Design and practice of training plan with blended learning courses for improvement of innovation ability in major of electronic engineering

Ziji Ma
College of Electrical and Information Engineering
Hunan University
Changsha, China
zijima@hnu.edu.cn

Zhikang Shuai
College of Electrical and Information Engineering
Hunan University
Changsha, China
szk@hnu.edu.cn

Yong Li
College of Electrical and Information Engineering
Hunan University
Changsha, China
yongli@hnu.edu.cn

Jiazhu Xu
College of Electrical and Information Engineering
Hunan University
Changsha, China
xjz@hnu.edu.cn

Feng Wang
College of Electrical and Information Engineering
Hunan University
Changsha, China
fengwang@hnu.edu.cn

***Abstract*—In the student-centered cultivation model, innovation ability and engineering skills of solving complex engineering problems is generally considered to be the key goal, which is usually broken down into small independent tasks arranged in different courses to support it from varying ways. However, at the implementation level, the actual training effect is not quite satisfactory due to the weak relationship between different courses and the lack of motivation for teachers to communicate with each other. In this paper, we propose a set of blended learning courses focusing on cultivating innovation ability throughout the undergraduate study period. Based on our design, the blended learning courses integrate MOOC, private course, comprehensive curriculum project, discipline competition and other types of courses, aiming to comprehensively improve undergraduates' innovation ability and engineering skills. These courses are arranged in different semesters and majors according to their general knowledge and specialization. After six years of practice for at least 3 generations of undergraduate students who have completed a whole training plan, we have collected a large number of data and made detailed analysis. It shows that undergraduates who participate in the complete learning process of the blended courses have obvious advantages in professional course scores, scholarship and award proportion.**

Keywords—blended learning, innovation ability, electronic engineering, project based learning

I. INTRODUCTION

OBE (Outcome based education) has been globally applied in educational reforms and becomes very popular in China for upgrading the conventional curriculum system. Improving the ability of innovation and practice, especially the ability to solve complicated engineering problems, has become a key task of engineering majors in more and more universities in undergraduate training, which is also an important goal of OBE education. Many colleges and universities have carried out a lot of reforms in this aspect and put forward many good methods. In Tsinghua University, they have built a new hardware platform to help the lower grade undergraduates of the computer major to carry out practical ability and innovation awareness training[1]. Some researchers have tried to fulfill the CDIO (Conceive, Design, Implement, Operate) concept of international engineering education and the project task-driven teaching method by further integrating into every link of major courses[2]. Lauren has proposed a so-called Innovation-Based Learning (IBL) that is a assessment framework to give students the freedom to demonstrate their learning by defining their own learning objectives and deliverables[3]. Recently, some researchers think that the traditional large-class education may have difficulty in providing individualized teaching. Then they have proposed to create a kind of blended course based on SPOC (Small Private Online Course) and flipped classroom as well as with both online and offline learning[4]. Some researcher propose the definition of project-based learning (PBL) of investigating and solving complex, real-world problems to promote undergraduates an entrepreneurial mindset[5]. Many other researchers have put forward their own views on how to improve students' innovative consciousness and practical ability, and have carried out very meaningful educational practice[6-7]. All of these reforms achieved some outcomes on improving student's innovation ability from their evaluation criteria. However, there is a big problem for teaching administrators and plan makers, which most of these studies focus on only one course. Once the course teaching is finished, the improvement task goes to the end as well. There is no continuity in effect assessment, and the budding innovation consciousness may wither rapidly due to the lack of continuous motivation. To address this issue, compared to related work, the contributions of this article are as follows.

1) We renewed the training plan with adding a set of blended learning courses to consolidate the undergraduate student's theoretical knowledge and cultivate their ability of innovation and practice, but not only one course about innovation education.

2) Based on our design, the blended courses run through the whole college program with blended learning of varying modern teaching types, including MOOC, small private course, comprehensive curriculum project, project-based learning, discipline competition, etc..

3) These courses are arranged in different semesters, from the grade 1 to the grade 4, and majors according to their general knowledge and specialization, but not just for some especial students. Thus, the courses form a kind of bridge between teachers and students. Those students who really

want to start their creative work or entrepreneurship can easily obtain information about innovation competition, even get helps from university via teachers.

