Novel Industry-University Engineering Education Cooperation Practice: Open Summer School 2018 co-organized by SEU, Xilinx, and ICisC

Prof. Yongming Tang, Southeast University

Prof. Yongming Tang has get the bachler, master and Ph.D degree from School of Electronic Science and Engineering of Southeast University in Nanjing, China. He became a teacher from 1998. Now he is the deputy dean, who is working on the curriculum for undergraduate students. He also organizes the FPGA Design Contest in Southeast University every year.

Mr. Jiahua Lu, Xilinx

Jiahua(Joshua) Lu is the manager of Xilinx University Program in Greater China, he is responsible for Xilinx technology academic collabortion in this region. He published 2 textbook about using NetFPGA, Zynq platform in chinese.

Yanfang Deng, Nanjing Integrated Circuits Industry Service Center
Dr. Susan M. Lord, University of San Diego

Susan M. Lord received a B.S. from Cornell University and the M.S. and Ph.D. from Stanford University. She is currently Professor and Chair of Integrated Engineering at the University of San Diego. Her teaching and research interests include inclusive pedagogies, electronics, optoelectronics, materials science, first year engineering courses, feminist and liberative pedagogies, engineering student persistence, and student autonomy. Her research has been sponsored by the National Science Foundation (NSF). Dr. Lord is a fellow of the ASEE and IEEE and is active in the engineering education community including serving as General Co-Chair of the 2006 Frontiers in Education (FIE) Conference, on the FIE Steering Committee, and as President of the IEEE Education Society for 2009-2010. She is an Associate Editor of the IEEE Transactions on Education. She and her coauthors were awarded the 2011 Wickenden Award for the best paper in the Journal of Engineering Education and the 2011 and 2015 Best Paper Awards for the IEEE Transactions on Education. In Spring 2012, Dr. Lord spent a sabbatical at Southeast University in Nanjing, China teaching and doing research.

Novel University-Industry Engineering Education Cooperation Program: Open Summer School co-organized by SEU, Xilinx and ICisC

Authors: Yongming Tang[1], Joshua Lu[2], Yanfang Deng[3], Susan M. Lord[4]
Author Affiliation：1. School of Electronic Science and Engineering, Southeast University, Nanjing, China, tym@seu.edu.cn; 2. Xilinx co., Shanghai, China, joshua.lu@xilinx.com; 3. ICisC, Nanjing, China; 4. University of San Diego, slord@sandiego.edu;

Abstract
Partnerships between universities and industry can help provide engineering students with education, hands-on experiences, and skills needed to become successful professionals. This paper describes a summer school offered as an alternative to an internship for undergraduate and graduate engineering students as part of a university-industry-government collaboration in China. Many Chinese colleges and universities are still troubled by the lack of effective internship resources, lack of opportunities to study new technologies directly from industry, and the poor continuity of university-industry cooperation projects. This paper describes the first offering of an open FPGA summer school led by Southeast University, Xilinx, and ICisC, a government based industry service company. The summer school was held for 15 consecutive days in July 2018 in Nanjing. It included two stages: technical training and project development. Xilinx provided the training content and training instructors. Southeast University provided event planning and some training instructors. ICisC provided the venue and logistical support. The summer school provided participating students with the latest industry technical training and real industry engineering projects, which can effectively expand their understanding of the industry and cultivate their practical and teamwork skills. 96 students from throughout China completed the entire program. Feedback from a survey at the end of the summer school showed that more than 70% of the students were highly satisfied with the program overall, the projects, and the environment. Students were enthusiastic in their support for the program with 77% wanting to participate in follow-up activities and 87% willing to recommend such activities to their teachers and classmates. This program is a good example of a successful university-industry-government partnership to provide an alternative internship experience for students that could serve as a model for other universities with similar aims.

