Using Project-Based Learning and Collaborative Learning in Software Engineering Talent Cultivation

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***Abstract*—Higher education is the most important way to cultivating software engineering talents in China, but there is an education gap between the industry and the universities. The current curriculum in university lacked in transferring the experience and skills to students. In this paper, we present how to use project-based learning and collaborative learning in software engineering talent cultivation. We established a learning organization in college of informatics of South China Agricultural University which was named Human Computer Interaction Studio (HCIS). Students can join HCIS on a voluntary basis, and then they can take part in a project team to become a team member. The team accepts a project according to their interest and ability, and then the project manager allocates tasks, formulated work and learning plan. The members of a team would exchange information, discuss some questions and accomplish their tasks together. The study had achieved many good effects in practice, employment and academia. Students can gain expertise, necessary experience and some skills after they used project-based learning and collaborative learning. The results indicated that using project-based learning and collaborative learning can be a good method for software engineering talent cultivation in university.**

Keywords-component; project-based learning; collaborative learning; software engineering; talent cultivation

I. INTRODUCTION

In China, higher education is the most important way of cultivating software engineering talent. But there are some common complaints about graduates of software-related subjects in industry and business, for example, lacking skills and patience, no cooperative spirit and low sense of team-work. Designing software according to user requirements is a complicated work, it usually is finished by a team and every person in team has different work. The team members should have expertise, necessary experience and some skills. The current curriculum of university lacked in transferring the experience and the skill for students. There are some factors affecting the education quality of software engineering in China. First, Chinese classrooms have long suffered from a lack of interactivity [1]. Secondly, facing this fast changing software environment, undergraduate courses lacked some necessary knowledge to be productive in a future work environment. Thirdly, traditional teaching method usually did not provide chances in practice ability of real software development. Last, undergraduates lacked experience of collaboration and cooperation. Researchers introduced some solutions in improving the software engineering talent education. Song et al. [2] proposed setting specialty direction to improve the pertinence and personalized talent education, which is helpful to narrow the gap between university and industry. They gave the concrete measures including some strategies and measures in curriculum construction, practical teaching. Deng [3] described a definition of high-level software talents with global suitability and discussed the characteristic of such talents. She presented a systematic way of how to effectively train such talents. Tian et al. [4] presented relationship between internationalization and Chinese characteristics and standards to measure internationalization. They used training international computer software engineers as an example to discuss some possible methods and their practices for internationalized education. We are interested in how to training undergraduates that could use the gained knowledge, ability and skills to solve problems and adapt to future work.

Educational researches have shown that students can get the knowledge actively and learn better when teachers used learner-centered teaching approaches [5]. Project-based learning and collaborative learning are two of these learner-centered approaches. Project-based learning (*PBL*) is a systematic teaching method that engages students in learning essential knowledge and life-enhancing skills through an extended, student-influenced inquiry process structured around complex, authentic questions and carefully designed products and task [6]. PBL is a useful approach to engage students' interest and motivate them for learning [7]. Collaborative learning (*CL*) is a learning process in which two or more people learn or attempt to learn something together [8]. The method emphasizes that CL is a social rather than an individual activity [9].

In this paper, we describe how to use PBL and CL for software engineering talent cultivation in South China Agricultural University (SCAU), and present the experience

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and results of our study. The paper is organized as follows: The next section introduces the contents of PBL and CL. In the third section, we introduce our methodology of talent cultivation in detail. In the fourth section, we present the implementation results of the study. The last section is conclusions and some future works.