Courses	Type	Teaching form	Description	Year
Innovation & entrepreneurship	General /Basic	MOOC& Lecture	Understand the basic concepts of innovation and entrepreneurship, and learn how to extract scientific problems from life	1
Introduction to computers and programming	Compulsory /Basic	Lecture & Experiments	master the object-oriented programming methods and ability	1
Engineering Practice and Innovative Design of Electronic Systems-1	Elective /Advanced	Training & Experiments	A SPC Integrated learning based on design of electronic circle	2
Engineering Practice and Innovative Design of Electronic Systems-2	Elective /Advanced	Training & Experiments	A SPC Integrated learning based on embedded system	2
Electric Circuits	Compulsory /Core	Lecture & MOOC & Experiments	Grasp the basic theory knowledge, analysis method and preliminary experimental skills	3
Fundamentals of Analog Electronic Technique	Compulsory /Core	Lecture & MOOC & Experiments	Cultivate the integrated ability of analyzing and solving problems in engineering practice	3
Specialty integrated Design	Compulsory /Advanced	PBL/CDIO	complete a complicated task with small budget as a student team	4

TABLE I. A PART OF BLENDED LEARNING COURSES IN THE IMPROVED TRAINING PLAN

II. DESIGN OF CURRICULUM WITH BLENDED LEARNING

As mentioned above, in order to ensure the sustainability of innovative education, rather than just in the form of an innovation course, the training plan are adjusted for which the courses of innovation and entrepreneurship are added into almost every grade. As shown in Table 1, in the first year, we mainly arrange general courses and basic skills courses. General courses are designed to give students a general understanding of the basic concepts of innovation and possible ways to start entrepreneurship work. While computer programming courses that do not need to rely on too much professional knowledge are designed to train students' basic skills. In the second year, we set up SPC (Small Private Course) courses for students of electronic and electrical majors. In our opinion, the second year of undergraduate is an important turning point. Since most of students begin to learn professional knowledge of their majors since grade 2. Those students who are interested in creative activities usually show a strong desire to pursue new knowledge and have strong willingness to devote more time to the SPC that is an extension of previous general courses. In the third and fourth years, we improve the course of specialty integrated design that is given an open task for every student according to the PBL concept. This course not only adopts flexible assignments, but also provides a certain amount of funding to give students' more freedom to realizing their design ideas. Other professional core courses, such as Electric Circuits, Analog Electronic Technique, are taught in both online and offline, and real engineering cases are added as teaching contents to cultivate innovation ability.

According to the different teaching targets, these courses adopt differentiated teaching forms, including MOOC, SPC, PBL, and so on, and form a combination of blended learning courses. Due to the large number of courses, representative courses of opening in different grades are selected as examples to illustrate these blended learning courses how to achieve the core mission of improving innovation ability.

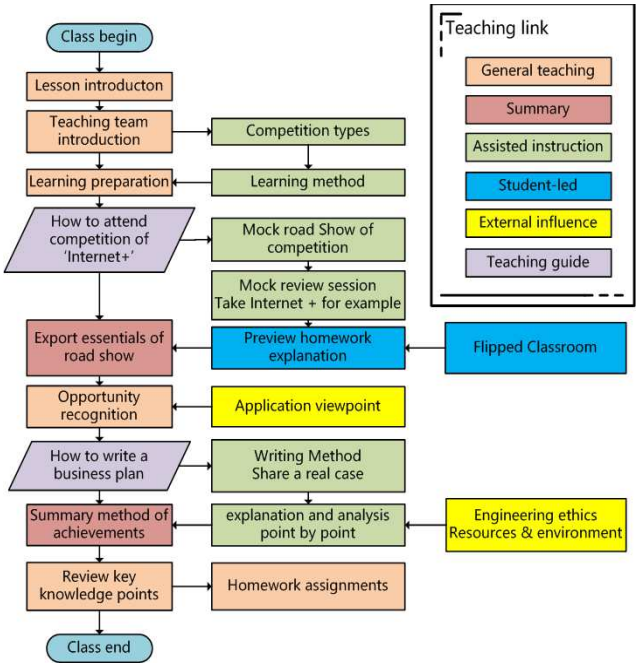

Fig. 1. The flowchart of an offline tutoring lecture of the course of Innovation & entrepreneurship

