**Practical Curriculum Development for Application-oriented Undergraduate Education from the View of Maker Education**

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**Abstract.** The Maker spirit and Maker Education have made important sense on developing suitable practical curriculums and realizing the differential school characteristics for the application-oriented undergraduate universities. The relative background, idea and problems were discussed first in this paper. The practical course ‘Digital Medical Instrument Development’ for biomedical medical engineering of Shanghai University of Medicine & Health Sciences was referred as an example, with the teaching theories of ‘learning by doing’, constructivism and scaffolding instruction, to express the idea, objectives, project tasks and evaluation of developing an application-oriented undergraduate practical curriculum from the view of Maker Education, with the goal of making a relative realistic environment of developing medical instrument for students.

**Introduction**

Maker is defined as ‘people who make use of modern 3D printing technology and other open source hardware to realize all kinds of creative ideas without profit purpose’ in Chris Anderson’s book ‘Maker: the New Industrial Revolution’[1]. This word has been written in the government work report accompanied with the slogan ‘Encourage people to start their own business and to make innovations’, become a buzzword of NPC & CPPCC (National People’s Congress and Chinese People’s Political Consultative Conference) for a moment. When a chemical reaction happens between Maker spirit and education, Maker Education emerges, which mixes the ideas of project learning, experienced education, innovation education, etc. It is suitable for the strong curiosity and rich imagination of the students [2]. Maker Education emphasizes that the learner is also an inventor, and the studying process is also a creative one. It focuses on turning different ideas into reality and shares common goals with the application-oriented undergraduate universities on training students with creative spirits and solid skills.

Shanghai University of Medicine & Health Sciences (SUMHS) is a new established application-oriented undergraduate university. In order to develop the advance of medicine-engineering combination and medical technique in personnel training, and protrude the educating characters for the application-oriented medical talented persons, the SUMHS has explored the deep spirit of Maker Education, developed several special-designed courses which can make full use of students’ initiative, creative and practical abilities in studying procedure. The course ‘Digital Medical Instrument Development’ which is opened in the major of Biomedical Engineering by the school of medical instrument is one of these courses. According to the theory of ‘learning by doing’, all the lessons are arranged in the laboratory, structured based on the students’ practice. The course focus on forming the creative thinking and innovation abilities for students, meet the requirements of major and career simultaneously for achieving the goal of making students back to the natural learning process as soon as possible [3].

The concept of the application-oriented undergraduate universities is first announced explicitly in ‘The 12th Five-year Plan of National Education Career Development’ by Ministry of Education in 2012 [4], with the aim of training application-oriented and technical persons and starting relative scientific research and service. In the situation that many universities have established the same major, the application-oriented undergraduate universities have to design differentiated education
mode and make students have creative and practical abilities in order to realize dislocated
development with the researching or teach-researching type universities. One of the most effective
solutions is to developing creative practice courses with high quality and pertinence.

‘Digital Medical Instrument Development’, which is designed by the school of medical
instrument of SUMHS, is a creative practical course for students studying the major of biomedical
engineering. It is based on the course of the same name for the junior college major ‘Medical
electrical instrument and its Maintenance’ which is originally a national quality course. The
direction spirit of this course is the realistic requirements to technical persons in the medical
instrument industry, while the target is to make students have Maker spirits. In this course, the
teaching theory and practical principle ‘learning by doing’ is fully run, the course architecture is
structured by students’ activity to gain the direct experience as the core value. Students achieve the
learning strategies, way of thought and studying customs by observing, thinking, experiment and
exploring in the professional scene specially designed for application-oriented persons.

Theory of Maker Curriculum Development

The ‘Learning by Doing’ Mode

The educating mode ‘learning by doing’ is referred by John Dewey more than one hundred years
ago, of which the basic principle is design the lessons by students’ activities. Its core spirit is to gain
the direct experience. In the simulating professional environment, lessons are organized by all kinds
of students’ doing—observation, experiment, exploration, operation and game [5]. The Maker
Education focuses on the ‘learning by doing’ mode mainly based on the topic study, and make
improvements on basic skills studying training, simulation project, creative topic exploration [6]. As
a creative Maker Education course, ‘Digital Medical Instrument Development’ is designed based on
the ‘learning by doing’ mode, by means of developing a real and complete medical instrument
project, which are divided into several topics to lead the students activities. It can make an
environment for students to understand the basic technology, professional skills, relative theories
and working process. Finally, students will achieve the professional integrities, such as being brave
enough to innovate, excellent communicating skills and doing well in team cooperation.

