effective docking between our university and famous IT production and training enterprises in the country, so that the OEP can truly land. Based on the strength of the team, cooperative enterprises also provided research and development projects for the base. The innovation of teaching content, teaching process and teaching mode, which is based on actual project-driven and aims at training qualified IT engineers and prospective project managers, should be carried out in time so as to deliver high-quality applied talents to enterprises and train students to qualified IT engineers or prospective project managers within four years in universities. In short, the base would be built into a project-oriented teaching, science research and project development, software production, technical consulting, industry training and social services center as a whole, but also can effectively solve the problem of student employment.

2. Base construction goals and content

2.1 Base construction goal

Cooperative enterprises and universities work together to determine teaching content, teaching process and teaching mode, and provide guidance for teachers and R&D projects for the base, and at the same time, the base gives priority to the delivery of talents for cooperative enterprises, with specific objectives as follows:

(1) Establishing core values. Cultivate talents with both moral and talent for the country, and do our best for our education and modernization.

(2) Adhere to the public welfare of education and the principle of providing education for all people without discrimination, so that ordinary students become outstanding.

(3) Research on the needs of various IT enterprises for talents and carry out teaching reform. Determine the curriculum system, formulate curriculum syllabus, produce excellent courses, and implement the automated teaching platform based on IT technology as far as possible.

(4) Achieving seamless employment between universities and enterprises. Before entering the base, some professional courses that students have learned are all popular computer programming technology and software project management technology. Students are more adaptable to achieve the purpose of learning for practice. In order to improve students' engineering ability, we let students participate in the small project. After that, students can participate in the research and development of practical business projects in enterprises, have actual feelings of the project and the ability to carry out the project, that is to say, eliminate the time lag between "entering the position after graduation" and "really being able to undertake the development task". In this way, we can realize the seamless employment for enterprises.

The base cooperates with all kinds of IT enterprises and IT training enterprises, constantly exploring an effective cooperation mechanism, expanding cooperation objects, and as far as possible gathering more enterprises who are willing to take the education as a public welfare. The cooperative enterprises of the base provide a certain number of R&D projects to the base every year, appoint full-time project managers with rich experience in project development and management, and appoint part-time instructors to achieve the sustainable development of university-enterprise cooperation and education.

2.2 Base construction content

2.2.1 Pattern optimization

In order to resolve the current difficulty of enterprise practice only for the senior in the campus, the current focus on the senior university-enterprise cooperation training model, changed to the four-year university-enterprise cooperation model from freshman to senior. Together with IT R&D enterprises and IT training enterprises, we study the training objectives, training paths, training contents and curriculum system. Combining with the actual situation of the university, the content and pattern of university-enterprise cooperation training for freshmen to senior students are effectively planned.

2.2.2 Reform concept

There are many training directions and posts for outstanding
talents in IT industry. Before diving into how this is done let’s focus on the development direction of WEB development and take into account the direction of mobile development. The direction of WEB development is decided as the current mainstream one. We aim at studying and analysing the training rules, considering the existing training plans of the university, designing individual learning plans for students, guiding students to learn independently by employing student-centred learning concept to enhance students’ learning ability.

The base allows students to participate in the actual business project development training as soon as possible. Students are encouraged with material incentives by giving them the corresponding remuneration according to their ability and performance to develop business projects.

2.2.3 Training initiatives

The base hopes that students can build up a global view of system design and development from the perspective of consolidating foundation and expanding software technology skills on the basis of absorbing the traditional computer theory. In the exploration and practice of the training system of outstanding talents, considering the existing technical reserves of teachers and students, the following training measures are to be implemented:

1) Revising and supplementing student training program in an all-round way

The implementation of OEP requires the hiring of instructors in enterprises to establish training plans, implement the training process, and develop software platform for OEP. The base undertakes a continuous stream of projects to support students to participate in the project practice. Enterprises and universities work together to guide students’ project practice and cultivate students' project development ability.

2) Implementing project-driven teaching reform

Most professional teachers in the base have enterprise experience, therefore, they can design and compile the syllabus according to their own project experience and development ability. When designing the teaching link, they can add project-driven teaching content to improve the percentage weight of practical parts in the traditional syllabus. The implementation process is as follows:

Firstly, according to the teacher's project experience, we evaluate the adopted projects and implement the project development according to the norms of software engineering process.

Secondly, according to the difficulty of modules and students' mastery of the required technology, teachers group students scientifically.

Thirdly, according to the progress of the project plan, the student development members carry out the project development under the guidance of the teachers and the process monitoring of the project.

At last, according to the simulated customer acceptance scenario, the project is reviewed and accepted, and the project summary report is completed. The technologies used by students are mainly divided into two categories: one is Java and dot Net technologies related to web applications and the other is mobile platform development technologies.

(3) Construction and operation of project training platform

The construction of project training platform is mainly based on the actual situation of students and teachers, according to the requirements of software enterprises for talents so as to establish a skill based project driven training platform. The base requires students to implement the method of "continuous coding and practice", and enter different train stages according to their skills as follows.