Introduction

The importance of university-industry partnerships has been recognized in engineering education throughout the world. For example, the American Society for Engineering Education (ASEE) has a division devoted to College Industry Partnerships [1] and sponsors an annual conference on Industry and Education Collaboration [2]. Many ways to develop partnerships between universities and industry are described in the proceedings from this division and conference with a focus on the United States. We highlight a few efforts here. Aggarwal described a partnership between a US university and General Electric (GE) Transportation for graduate students that provides an internship that is half-time during the academic year and full time in the summer [3]. Berkowitz and colleges describe a partnership between a US university and the USA National Aeronautics and Space Administration (NASA) aimed to help recruit women and minorities to

engineering [4]. Dallas and colleagues describe a long-standing partnership that provides internships for undergraduate and graduate students within the semiconductor industry [5].

Outside the US, there are many other successful university-industry collaborations, some of which are international involving multiple countries. For example, Woolgar examined the policies promoting university-industry links in Japan [6]. Xuehong and colleagues reported on an industrial internship program for environmental engineers in Western China [7]. Larsen et al. describe a summer school held at a company in Denmark which brings together undergraduate and masters students from different countries throughout Europe and from different engineering majors to work on multidisciplinary projects and develop professional skills [8]. Texas A&M University in the USA has developed international internships to facilitate engineering students' having experiences outside the USA [9]. In Australia, the Royal Melbourne Institute of Technology (RMIT) established the RMIT International Industry Experience and Research Program (RIIERP) in 1992 to facilitate students' international internships to better prepare them for the global context of engineering work [10].

Another way academic and industrial partners can collaborate is through summer schools devoted to a particular technical area. An excellent example is the LASER summer school offered since 2004 where international experts in software engineering from across the world deliver lectures to industry professionals as well as PhD students [11]. The IEEE Magnetics Society sponsors an annual Summer School for graduate students [12]. The IEEE Computational Intelligence Society holds an annual Summer School for undergraduates, graduate students, post-docs, and young researchers [13]. The focus of these schools is typically on education on the latest technology rather than projects.

The project described in this paper is a university-industry-government collaboration in China. The partners worked together to offer a summer school as an alternative to an internship for undergraduate and graduate engineering students throughout China. The summer school includes education as well as practical experience with current FPGA technology. This innovative partnership can serve as a model for other programs with similar aims.

Context of China
To better prepare students for the fourth industrial revolution including big data, cloud computing, and intelligent manufacturing, the Chinese government has proposed the "New Engineering" series of educational reform projects to improve the quality of professional personnel training, including the Excellent Engineer Training Program, Engineering Education Accreditation, Industry-University Cooperative Education Project, etc. [14, 15]. As part of these educational reforms, most Chinese universities have focused on expanding joint educational activities with industry from curriculum construction to subject competitions to internship training, as well as joint capstone design projects, etc. Fan and Shao provide an overview of plans, programs, and challenges for university-industry collaborations in China [16].

Although most Chinese colleges and universities have realized the importance of university-industry cooperation for the training of engineering professionals, there are still challenges in the actual implementation of these efforts. For example,

- Many industry experts have little teaching experience so have difficulty teaching traditional university classes,
- Most Chinese industries haven't set up standardized annual internship programs due to business competition pressures,
- There are big differences between the industry's technical training resources and the university's classic curriculum

As a result, there is still a lack of resources for effective university-industry cooperation in colleges and universities throughout China. Most university students do not have access to the latest technology in the industry. The continuity of university-industry cooperation projects is usually poor. The number and quality of university-industry cooperation resources in different Chinese universities varies greatly. The universities with higher reputations often have more resources for university-industry cooperation. Therefore, the Chinese government encourages and recommends expanding effective university-industry cooperation resources to surrounding universities.

Summer School Partners
In this paper, we describe an innovative partnership between a university, a company, and a government entity to deliver a summer school for engineering students as an alternative to an internship. This program was open to all eligible students in China, not just those at the university partner.

Southeast University (SEU), located in Nanjing, is one of the key universities directly under the Chinese Ministry of Education. It is among the first group of Excellent Engineer Education Program universities. SEU is a comprehensive research university where majors such as electronic engineering and information science are ranked highly and have large enrollments. In recent years, SEU has established many university-industry cooperation projects with well-known domestic and foreign companies in the electronic engineering field.

