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SPIED: an international maker education practice of China, Japan and Korea

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ABSTRACT: Maker education is an ideal way for cultivating high-qualified talent that possesses an innovative spirit, multi-discipline knowledge and creative capability. Since 2013, a programme named *The Summer Programme on Innovative Engineering Design* has been held by several universities of China, Japan and Korea, including Jiangsu University, Yamaguchi University, Kunsan National University and others. This programme is a two-week international maker education project for undergraduate and graduate students, and its target is to improve students' ability in the aspects of innovation, creation, sharing and cooperation. After four years' successful practice, it has gradually become a regionally-famous international education project in East Asia.

INTRODUCTION

Maker is a hot word for current East Asia, and it represents a group of people that devote themselves to transform a variety of innovative ideas into reality only out of interest, and by sharing their creativity with the public [1]. Maker education aims to cultivate students with innovative ideas, interdisciplinary knowledge and practical ability. In essence, maker education and innovation education are in the same strain, and maker education supports STEAM education and *vice versa* [2][3].

For innovation education, maker education has the same cultivation goals that is try to promote innovative consciousness and innovation ability in the learner. However, maker education is more focused on practical education and it can be regarded as an effective way to implement innovative education. STEAM education emphasises the study and integration of multidisciplinary knowledge, which is also the key point of maker education.

As the main characteristic of maker education, transforming ideas into objects needs the support of multidisciplinary knowledge, so STEAM education can provide a knowledge base for maker education. Innovation, creativity and knowledge integration are presented in maker education, and in the direction of current higher education, furthering and deepening maker education is a benefit for improving the quality of talent training, and meeting the social requirements of talent with innovative spirits, professional skills and high practical ability.

Since 2013, several universities in China, Japan and Korea including Yamaguchi University, Jiangsu University, Kunsan National University, Chungbuk National University, Chonbuk National University and others, began to implement a series of international education cooperation projects, and launched a positive exploration for international maker education practice. Within these cooperation projects, the Summer Programme on Innovative Engineering Design (SPIED) is a typical representative of maker education [4][5].

SPIED has now been successfully held for four years, the total number of participant students is close to 300, and it has gradually become an influential international innovation education cooperation project in East Asia.

BRIEF INTRODUCTION OF SPIED

The training target group of SPIED is senior students and first-year graduate students with majors in mechanical engineering, electronical engineering and computer science. The teaching team considers that the majority of industrial products are composed of mechanical parts, electronical parts and software systems, so the innovation design must be a collaboration between students with these three professional backgrounds.

The SPIED period is two weeks, including one week of comprehensive knowledge teaching and one week of team innovation practice. It is held in the last two weeks of August, and is hosted by universities of three countries in turn. During SPIED, English is used as the language of communication. Students in different majors from different countries are divided in several groups to engage in creative activities in order to achieve the intermingling of multidisciplinary knowledge and promotion of team awareness. The implementation of SPIED over the past four years has been as shown in Table 1.

Table 1: Basic information on SPIED.

Project name	Host university	People involved	Participating universities	Maker space facilities
SPIED 2013	Yamaguchi University (Japan)	CN: 19	Jiangsu University Chongqing University of Technology	Lego NXT robot
		JP: 18	Yamaguchi University	
		KR: 11	Kunsan National University University of Seoul	
SPIED 2014	Jiangsu University (China)	CN: 32	Jiangsu University Dalian University of Technology Chongqing University of Technology Xihua University	Arduino development kit Fischer robot
		JP: 22	Yamaguchi University	
		KR：20	Kunsan National University University of Seoul Chungbuk National University	
SPIED 2015	Kunsan National University (Korea)	CN: 15	Jiangsu University	Arduino development kit 3D printer
		JP: 15	Yamaguchi University	
		KR: 43	Kunsan National University University of Seoul Chungbuk National University Chonbuk National University	
SPIED 2016	Yamaguchi University (Japan)	CN: 34	Jiangsu University Chongqing University of Technology Xihua University	Arduino development kit 3D printer Lego EV3/NXT robot
		JP: 27	Yamaguchi University Kyushu University of Technology	
		KR: 37	Kunsan National University University of Seoul Chungbuk National University Chonbuk National University	

The implementation of SPIED is carried out according to the following rules:

1. Grouping rule. Each group includes 3-5 students, with at least one student from China, Japan and Korea, respectively, and at least one student majoring in mechanical engineering, electronical engineering or computer science. Under this grouping rule, students can benefit from collaboration with students with a different major and cultural background and by strengthening their international communication skills.