A. Innovation & entrepreneurship (I & E)

This course combines MOOC and offline tutoring to make students establish the basic concepts of innovation and entrepreneurship and accumulate relevant knowledge, after sorting out the basic problems of innovation and entrepreneurship. The content of MOOC is mainly systematic knowledge, while offline tutoring is responsible for the guidance of practical application. Especially in view of the China College Students' "Internet+" Innovation and Entrepreneurship Competition with shorten form of "Internet+", that is the most influential innovation competition in China for college students, the course has s special session about how students prepare for this competition. The winning teams who won the "Internet+"

competition are always invited to introduce their experience in the competition and their skills to win the favor of investors, as well as share documents and information on the road show when winning the prize. The Fig.1 below shows the specific arrangement of an offline tutoring class. As an example of classroom teaching, we comprehensively adopt two popular teaching methods, flipped classroom and case teaching, which achieve good teaching effects. Students listened more carefully and their participation increased greatly. The Fig.2 shows a Web's screenshot of the course's statistics. The line chart shows that students maintained a high learning enthusiasm throughout May, 2022, especially around the time when we conducted offline instruction.

Fig. 2. A screenshot of MOOC's website of I & E

B. *Engineering Practice and Innovative Design of Electronic Systems*

This course is aimed at enhancing student's ability of engineering practice of innovative design of electronic systems. As a SPC, there are about 30 students in each small class who are divided into 7-8 groups. For its project-based training and small class size, the teaching is mostly conducted in labs. And students can also make an appointment online to complete assignments in labs after classes. It gives students an open chance to stay in labs to study the way of engineering innovation.

In terms of teaching methods, the course also adopts a combination of online and offline means. Online teaching adopts semi-virtual system instead of simple software simulation. Students can remotely observe the waveform and measure its values at arbitrary probe points through cameras and real instruments to evaluate the performance of their circuit design, which is shown in the Fig.3 .In this course, students are additionally provided pocket boards[8]. Each student is given 1-2 embedded development boards so that students can easily design and develop any creation anywhere. Students need to submit a small creative work of their own design as one of course assessments. Fig.4 below is a small final work designed by students, which is a small coin exchange device. Users can exchange several coins as change by swiping their campus cards.

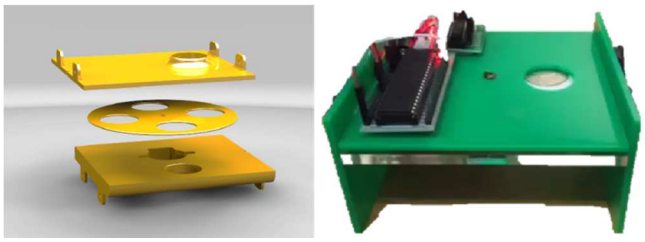

Fig. 3. A student's final assignment work

C. *specialty integrated design*

As a compulsory course, specialty integrated design is the last comprehensive practice in undergraduate education. This course is taught by using PBL (Project-Based Learning) that is one of popular blended teaching modes. In Fig.5, this course includes five important stages: Planning, Hardware & software design, Implementation & debugging, Networking & system testing, Summary & defense. In contrast to the traditional integrated design, our proposed course has been reformed in four aspects for the improvement of innovation ability. Firstly, students can set the design target by themselves under certain conditions of several main design elements, instead of traditional limited contents. Secondly, each team is given a certain amount of funds that is free for students to use. Thus, students are both project managers and executors, rather than just completing an experimental task. Thirdly, the course is completely in accordance with the process management mode of engineering projects. Each student in the team has his own task and needs to get used to communication and cooperation with teammates. Finally, the scoring method is based on the technical indicators proposed during the task planning period, and the one-time assessment is replaced by the process assessment.

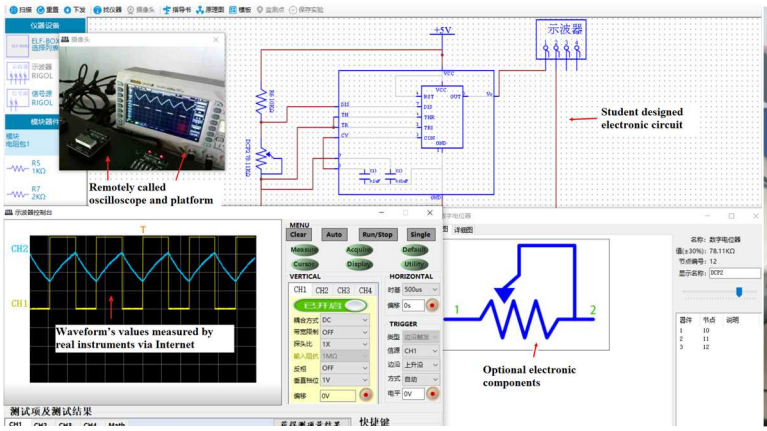

Fig. 4. The Remote online experiment interface (left) and the offline SPC (right)