Xilinx is the inventor of field programmable gate array (FPGA) technology and is a leader in highly-flexible programmable silicon, enabled by a suite of advanced software and tools [17]. Xilinx has a development center in China, as well as a University Program to co-operate with Chinese universities. Since 2012, Xilinx and Southeast University have cooperated in the field of talent training in FPGA design, including academic course construction, competitions and summer school organization.

Nanjing Integrated Circuits Industry Service Center (ICisC) is a government-based industry service company located in the heart of the Jiangbei New District, a national industry development zone in Nanjing, which is expected to create a sustainable IC industry ecosystem [18]. In 2017, ICisC cooperated with Southeast University and Xilinx to organize the first National Undergraduate Student FPGA Design Competition.

Two of these partners, SEU and Xilinx, have experience working together on a program for SEU students. SEU has many internship programs and sets requirements for these internships. For example, the School of Electronic Science and Engineering of Southeast University requires companies to provide students with paid internships of no less than one month so students have a

sufficient experience of an actual job. However, there are not enough internship opportunities for all students. Therefore, beginning in 2013, SEU and Xilinx cooperated to organize the FPGA Summer School on the SEU campus. The summer school is available to students from relevant majors at SEU and usually lasts for four weeks during the summer vacation. SEU handles registration and provides facilities. Xilinx provides the latest technical training and project guidance. At the closing ceremony of each year's summer school, experts from both academia and industry jointly evaluate the project report. The summer school recruits about 40 junior students every year and has turned out to be a good alternative for internship practice [19].

FPGA Summer School
In early 2018, Xilinx and SEU expanded their partnership to also include ICisC and to develop a summer school open to students throughout China. This collaboration aims to improve the Nanjing IC talent ecosystem, upgrade SEU, and create a novel internship-practice type university-industry-government cooperation activity. SEU is responsible for the overall planning and part of the training. Xilinx is responsible for the main training lectures and providing an industry project contact including covering any travel expenses. ICisC provided the venue including covering any necessary costs and logistical support including staff to help with registration. ICisC also provided financial support for the university professors and other experts who gave lectures during the first phase of the Summer School.

This program is open to all undergraduate and graduate university students nationwide with a background in FPGAs or Embedded System programming. The program was advertised on the websites and WeChat public accounts of Southeast University, Xilinx, and ICisC. To apply, students submitted an electronic application including describing their experience with FPGA design. Based on these applications, a group of SEU faculty and industrial experts selected the students to attend the summer school. . Students did not pay tuition but did pay for travel expenses including lodging, food, and transportation. This is estimated to be about 3500 RMB or $500 US. Depending on the requirements of their home institutions, students might be able to earn internship credits for completion of this program.

Implementation of Summer School in 2018
The first Open FPGA Summer School was held in July 2018 and lasted for 15 days, including two parts: the latest FPGA design technology training, followed by design projects provided and supervised by FPGA companies. The detailed schedule for the Summer School is shown in Table 1. The first 6 days are the first phase of technical training where the morning includes technical lectures and the afternoon is hands-on training. The next 9 days is the second phase of project design, including project selection, project design, and project report. The industry instructors participate in the development and guidance, and finally the industry and university instructors jointly review the project report. In the first phase, two competency tests were arranged, and in the second phase, corporate visits and entrepreneurial lectures were arranged.

The opening ceremony on the first morning lasted about one hour and included a detailed introduction to this summer school's daily schedule, the requirements for daily attendance, and expectations for the likely amount of work pressure that students will face in the intense technical learning and project design.