II. PROJECT-BASED LEARNING AND COLLABORATIVE LEARNING

Project-based learning (PBL) is an instructional method based on constructivist Learning Theory. It is considered to have great potential to enhance students' motivation and learning [10]. PBL offers an engaging instructional method to make learners active constructors of knowledge. Rooted in constructivism and cooperative/collaborative learning, project-based learning has strong theoretical support for successful achievement [11]. The method built on authentic learning activities that engage students' interest and motivation [5]. There are many successful examples about PBL in different periods of education, and researchers made some different definitions about PBL according to their experiences. Barron [12] thought that PBL was designed to be used for complicated task that require students to investigate in order to understand. According to Moylan [6], it is a systematic teaching method that engages students in learning knowledge and skills through learner-centered process. Overall, PBL is a learning method that organizes students' learning activities around specified projects. The benefits for the students working in a PBL learning environment are tremendous. Some benefits are listed as below:

- Students have a further understanding of knowledge by PBL.
- PBL stimulates students' interest and independent character of learning engages students' interest.
- Students get some practicing skills in process of problem solving.
- Students can improve communication skills by PBL.
- Teacher can understand each student's ability to work by PBL.

With the benefits of PBL, there are some concerns when using PBL in China. Firstly, many educators lacked ability to create appropriate PBL environment. Secondly, if PBL was used in a course, the course could be unfinished on time because teachers require a lot of time to introduce the process of PBL in classroom. Last, students would be allocated in different groups; the leader of group usually lacked management experience of project.

Another instructional method is collaborative learning (CL). It is a learning process in which two or more people learn or attempt to learn something together. Nattiv [13] pointed out CL was a teaching method which allowed students to be "inter-dependent" in learning, working, and role-playing when they dealt with a shared goal to accomplish their tasks. Slavin [14] introduced that CL made every learner exchange information and responsible for their learning in the activity that was carefully planned and designed, so they can further interact with other learners in the group and be motivated to promote their learning. Hence, CL can improve students' interaction ability and team work spirit. However, some problems could affect the effective and successful group collaboration. Liu et al. [15] revealed that the main problems induced by learners included poor motivation, lack of individual accountability, and negative interdependence among group members.

There are some similarities and differences between PBL and CL, PBL emphasizes the process of problem-solving, but CL emphasizes that its process is a social rather than an individual activity. Based on existing examples [16] [17] for PBL and CL, our work focused on how to use PBL and CL in software engineering talent cultivation.

III. METHODOLOGY

The study began in 2007. We hoped that our methodology can improve students' experiences and skills which they could use in future work environment. It was difficulty to achieving our goal in a certain course, so we established a learning organization in college of informatics of SCAU which was named Human Computer Interaction Studio (*HCIS*). We quite agreed with that not all graduates would engage in software development, so students would apply for HCIS membership on a voluntary basis. If their applications are successful, they can join in a project team and become a team member, all work about project will be done in free time and holiday. We thought the voluntary basis could solve the "poor motivation" problem of CL. About PBL, one important question is how to set appropriate projects. The sources of projects in HCIS have three areas, scientific research projects, information systems of college and university, and some industry projects. Another important question is how to form a project team. For better cooperative learning (CL), the students were grouped according to learning interest, ability and different grades. The group members were not fixed, and would be grouped again when their project had been done. The grouping mechanism can avoid students' dependence, and can improve students' communication skills and cooperation ability. Each team included a project manager and 3~5 members, they usually were in different grades. The project manager was a senior student and had some PBL experience; his duty was to allocate tasks, organize discussion and debate, and give members technical advices. Although PBL and CL emphasize learner-centered learning, instructors play an important role in our study. There were six instructors that work voluntarily in HCIS. Each instructor guided and supervised some projects according to his area of expertise; the team of project can get professional advices from their instructor. Instructors also gave all members technology lectures in every two weeks. The procedure of project development in HCIS likes Figure 1.

The first step, the team of project accepted a project according to their interest and their ability, and got more information about the project from the instructor. The second step, the project manager allocated tasks and formulated work and learning plan, all members of team were asked to present their advices about the project. The third step included learning relevant knowledge, project development,

discussion and debate. HCIS encouraged students to use CL method in learning knowledge. The study also found that students got some good learning effects through CL; they were more positive and more efficient in learning process, and they liked to exchange ideas with peers and instructors. Project development is an experiential work and a repetitive process in most cases. Students can get software development experience from the process of project development. They also required discussion and debate to find the correct direction. All of these can cultivate their independent thinking ability, communication ability and engineering practice ability. The fourth step included project inspection and usability test. The team applied project inspection when they thought their project was perfect.