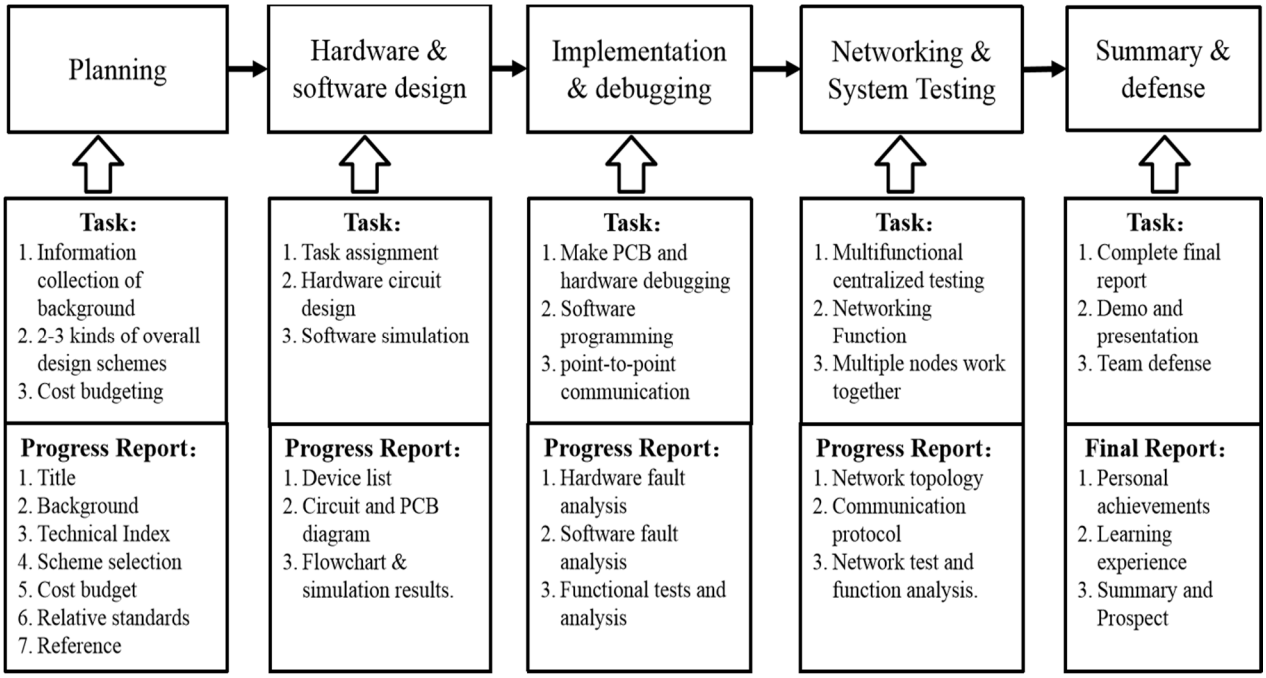

Fig.5. The improved specialty curriculum design with high freedom

III. THE AFFECTION OF PRACTICE

From 2016 to the end of 2021, at least three generations of students have gone through a complete teaching process. Based on six consecutive years of practice, students' innovative ability to deal with complex engineering problems has been significantly improved after the execution of the blended learning courses. The practical effect is reflected in at least these aspects.

1) The overall innovation ability of students has been improved. More enterprises recognize the professional knowledge and practical skills of our students. The preliminary employment rate of undergraduates in electronic engineering major was raised to over 95 percent. The electronic Engineering major has also successfully passed the international engineering education accreditation, which further improves the standardization and advancement of teaching.

2) The offering of courses indirectly drives students' interest in traditional basic courses of the electronic engineering major. Since students are aware of the fact that innovative ideas always come from the professional foundation. If they do not learn basic courses well, it is difficult to have any brainstorming, or have good ideas can not be realized. The examination results of the basic courses of electronic specialty were significantly improved. The number of students who scored 85 or more increased to about 18 percent from 10 percent, while the number of students who failed dropped to less than 10 percent from about 25 percent.