Table 1. 2018 National FPGA Summer School Calendar

Date	Morning Arrangement	Afternoon Arrangement
July 09th	Opening Ceremony, **Test 1:** Fundamental FPGA Programming Ability	**Lecture:** FPGA technology Roadmap and Device Architecture
July 10th	**Lecture:** Vivado Design and Zynq Device Architecture	Hands-on Labs
July 11th	**Lecture:** Zynq/Pynq Development and Timing Constriction	Hands-on Labs
July 12th	**Lecture:** High Level Synthesis	Hands-on Labs
July 13th	**Lecture:** Huawei Cloud Acceleration Design	Hands-on Labs
July 14th	**Test 2**: FPGA Training series	Company Project Announcement
July 15th	Company Project Announcement + Grouping + Project Selection	
July 16th ~ July 21st	Development Plan Discussion Project Development Company tours	Project Development Lecture: Innovation on Commercial Mode Lecture: IC Entrepreneurship Examples
July 22nd	Project Report PPT and Video Demo Submission	Best Design Team Recommendation
July 23th	Top10 Design Teams Review	Closing Ceremony

Just after the ceremony is the first test. All participants completed 5 digital circuit fundamental programming questions individually. Students had 2 hours to submit the necessary programming codes and functional simulation results. The test results were scored that afternoon and those scores used to determine groups. Each group generally consisted of three students, one each from the results of the test scores (high, low, and medium) with each group of students coming from different universities. Thus the students from the same university were separated. Students worked in this first grouping throughout the first phase of the FPGA technique training lectures and in the hands-on labs every afternoon. This grouping scheme balances the level of students in each group and creates an atmosphere of working with a team of strangers similar to what engineers might experience in industry.

The first phase of the technique lectures included the application of the latest development techniques and tools such as the Vivado development process, Zynq/Pynq hybrid programming technology, and High Level Synthesis (HLS) design methodology. Since this technology has just emerged in the past two years, there are no courses available now in most Chinese universities. Thus this is completely new content for all the students and focuses on practical application including four sets of hands-on labs to complement these lectures. All the lectures were led by four senior engineers from Xilinx. Their familiarity with the technology and good training skills were very helpful to the students. Each study group had access to a new set of Pynq_Z2 development boards for these hands-on labs.

In the last morning of the first phase, all participants were required to individually complete the second 3 hour test. These 50 questions were all based on previous technical training lectures and hands-on labs. This test examined the previous training mastery and served as the reference for team member selection for the second phase of the industry project.

The second phase began with the release of project descriptions from the FPGA company Xilinx, or its partner E-Element, or other FPGA customer companies such as Radium Technology. Overall, there were 10 projects. Each project description was developed by engineers and included research background, research goals, design difficulties, and expected results. Students could choose to work on a project by themselves or in groups. There were enough students in the summer school so that all projects had at least one group. Some of the projects had 2 - 4 groups resulting in more than 20 design teams of two to five students. After the instructors determined which students would work on which project and in what group, each group was required to set out their development plan under the guidance of the engineer from industry by that night.

After that, each group carried out project development according to their plan for 6 days. On the day before the last day of Summer School, each group was required to submit a project design report presentation (in PowerPoint) together with a demonstration video. On that day, all the teams voted to recommend the teams with outstanding results to participate in the final design review. On the last morning, university professors, industry engineers, and all student participants listened to the reports of the recommended twelve candidates and selected the top ten design teams for this Summer School. In the final afternoon, the closing ceremony was accompanied by an event review and award announcement. Every student who finished the entire process received a certificate of completion for this Summer School.

During the second phase, some company tours and entrepreneurial lectures were included so that students can understand more about the real corporate work environment.

Some photos of this FPGA Summer School are shown in Figure 1.

(a) Student on-site Registration Desk   (b) Opening Ceremony

(c) FPGA programming ability test

(d) Technique Lectures

(e) Hands-on lab instruction

(f) Project Announcement

(g) Project Development

(h) Project Report

Figure 1. Photos of 2018 FPGA Summer School Organization

Impact of Summer School

The organization of the summer school had many corporate elements, including the lectures on current technology and practical projects from companies with results evaluated by industry experts. It also created a professional work experience including working with strangers, challenging topics and projects, strict attendance system, and comfortable working environment. All of these aspects can help students better understand research and development (R&D) work and become more familiar with engineers' career experiences. Not only do students learn new FPGA design skills, they also learn about the professional positions of electronic engineers. This program helps students gain valuable skills in teamwork, lifelong learning, and solving practical problems, skills that may be difficult to achieve in the classroom.