The Constructivism

The constructivism theory in education emphasizes that students are the main part in the learning
process, which is positively creative, based on the original knowledge background, experience,
psychology development and cognitive structure. Constructivism has announced that students are
the leaders in study, who need to be enthusiastic enough to learn, to explore, and to build a
knowledge system. It should drop the traditional teaching method that teachers are the center of
class, while knowledge is passed on to the students passively. Teachers are encouraged to change
their roles played in the teaching procedure, to become a guide and companion to make students
understand and digest information they receive, and construct the knowledge system. The theory
has a positive sense for developing the practical curriculum based on the Maker spirit. In the class
of the course ‘Digital Medical Instrument Development’, teachers lead students to learn by
themselves positively, let them be the major of the lessons. The teaching progress is designed as
topic tasks, in which students are encouraged to observe carefully, think separately, and work
together to analyzing and solving problems in order to improve their abilities on observing, thinking,
judging, analyzing and solving problems significantly. After study the course, students can make
full use of the theories and methods to recognize, analyze and handle the smart device controlling
problems in medical instrument development flexibly.

The Scaffolding Instruction

The function of Scaffolding Instruction is to supply a concept framework which is necessary for
understand the knowledge to be constructed. The concepts in this framework are a necessity for
help learners understand the questions they are studying further. Hence, the complex study tasks
need to be decomposed for leading learners to understand deeply step by step [7]. The teachers supply many kinds of scaffoldings to promote the interaction between teachers and students, especially the interaction between one student and his partners. The Scaffolding Instruction mode usually contains five segments: First, build concept frameworks according to the current learning topics. Second, guide students into a certain problem situation. Third, let students explore separately, teachers may give some tips at a proper time. Fourth, students consult and discuss to understand all the contents they have learned completely. Five, evaluate the study effect, including students’ self-evaluation and the individual assessment by the whole learning team.

During the teaching process of the course ‘Digital Medical Instrument Development’, according to requirements of the training plan, teachers supply the real developing environment of the medical instrument with different questions for students, and build some most suitable forms of scaffoldings based on the solving problems and completing tasks to be some developing learning tasks. Through finishing these tasks, students’ level will be higher on the amount of knowledge and ability of giving solutions.

Development of the Course

Course Target

(1) Knowledge and skills
Students can solve actual problems by comprehensive technical applications of single chip microcomputer, C program design, analogous circuit, digital circuit, biomedical sensors, understand the working principle and structure of digital medical instruments, know the developing progress, project allocation, design and realization of digital medical instrument products well. In addition, they will be familiar with the ways of debugging the software and hardware of digital medical instruments.

(2) Method and process
Through dividing a complete developing program of digital medical instruments into several module tasks, students study and explore voluntarily to complete these module tasks step by step. They can achieve the creative abilities, such as understanding faculty, perception, creativity and so on, by a series of practice, like observation, thinking, design, manufacture and experiment. Besides, they can enlarge and update their knowledge system gradually during the procedure of communicating and interactive learning with teachers and students.

(3) Professional accomplishment and attitude
The course supplies a real environment of developing medical instrument products, students can actually find the promotion which digital medical instruments bring to the development of modern medicine, and the reform of human healthcare industry. They can also gain good professional accomplishment in the career of biomedical engineering research and medical instrument development, and the working attitude, such as brave to explore and positive to practice.

Design tasks of Maker Course Projects
The lesson periods of the course ‘Digital Medical Instrument Development’ are 96 in total, 8 lesson periods every week. All the lessons are given in the ‘Digital Medical Instrument Open Laboratory’, which is different from ordinary labs. The laboratory is open to all the students who study this course in spare time, besides for finishing the normal experiment tasks. Faculty advisers and office hours are arranged at fixed time every week. Students are able to search materials, simulating circuit, discuss in groups, set experiment platform, etc. In addition, mobile social apps, such as WeChat, are utilized to organize communication groups for students sharing learning experience, discussion and materials instantly. In the meantime, teachers will introduce students to join the chat groups established by medical instrument manufacturers in order to receive frontier industrial knowledge and technology.