3) A number of outstanding students with top-notch innovation ability have emerged, who have achieved excellent results in typical discipline competitions, including China College Students' "Internet+" Innovation and Entrepreneurship Competition, National Undergraduate Electronics Design Contest, China Robot Competition, and so on. We analyze the teaching effect depending on the development of students who passed the blended learning courses. We choose the students who selected the course of Engineering Practice and Innovative Design of Electronic Systems 1 and 2 (EPIDES 1&2) as an example. The statistical results are shown in the Figure.6, in which the NSC is nearly stable around 30. We choose 2 important index, NSA and NSG, which are respectively about 50% and 40% in our College in recent 5 years, to show the effect of our blended innovative course. For the students who passed the EPIDES 1&2, the ratio of NSA and NSG is significantly higher than the average level. Although the statistical data include 6 years, the data in 2020 and 2021 looks obviously worse, since most of discipline competitions take place in the summer holiday and those students still in grade 3 and 4.

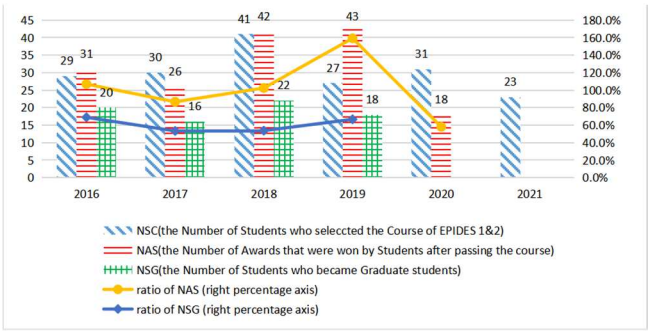

Fig.6. The statistical results of the development of students who selected one of our blended courses, EPIDES 1&2.

4) Only those students who can do well in traditional basic learning are likely to choose innovative courses. It takes a lot of time out of class for students who attend the innovation training to deal with those project-based learning. In fact, students who go through the entire innovation training program receive a scholarship 70 percent of the time.

In addition, the implementation of these works has brought an unexpected benefit.Thanks to the gradual introduction of advanced teaching tools such as MOOCs and

remote experiments since 2016 for education on innovation ability, the impact of COVID-19 on normal teaching order has been reduced, and students are still able to complete their studies smoothly and their skills have been well trained.

ACKNOWLEDGMENT

This work is partly supported by Excellent Teaching Team Project of Hunan Province, No.2019YXTD058; Graduate Education Reform Of Hunan Province, No.2019JGZD016; Hunan Academic Degree and Graduate Education Reform Project, No.2020JGYB056; and University-Industry Collaborative Education Program, No.202102504001.

REFERENCES

[1] Shanshan Li, Xiaojun Wu, Chengbin Quan, “Training students' practical and innovation ability in hardware experiment”. FIE 2017, pp. 1-5

[2] X. Liu, J. Song, Y. Qin, B. Zhang and W. Li, "The Educational Reform and Exploration of Data Communication Technology Under the Blending Model of School, Enterprise, Industry and Education," 2021 International Conference on Internet, Education and Information Technology (IEIT), 2021, pp. 35-39

[3] L. Singelmann, E. Alvarez, E. Swartz, M. Pearson, R. Striker and D. Ewert, "Innovators, Learners, and Surveyors: Clustering Students in an Innovation-Based Learning Course," 2020 IEEE Frontiers in Education Conference (FIE), 2020, pp. 1-9.

[4] R. Li and Y. Lou, "The reform and practice of the training of computer innovative talents based on SPOC teaching model," 2019 14th International Conference on Computer Science & Education (ICCSE), 2019, pp. 165-167

[5] C. Vignola, J. London, R. Ayala and W. Huang, "Cultivating an entrepreneurial mindset in an undergraduate engineering statistics course using project-based learning," 2017 IEEE Frontiers in Education Conference (FIE), 2017, pp. 1-4

[6] Y. Li, "On the Innovation of Blended Teaching Mode of New Engineering Based on “Artificial Intelligence +”," 2021 International Conference on Computers, Information Processing and Advanced Education (CIPAE), 2021, pp. 167-169.

[7] S. H. S. Ariffin and N. E. Ghazali, "Structured Techniques in New Academia Learning Innovation (NALI) for Professional Engineering Practices Course," 2017 7th World Engineering Education Forum (WEEF), 2017, pp. 904-909.

[8] O. H. Graven and J. Bjørk, "The use of an Arduino pocket lab to increase motivation in Electrical engineering students for programming," 2016 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), 2016, pp. 239-243