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The 2018 open national FPGA Summer School attracted nearly 200 students from all over China to apply. 120 students were selected to participate in the Summer School by both university professors and Xilinx engineers. There were 19 female students and 101 male students. Half of them were undergraduate students and the rest were master students. More than half of the enrolled students came from universities in Nanjing. About 40% of the students came from universities in other cities. In the end, 96 students completed all technical training and project development work, and obtained a certificate of completion.

To gain a deeper understanding of the impact of this Summer School, two anonymous questionnaires were conducted. The survey given at the end of the technical training phase was used to assess the specific content and effectiveness of particular instructors during this phase and provide feedback for improvement. The second survey was given at the end of the closing ceremony to assess the overall program. 75 students completed the final survey. Some key results are shown in Tables 2 and 3.

Table 2 Student responses at end of summer school (N = 75)

Rate your level of satisfaction with the	*Very Satisfied*	*Generally Satisfied*	*Not Satisfied*
2018 National College Student FPGA Summer School overall	55 (73%)	18 (24%)	2 (3%)
form of the project from the industry engineer	55 (73%)	18 (24%)	2 (3%)
projects' development environment and experimental conditions provided by ICisC	53 (71%)	21 (28%)	1 (1%)
selection of the "Top Ten" projects	40 (53%)	35 (47%)	0 (0%)
guidance of the business mentor in the project development process	25 (33%)	38 (51%)	12 (16%)
guidance from the company's mentor on the project proposal writing	22 (29%)	48 (64%)	5 (7%)

The results from the final survey in Table 2 show that students were very satisfied (over 70%) with the Summer School overall, the form of the project, and the environment and experimental conditions provided by ICisC. About half the students were very satisfied and half generally satisfied with the selection of the top ten projects. Overall, students were satisfied with the guidance of the mentor in the project development process and guidance on proposal writing but most were generally satisfied with only a third being very satisfied. For a first offering, these results are promising. They do indicate room for improvement particularly in the selection of the "top ten" projects and helping mentors to interact effectively with students.

As seen in Table 3, most students were enthusiastic about participating in follow-up activities or recommending ICisC activities to teachers or classmates.

Table 3 Student responses at end of summer school (N = 75)

Are you willing to	Very looking forward to follow-up activities or very willing to	Look at the situation	Not willing to come again or Won't recommend
participate in follow-up training or competitions by ICisC? Q33	58 (77%)	16 (21%)	1 (1%)
recommend ICisC activities to teachers or classmates? Q34	65 (87%)	8 (11%)	2 (3%)

Summary

Southeast University, Xilinx, and Nanjing ICisC jointly organized the first open National FPGA Summer School in 2018 over 15 days. This activity aims to address the lack of high-quality internship projects for many Chinese universities. It explores a model for a successful internship university-industry-government cooperation. This summer school included two stages of technical training and project training. The technical training comes from Xilinx's latest FPGA design technology, which was taught and experimentally guided by Xilinx's senior engineers. The project training included actual R&D projects from Xilinx and its user companies. Engineers from industry and university professors jointly guided the project development. The two tests and two different team assignments in the activity, the compact and challenging study and development tasks, as well as the pre-planning and post-reporting mode of the project provided the participating students with training that is valuable for industry. 96 students from across China completed the program. Students' responses on a survey at the end of the Summer School showed that overall, they were very satisfied with the program, the projects, and the environment. 77% of students would like to participate in follow-up activities and 87% would recommend such activities to their teachers and classmates. Thus, based on this first offering, this summer school activity appears to be a good alternative to internships which provided valuable opportunities for students. We plan to incorporate students' feedback into improving the second offering of the summer school planned for Summer 2019.

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