2. Teaching rule. The teaching content covers the basic knowledge of mechanical system design, electronic system design and software development. The teaching work is coordinated by professors from three countries. Because the teaching is limited to one week, the authors have adopted an on-line - off-line hybrid teaching method.

3. Innovative practice rule. During one-week maker practice, each team should follow a theme (such as smart home, intelligent campus, aging society, etc) to realise an intelligent device. The innovative design idea must be proposed by the students themselves and will be evaluated by a team of professors. After passing an evaluation, each team should convert its idea into a physical device and, then, show the team work to all professors and students on the final day of SPIED.

EDUCATION PROCESS DESIGN

Following the typical stages of maker education, the SPIED project is also designed from three aspects - construction of maker space, basic knowledge teaching and extensive maker training. Considering that the majority of current innovative works are comprised of mechanical systems, control systems (such as a microcontroller, PC or ARM controller) and remote clients (a mobile phone or tablet); hence, one constructs maker space and designs teaching content according to this conception in SPIED.

MAKER SPACE CONSTRUCTION

A maker space provides a field containing infrastructure and development devices for teaching and practice. The SPIED project requires organisers to provide a field with a wireless network, enough power supply interfaces, development devices and projection device for at least 80-100 students. Table 1 lists the development devices of maker space provided in previous SPIED, including a Lego robot, a Fischer robot, Arduino development kits and a 3D printer. Mechanical parts of the Lego or Fischer robot, and the 3D printer can provide different mechanical components, simple or complex or custom-made, to meet the requirement of mechanical system design for students' works. The controller of Fischer robot or Lego robot, and Arduino kit can provide basic or advanced control system development for students. Combined with students' own Android phones, devices shown in Table 1 can realise most intelligent applications.

BASIC KNOWLEDGE TEACHING

Basic knowledge teaching is a necessary part of maker education - even if the participant groups are graduate level, they may not have enough knowledge and skills for innovative development. The teaching content of previous SPIEDs is shown in Table 2. The content includes mechanical system design, electronic system design, Android programmes development, and one or two control system development courses (for the development platform in a given year).

Table 2: Course list of previous SPIED.

SPIED 2013	Mechanical system design, electronic system design, Android programming, introduction of Lego Mindstroms control
SPIED 2014	Mechanical system design, electronic device design, Android programming, microcomputer software development, mechanical and control system design with Fischer robot, design and development of smart house, run-to-run control in high-mixed manufacturing process, machine vision and its application
SPIED 2015	Mechanical system design, electronic device design, Android programming, development tools of RoBoRoBo kits, microcomputer software development, 3D printing design, innovation applications system design
SPIED 2016	Mechanical system design, electronic device design, Android programming, Lego Mindstroms control, Arduino programming, 3D printing design, some special topics

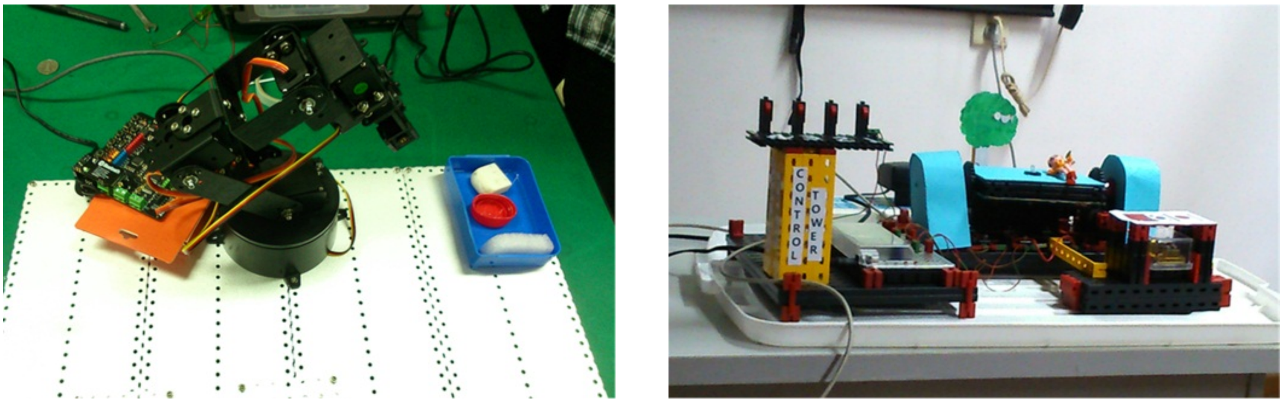
Since 2015, 3D printing technology has been adopted as a required course. The courses above have provided powerful knowledge and skills support for maker design. Due to the fact that the teaching time of each course is limited to three or four hours, the course can only be taught around the key knowledge and, then, the students need to learn details by themselves after class. The SPIED teaching team has built an on-line teaching platform based on Moodle for carrying out on-line - off-line hybrid education. Based on the teaching of basic curricula, some special reports of about two hours' duration focusing on the hot spots in innovative research are provided, to expand the innovative view for students.

