

Teenagers' STEM-based Innovative Courses Design

Jun He
College of Information Science
and Technology
Beijing Normal University
Beijing, China
hejun@bnu.edu.cn

Xiaocui Yu
College of Information Science
and Technology
Beijing Normal University
Beijing, China
xiaocuiyu@126.com

Xiaoming Zhu*
College of Information Science
and Technology
Beijing Normal University
Beijing, China
zxm@bnu.edu.cn

Bo Sun
College of Information Science
and Technology
Beijing Normal University
Beijing, China
sunbo@bnu.edu.cn

Qingmei Cheng
Beijing Information
Technology College
Beijing, China
Chengqm@bitc.edu.cn

Junchao Gui
Beijing Jingshihui Technjology
Co., Ltd.
Beijing, China
jchgui@139.com

Abstract—Recently, interdisciplinary education has been the trend of the education curriculum reform. In this paper, we report on the thought of teenagers' STEM-based innovative courses, which aim at developing students' scientific literacy and creative creativity through hands-on practice. Researching on project-based teaching methods, we have designed innovative design courses for the grade three to six based on the primary curriculum standards for science and information technology of China in 2012. With Arduino and 3D printing, a set of complete STEM-based innovative courses around smart homes has been produced. Its evaluation and assessment methods have also come up, which are the feedback of students' ability. The paper shows the main thought and some typical examples integrally.

Keywords—STEM, innovative course, primary, evaluation, curriculum standards

I. INTRODUCTION

The goal of teenagers' STEM education is to cultivate the 4C core competencies required for talents in the 21st century, namely Innovation and Creativity, Critical thinking, Communication and Collaboration [1]. Many educators are trying to improve the students' capabilities in thinking and creating new ideas [2]. Therefore, how to devise STEM-based innovative design course has been one of the hot topics in educational circles. On the other hand, class evaluation and final assessment are an important part of courses and an effective way to promote students' ability and teaching quality. It is necessary to design a very evaluation and assessment method.

In recent years, STEM education has developed rapidly. Much more middle schools have STEM courses and many STEM-related products have been poured into the market, typically like Lego Building Blocks [3], Capability Storm Products [4] and Arduino. Teenagers' STEM education in China is still not mature. It is necessary to develop a set of teenagers' STEM curriculums according to the basic knowledge.

The work reported in this paper is aimed at a set of different levels of elementary STEM-based innovative courses according to the science and information technology

curriculum standards for primary schools. Furthermore, detailed teaching methods, students' evaluation and assessment contents and methods are also necessary.

The remainder of this paper is organized as follows. Section 2 presents STEM-based teaching methods. Section 3 analyzes primary curriculum standards for science and technology, and designs different elementary grades innovative course. Section 4 presents complete evaluation and assessment contents and methods. Section 5 presents concluding remarks.

II. STEM-BASED TEACHING METHODS

As a comprehensive course, there a variety of teaching models, such as exploring method, experimental method, group cooperative method, and so on. Courses provided in this paper is based on the group cooperative Project Teaching. As shown in Fig 1, teachers would firstly create project-related lift situations to simulate students' interest, then guide them to research and identify problems. Next, Students need to learn and master the principles of various disciplines involved in the project, and then establish models, which would be tested and verified by group work. In the last, students should give a report or summarization on what they have done, which may reflect and expand what they have learned [5] [6]. Therefore, a well-designed STEM courses should connect abstract knowledge with students' life. The project-based teaching method is suitable since it motivates students' ability to solve problems and creativity.

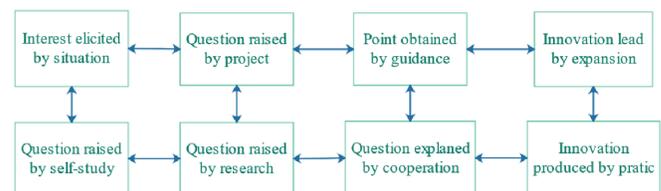


Fig. 1. Teaching method

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III. STEM-BASED INNOVATIVE COURSES

According to the primary curriculum standards for science and mathematics, students are required to observe phenomena, measure objects, predict results, design surveys, collect data, compare results and draw conclusions [7]. In other words, students should have ability to discover problems, make assumptions, design experiments and establish models, to solve problems and draw conclusions. Science courses designed for all grades of primary school include basic physical knowledge of matter, energy, force, movement, power and machinery, electricity and magnetism [8]. On the other hand, according to the technology curriculum standards, besides the basic function of commonly used sensors, programming ability in graphical environment is required. We have designed a set of courses centered on smart home, which includes door bell, infrared alarm, sound control lamp, smoke alarm, variable speed fan, password lock, temperature and humidity display screen, intelligent curtain, alarm clock, mechanical porter, automatic plant watering device, and pet and so on [9,10]. And Arduino, and 3D printing are used as teaching aids. The thought of designing specific curriculums is depicted as follows, whose typical examples are also given.