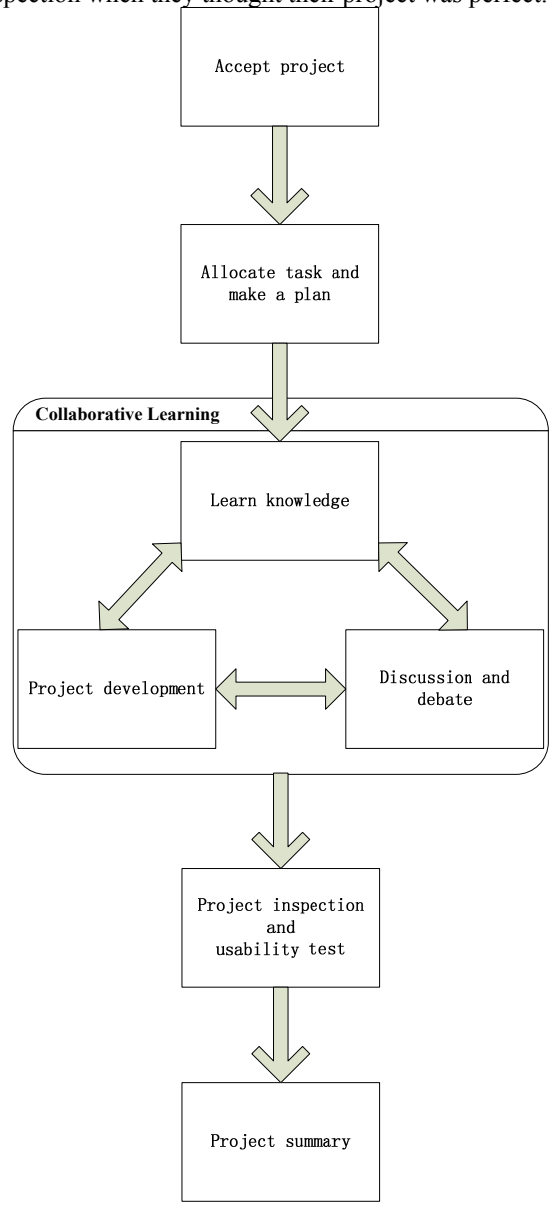

Figure 1. Flow chart of project development in HCIS

Instructors and other HCIS members checked the project according to initial requirement, function and interface. In our experience, most of the projects usually need to be modified; the main reason is the lack of development experience and skill. The last step, if the project passed inspection and usability test, the project team would summarize experience and defect about just finished project. They also were allowed to join the other team or start a new project.

IV. RESULTS

A. *Students' opinions about HCIS*

Forty one students of HCIS filled out a questionnaire to report their attitudes toward the learning mechanism of HCIS, all questions used five-point Likert scale. Table I lists the percentages of the students' agreement levels on the questions. According to the students' responses, most of them thought that the mechanism of HCIS is an effective way to learn software development. About 80% agreed that learning in HCIS was helpful to in gaining knowledge, improving the ability of team work and the ability of independently thinking, enlarging positivity and initiative of learning. About 65% thought that learning in HCIS had improved their ability of communication. About 60% thought that instructors' advices were helpful to project achievement. About 85% thought learning in HCIS was very useful to future work and was pleasurable.

B. *Some good effects*

The study has got many good effects in software engineering talent cultivation. We analyzed employment situation about HCIS members who had graduated. The graduates have the very strong self-confidence and communication skill. They also presented good ability and experience of software development. Almost all of them got software development jobs in some well-known computer companies. On the practice side for study, HCIS have finished some software systems that have been used successfully; for example, College of Informatics Web Site (see Figure 2), Online Exam System (see Figure 3) and Recommend System of SCAU Library (see Figure 4). These software systems proved that the students had gained competent expertise by using PBL and CL.