1) Java/mobile development foundation and basic literacy preparation;
2) Java Web/APP process development;
3) JSP/APP page view development;
4) Framework development;
5) Software project development.

Each of these five stages is a link between the past and the future. After assessing the skills of the students entering the base, they choose a certain stage to start the practical training.

(4) Establishing the mechanism of sustainable development for teachers

The characteristics of engineering education and the increasing update of computer technology require teachers to have a considerable level of technology. Therefore, the following sustainable development mechanisms for teachers should be established as follows.

1) New teachers entering the base are required to project research and development in an enterprise for at least half a year, and other full-time teachers who have been on the post are required to enter the enterprise for learning and observation according to the actual situation, so as to understand the mainstream development technology and trend of the current industry.

2) Professional teachers are encouraged to integrate their own research projects into classroom teaching, so that teaching can be rich in practical application, and students are encouraged to participate in research projects of teachers.

3) Inviting managers or engineers with rich experience in project research and development to enter the base for practical guidance or technical discussion, and requiring professional teachers to cooperate with them to provide guidance to students.

(5) Improving and implementing the professional education tutor system

Tutor system is an important measure to carry out
individualized training. Tutors provide individualized guidance on students' study, research and life planning from freshman, and teach students in accordance with their aptitude, which is conducive to the emergence of potential excellent undergraduates from freshman. The tutor will put forward the target project according to the professional training plan and guide the students to complete the project. Students from sophomore year will be handed over to teachers in the tutor library. According to the tutor's own professional direction, the students will be guided to complete the practical links in the training plan, including curriculum design, technical practice, graduation design, etc. In addition, we let students participate in project development as much as possible to achieve engineering training.

(6) Reform of teaching mode
Adopting the mode of "Internet Plus" excellent engineer training, i.e., combining with the actual situation of our university, we have developed a supporting platform named Gao College (www.gwxuetang.com) by adopting advanced teaching methods such as MOOC [3], flipped classroom and micro courses, as shown in Fig. 1. Based on Gao College platform, it can effectively carry out online and offline mixed teaching, collaboration between enterprises and universities to train outstanding engineers, effectively realize the student-centred teaching mode, effectively enhance learning initiative of students and learning efficiency, and greatly improve teaching efficiency and teaching effect at last.

Gao College platform supports the centralized compilation and process improvement of the syllabus. The introduction, privatization and autonomous management of the course video and question bank are also supported. It helps to complete the intelligent generation and multi

Fig. 1 The teacher's portal in Gao College

Fig. 2 Assignments and after-class exercises based on the teaching calendar

Fig. 3 Personalized autonomous learning

Fig. 4 The hybrid teaching mode of online and offline

semester reuse of the teaching calendar. The platform supports the automatic arrangement and intelligent correction of assignments and after-class exercises based on the teaching calendar (Fig. 2). We provide sufficient mode freedom based on SPOC, MOOC, MOOP and flipped courses to let students carry out personalized autonomous learning (Fig. 3). It can realize the real-time interaction between teachers and students, and the hybrid teaching mode of online and offline (Fig. 4). The data mining is completed after class to support personalized learning. The system is able to track the learning trajectory, realize the whole process care, support the evaluation and assessment of students' process learning. Finally, the platform supports the whole process management of experimental teaching, i.e., automatic arrangement of experimental topics, automatic correction of experiments, automatic generation of results and experimental reports. The student side of Gao
College platform also supports ubiquitous learning, which is implemented through mobile application (Fig. 5).

2.2.4 Role division

(1) **Base Expert Steering Committee**

The members of the committee are composed of relevant leaders and experts from universities and enterprises. The base conducts activities under the guidance of the committee. The committee grasps the development direction of the base and guides the construction of the base macroscopically.

(2) **IT manufacturing enterprises**

They provide R&D projects for the base, assign full-time and part-time project managers or project engineers to guide students in project-based learning or projects development, carry out project-based curriculum construction together with base teachers under the support of training enterprises, appoint managers to guide the base to establish enterprise management system for the base.

(3) **IT training enterprises**

Considering the needs of the enterprise and the training requirements of excellent engineers, teachers and enterprise engineers work out the base curriculum construction plan. They work together to implement project-based teaching and training. When the base course construction has achieved extraordinary results, it can be considered to introduce the base course into the classroom teaching and popularize them in the university. The credits of the relevant courses of the university can be exchanged if possible.

(4) **University teachers in the base**

They generally coordinate the relationship between the base and various enterprises, continuously find cooperative enterprises and undertake enterprise R&D projects, so as to expand the employment channels of students. Also, they are responsible for the training process of excellent engineers and the process of project R&D, curriculum construction and teaching implementation of the base, together with cooperative enterprises to apply for various projects, so that more teachers can participate in the construction of the base.