A. Course for Grade Three

For the third grade students, the goal of the course is to train their hands-on ability and cultivating students' scientific literacy and logical thinking.

In order to inspire their interest and enthusiasm, we have designed some cases with simple function, with which students may understand the environment of intelligent controlling by initially contacting Arduino. What's more, the concept of circuit loop and its working principle are also the destination of this stage. For example, students can make flashing lights and breathing lamps by LED lamp. In this process, they may know about the control principle of LED lamp and the working principle of delay module by changing the parameters, observing experimental phenomena and comparing the results. At the same time, the concept of energy conversion will be transformed to them.

B. Course for Grade Four

Because students of the grade four gradually have independently thought, on the basis of Grade three, we have added sensors to the content of the courses of this stage, whose function are compared with humans'. So that, they can understand the basic meaning of robot instructions, programs, algorithms, and the flow chart of simple robot programs. In this stage, programming has been introduced with graphical modular programming tools. By designing simple programs, downloading them to the controller and finally observing it executing, they can understand the function and importance of the control system [11].

For example, students can make acoustic control lamp. In this process, they may know about the principle of sound production and the transmission process of human ears. They can understand concepts of voice loudness, pitch variation and voice frequency by experiment. They would learn to use serial monitor and master programming with conditional statement.

C. Course for Grade Five

According to the research verdict of the famous psychologist Jean Piaget, the fifth grade students have reached the stage of formal operations (Formal Operations Stage, 11, 12 and later) [12]. During this period, students can make abstract logical reasoning, make hypothesis deductive reasoning, seek the reality in the possibility, and find the correct answer. Students have a certain understanding of the application of sensors and simple logic. Therefore, the curriculums designed for this grade aims to strengthen the ability to complete complex programming, and solve more complex life problems.

For example, students can make time controlled curtain, which composed of some subroutines, like clock setting, curtain opening and closing and so on. They may learn to use buzzer, digital tube and steering gear and other sensors together. It is a complex engineering.

D. Course for Grade Six

Engineering is the general term for the complete practical activities and processes in human transformation of material nature, whose purpose is to produce specific products [9]. On the basis of former training, the courses designed for this stage require students to design and complete the whole project by themselves, which may test their mastery of the previous learned content and the ability to design and solve problems by hand.

For example, students can make mechanical porter, which can carry something with specific size to somewhere by infrared remote control. They need to draw complex flowcharts firstly and then stitch model by 3D printing blocks. In this process, they should think and design actively to solve problem.

IV. EVALUATION AND ASSESSMENT METHOD

Evaluation and assessment are important, which benefit teachers and students both. The results can feedback students' understanding on knowledge, programming logic, and completion of tasks, so that teachers can make timely adjustments on the next course to ensure the quality of teaching. In other ways, the evaluation on students' learning ability and innovative talents promotes the establishment and development of students' scientific literacy [13].

A. Evaluation and Assessment Principle

The goal of STEM-based innovative design course is to cultivate students' innovative spirit and practical ability. Therefore, the evaluation and assessment method should emphasize process, experience and participation of the whole staff. It is mainly teacher evaluation, which includes class process and course final evaluation.

B. Evaluation and Assessment Method

Students need to innovatively design robot to complete project. The method for class process evaluation is shown in Table I. It is a comprehensive evaluation on students' learning attitude, task participation, project completion and knowledge

understanding. Teachers need to ask each group member questions to know his mastery level, and then evaluate whole work. The course final evaluation is mainly focusing on the completion of the project. The evaluation method is consistent with the curriculum evaluation.

TABLE I. EVALUATION CONTENTS AND METHOD

Evaluation Contents	Evaluation Method
mastery of subject knowledge	ask each group member questions
understanding of program logic	modify program parameters, predict experimental results
participation of projects	complete project content
learning attitude	whether communicate in class, listen carefully and take notes, do something unrelated, ask questions actively

V. CONCLUSIONS AND FUTURE WORK

In this paper, a set of complete solution to STEM-based innovative courses and evaluation method for primary grade three to six are produced. With the research on the primary curriculum standards for science and mathematics, we have designed courses modeled on Smart Home System and teaching aids based on Arduino and 3D printing. Considering the learning ability and logical thinking ability for different grade students, the innovative courses is classified to different levels. The teaching method presented is suitable to arouse students' enthusiasm and innovation. The evaluation and assessment methods are comprehensive, including students' knowledge understanding, task participation, project completion and learning attitude. In the future, we will put them into practice, and optimize them via introducing some artificial intelligence thoughts and technology.

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