In view of students' academic research, students of HCIS have published seven academic articles since 2007. The four of them have been recommended admission to postgraduate school. With the obvious results, more and more students like to join HCIS and use PBL; the membership of HCIS was enlarged to 125 in 2011 since 8 in 2007. As the increasing number of HCIS members, we also had to face some management problems, for example, lack of instructors and effectively communication.

TABLE I. PERCENTAGES OF THE STUDENTS' AGREEMENT LEVELS ON THE QUESTIONS ABOUT HCIS (N = 41)

Question statement	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)
Joining HCIS is helpful to your learning	2.44	7.32	12.20	41.46	36.58
Process of project development is helpful to learn expertise for you	2.44	2.44	9.76	26.83	58.53
Learning in HCIS has improved the ability of independently thinking and solving problem	2.44	0	9.70	51.22	36.58
Learning in HCIS has improved the ability of communication	4.88	12.20	17.07	48.78	17.07
Learning in HCIS has improved the ability of team work	2.44	4.88	14.63	53.66	24.39
Learning in HCIS has enlarged positivity and initiative of learning	2.44	2.44	14.63	26.83	53.66
You learned some professional knowledge that not be in the textbooks	4.88	2.44	4.88	34.15	53.65
Instructors' advices are helpful to project achievement	7.32	12.20	19.51	41.46	19.51
Learning in HCIS is very useful to future work	7.32	2.44	4.88	36.59	48.77
Learning in HCIS is pleasurable	2.44	0	14.64	41.46	41.46

Figure 2. College of Informatics Web Site

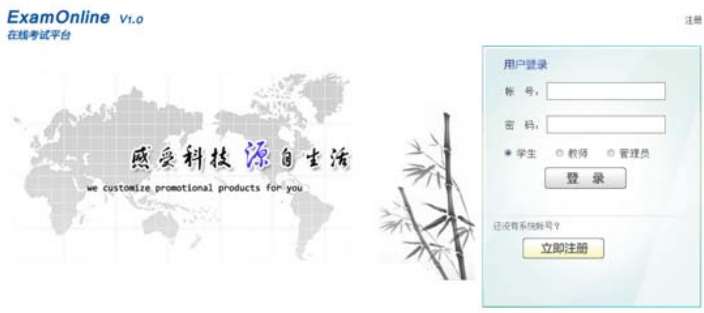

Figure 3. Online Exam System

Figure 4. Recommend System of SCAU Library

V. CONCLUSIONS AND FUTURE WORKS

In this paper, we presented our study on how to use PBL and CL on software engineering talent cultivation within a learning organization at undergraduate level. There are three features in our methodology. First, we used PBL and CL in a learning organization, not a certain course. Second, all of the students joined HCIS on a voluntary basis, which could solve the problem of "poor motivation". Finally, PBL and CL emphasize "learner-centered", and rely on the learning group that take full responsibility for their learning. According to our experience in HCIS, about 60% students thought that instructors' advices were helpful to project achievement, so the instructors could play an important role in using PBL and CL, especially in China. Besides giving correct orientation and ensuring projects' success, instructors' advices also enhanced students' confidence in the learning process.

The practice of the two instructional methods also received many good effects. The undergraduates in HCIS become more active and confident, and also gain expertise, necessary experience and some other skills. The graduates from HCIS usually presented good ability and experience on software development, and received better offers than the other graduates.

In conclusion, software engineering talents require expertise, communication skills, cooperative spirit and high sense of teamwork, but the curriculum of current Chinese higher education lack these contents. PBL and CL are all constructivist instructional methods. They all emphasize "learner-centered". The existing examples of them have proved that they can enhance learning actively and improve communication skill. This paper presented the mechanism of HCIS, an example of using PBL and CL. The results indicated that using PBL and CL could be a good idea in software engineering talent cultivation. In future work, we will try to use computer-supported collaborative learning (CSCL) [18] to solve the management problems that were mentioned in section IV. CSCL may make a collaborative learning environment to support group members' coordination so that they can complete the tasks more efficiently.

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