3. **Quantitative evaluation of training results**

To demonstrate the usefulness of our approach, we show how to apply an evaluation method. With the deepening of curriculum reform, the results of reform and teaching effect evaluation can guide the reform of our base in practice. Because of the uncertainty of the objective world and the fuzziness of people's understanding of the object, students and teachers always face the uncertain environment when evaluating the teaching effect of the course. For the so-called semi-structured problems and the vast amount of fuzzy information on the Internet, i.e., almost certain, probable, possibility, to name a few, it is also a large number of events to be faced in the evaluation of teaching effect. The decision-making of teaching effect evaluation should be balanced, coordinated and optimized. Generally, it is not a single criteria decision, but a multi-criteria decision, not a single level criteria system, but a multi-level criteria system. Referring to the AHP [14] (analytic hierarchy process) method, we set up the teaching effect evaluation index system and multi-level fuzzy evaluation model from the non-dimensional evaluation indexes of teacher evaluation of learning, student evaluation of teaching and employer evaluation, so as to realize the multi-index evaluation of the base curriculum reform and teaching effect.

3.1 **Construction of teaching effect evaluation index system**

Because some evaluation factors of the evaluation object often have a certain degree of fuzziness, that is, nonlinear characteristics, so the fuzzy comprehensive evaluation model is used in the evaluation of teaching effect in the base. In addition to the weight of each evaluation item, the score of each evaluation item should also be given in the questionnaire. Combined with the actual situation of teaching reform, we give the evaluation criteria including three first-class indicators, and establish corresponding second-class evaluation indicators (as shown in Fig. 6).
When we construct the index system of teaching reform and effect evaluation, we mainly consider whether we can achieve the goal of reform through the base curriculum reform, that is, whether we can improve students' interest in learning and help them acquire the ability to solve practical problems through case teaching and interactive discussion based on engineering projects. Therefore, the emphasis of constructing curriculum reform and teaching effect evaluation index system is different from that of traditional teaching evaluation index.

3.2 Teaching effect evaluation

Since 2009, we have introduced undergraduates majoring in computer science and technology into the base for training. At the end of the whole training course, some students were randomly selected by questionnaire to evaluate teaching. This paper compares the teaching effect evaluation of students graduating in 2017, 2018 and 2019. We randomly selected some graduates of each class, and contacted the corresponding employers for relevant evaluation. We show the teaching effect evaluation of graduates in 2017, 2018 and 2019 in the base as shown in Table 1, where e1, e2 and e3 respectively represent the teaching effect evaluation of each evaluation index of graduates in 2017, 2018 and 2019. Using the model of teaching effect evaluation based on AHP proposed in this paper, the comprehensive judgment is: \( B = A*R = (81.1, 84.1, 88.6) \). The data shows that the graduates in 2019 have the highest evaluation value in the evaluation of the teaching effect of the graduate in 2017, 2018 and 2019 performing base courses. It can be seen that with the deepening of teaching reform and curriculum construction, the teaching effect of the base courses has been gradually improved, students' interest in learning the courses set up by the base has been gradually enhanced, and students' engineering ability has also been greatly improved. The evaluation of students' internship units and employers also shows this.

| Table 1. Curriculum reform and teaching effect evaluation form |
|----------------------------------|
| **first-class indicators**       | **R1** | **R2** | **R3** |
| Weight                           | 0.4    | 0.4    | 0.2    |
| **second-class indicators**      |        |        |        |
| **Weight**                       |        |        |        |
| R11                              | 0.2    | 0.2    | 0.2    |
| R12                              | 0.2    | 0.2    | 0.2    |
| R13                              | 0.5    | 0.5    | 0.4    |
| R14                              | 0.5    | 0.5    | 0.3    |
| R15                              | 0.3    | 0.3    | 0.3    |
| **2017 graduates-e1**            | 90     | 87     | 86     |
| **2018 graduates-e2**            | 92     | 89     | 88     |
| **2019 graduates-e3**            | 93     | 91     | 89     |

4. Conclusion and future works

Based on our special love for the training of outstanding engineers, in recent years, teachers of the base have spent most of their weekends and holidays together with students to learn and discussion together in the university. The results are gratifying through more than four years of excellent engineer training practice activities. In the experimental group, a high proportion of junior can be independent of participating in the development of commercial projects, and all senior have the ability to develop commercial projects. Before graduation, students in the experimental group personnel have grasped the...
application and practice ability, which ordinary students have one year after graduation. Some juniors have income and no longer need the cost of study and living from their parents, which is abnormal in China. All senior can get 2000 to 6000 yuan of monthly internship salary, which is uncommon in the city. Students from the base are very popular by employers.

The impact of the industrial revolution is far-reaching, from which we can learn for the cultivation of software talents. But the process is long. Only through unremitting exploration and practice, can we gain something. Standing on the shoulders of our predecessors, we have established a sense of responsibility of "preaching, teaching and solving puzzles". With the tide of the national OEP, the training of excellent engineers based on the university-enterprise cooperation pattern will play a positive role in the successful implementation of OEP in our university. We will explore and refine more effective mechanism to deepen cultivation effect in the future.

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