The overall task of the course is to design and finish a simple-functional electrocardiograph (ECG) device based on the knowledge and technique, such as, single-chip microcomputer,
analogous circuit, digital circuit and C program etc. The reasons for choosing ECG device as the object to learn are: (1) the ECG device is one of the most typical digital medical instruments, which is common in cardiac disease diagnosis. (2) It is suitable for undergraduate students to study and improve by themselves because of its mature technology, moderate difficulty, wide application and rich in references. According to the developing process of ECG device, the contents are divided into several task modules. The core knowledge contents of each module task are designed closely according to the request of Maker Education, and mix the knowledge and strategies students need to master into the well-designed tasks. Students finish these rich-challenging tasks, find and master the digital medical instrument developing procedure, taking the ECG device as the typical example during the process of ‘learning by doing’. Finally, the whole course frameworks designed and guided by teachers are completed for developing digital medical instruments.

Each module task is in moderate difficulty to promote students’ positivity on studying and researching. By reading references, thinking individually and working in team, students start project research, in Figure 2. Teachers guide them to explore and design different kinds of solutions to complete the same task, encourage sharing their experience, for example, in the project ‘Single-chip microcomputer cannot recognize ECG signal, what to do? – A/D converting’, after reading teaching material and searching references, students decide to adopt the 8-bit chip ADC0809 which is commonly used as the Analog / Digital (short for A/D) converter. But when students want to detect the completing signal of converting EOC based on single-chip microcomputer, they refer three kinds of plans: program query, delay and interruption. At the moment, teachers can encourage them to consider the advantages and disadvantages of these plans by considering the actual usage, for example, CPU load, converting speech, port occupancy etc. The best decision will be made after communicating and sharing experiences. Through a series of studying projects, students not only enhance their understanding of the professional knowledge and its application, but even master the basic thought of judging right or wrong and optimizing the plans. They can enjoy a real and vivid period of experience on the development of medical instruments.

**Course Evaluation**

Developing the application-oriented undergraduate practical courses from the view of Maker Education, the evaluation method should be focused on the forming the students’ creative sense, promoting the ability of practice and raising the scientific professionalism. It need not only evaluate the study effects, but also do a comprehensive assessment of the periodical effect in the study process. Teachers should encourage students to complete the following requires in each project: 1) Writing study notes to record the key knowledge points, and the questions, ideas about answering the questions and the multiple ways of getting answers during the procedure of studying and exploring. 2) Recording the process of developing the medical instruments by shooting videos and WeChat sharing, and uploading to the popular video website or chat group of studying the course or designing medical instruments to share technical experiences and studying notes with teachers and class. 3) Finishing a complete developing report, by means of succinct words to integrate all the achievements and introduce the self-made digital ECG device, of which the functions, usage method, technical characters and parameters are concluded. Teachers should inspire students pay attention to the user experience and merge into the developing process of medical instruments truly.

**Conclusions**

‘Encourage people to start their own business and to make innovations’. The key word is ‘innovation’. The course ‘Digital Medical Instrument Development’ take a response on outstanding the school characteristics of the biomedical engineering major in Shanghai University of Medicine & Health Sciences. It is also a practical course of training technical persons and talented Makers who are badly needed in the industry of medical instruments. In order to change the traditional teaching mode, encourage students to have Maker spirits, positive and enthusiastic characters on studying, this course has made an exploration in the Maker Education of university engineering teaching. As a major core course, ‘Digital Medical Instrument Development’ takes the idea
‘everywhere can be creative space, every time can be creative moment, everybody can be Makers’ as the training purpose, makes full use of the present teaching resources in the limited conditions to raise the quality of training talented persons. Though there are still some difficulties, we are confident that there must be a best way to have the Maker Education plays the most important role in the teaching career of application-oriented undergraduate universities by the constant research and exploration.

References