MAKER EXTENSIVE TRAINING

Extensive training requires around four-five days for innovative team work. Considering that learning by doing is the typical feature of maker education, extensive training is a key part of SPIED. At this stage, teachers first guide all students to do a half-day of brain storming to train their innovative thinking ability. After that, student teams conceive ideas on their own, according to a certain theme, then, student teams are required to accomplish a presentation to report their primary designs a team of professors. The report content must include background, existing problem, innovative points, technologies, feasibility and expected results.

After the presentation, the team of professors evaluates the idea and design scheme, then, gives some suggestions. The evaluation is repeated several times until the design solution is fixed. Finally, the student team must complete their works within two-four days. The last day of SPIED is dedicated to a final report, and each team has 20 minutes to show their results, and to elaborate on design ideas and processes.

Over the past four years, the student teams of China, Japan and Korea participating in SPIED, have designed many intelligent innovative works from different major backgrounds. Figure 1 shows two typical design works of SPIED: one is a robot for filling prescriptions and the other is a smart outdoor bench with a retractable roof. The first work can automatically take traditional Chinese medicine using a mechanical arm according to the prescription inputted into an Android phone. The second work can automatically adjust its roof according to the outdoor environment and the roof can be also controlled using an Android phone. Although these two works seem a little simple, students already experience an entire design process as a maker during one week's practice. The photos of this project and each team work can be seen on the official Web site of SPIED.



a) b)

Figure 1: Two typical design works of SPIED: a) a robot of filling prescription, b) a smart outdoor bench.

CONCLUSIONS

The training target group of SPIED is senior students and first-year graduate students whose major is in mechanical engineering, electronical engineering or computer science. The teaching team considers that the majority industrial products are composed of a mechanical part, an electronical part and software systems, so the innovation design must be a collaboration between students with these three professional backgrounds. The SPIED lasts for two weeks, including one week of comprehensive knowledge teaching and one week of team innovation practice. It is held in the last two weeks of August, which is hosted by universities of the three countries in turn. During SPIED, English is used the communication language. Students in different majors from different countries are divided in several groups to engage in creative activities in order to achieve the intermingling of multidisciplinary knowledge, promotion of team awareness. The implementation of SPIED over the past four years are shown in Table 1.

As a maker education project, innovation, creation, sharing and collaboration, are the typical characteristics of SPIED. Nowadays, SPIED is one of few international graduate maker education activities for East Asia. By participating in SPIED, students from China, Japan and Korea can have two weeks' opportunity in which they can cooperate with foreign students. They can improve their English communication and expression ability, master several development skills preliminarily, learn about complementarity in several professions and experience the entire process of maker design. Even if not every team's work has theoretical depth and could be further extended as a research topic, but the participation of SPIED is still a good short-term learning project.

After this summer project - SPIED, there are also other two projects that are collaborations between Jiangsu University, Yamaguchi University, Kunsan National University and others, including an International Conference on Innovative Application Research Education (ICIARE) and a Creative Engineering Design Competition (CEDC). These two activities are held in December of every year. CEDC 2015 was held in Jiangsu University, and the participants came from 12 Chinese universities, four Japanese universities and seven Korean universities. More than 260 teachers and students took part in this project. CEDC 2016 was held in Chonbuk National University, and the number of participants was also more than 250. Today, SPIED, ICIARE and CEDC have attracted more and more attention from universities in China, Japan and South Korea, and become a pageant of innovation education in East Asia.

In future, the teaching team of SPIED will try to explore further how to strengthen scientific research cooperation between universities of the three countries and to build a strong long-term international student group.

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