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Zh. Mamatnabiyev[1], M. Zhaparov[2]
[1]Suleyman Demirel University, Kaskelen, Kazakhstan
[2]Paragon International University, Cambodia

PROJECT-BASED CURRICULUM FOR INTERNET OF THINGS ONLINE COURSE

Abstract. Nowadays, the applications of the Internet of Things (IoT) are getting popular and the number of internet connecting devices are increasing very fast. Many IoT courses are being taught in educational universities. However, the curriculum of the courses does not answer to the requirements of the industry and market, and students have not enough knowledge if they are getting the course online, where there is no offline lab work. Project based curriculum for online IoT courses is developed and grades of the student projects are compared with the knowledge of the students before project implementation. The comparison results are promising and future works are discussed.

Keywords: IoT, education, curriculum, project development, online course.

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Аңдатпа. Қазіргі таңда заттардың Интернеті (IoT) қосымшаларының қолданылу аясы кеңеюде және Интернетке қосылатын құрылғылардың саны өте тез өсуде. Білім беру мекемелерінде көптеген IoT курстары оқытылғанымен, курстардың оқу жоспары өндіріс пен нарық талаптарына жауап бермейді. Ал егер студенттер курсты желіден тыс, зертханалық жұмыс жоқ жерде алған жағдайда талапқа сай келмейтіні анық. Интерактивті IoT курстарына арналған жобалық оқу жоспары құрылды және студенттердің орындаған жобаларының бағалары мен жобаны іске асырар алдында алынған сауалнама нәтижелері салыстырылады. Салыстыру нәтижелері өте жақсы және болашақ жұмыстар талқыланады.

Түйін сөздер: заттардың Интернеті (IoT), білім беру, оқу жоспары, курстық жоба, онлайн-курс.

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Аннотация. В настоящее время приложения Интернета вещей (IoT) становятся популярными, и количество устройств, подключающихся к Интернету, очень быстро растет. Многие курсы IoT преподаются в учебных заведениях. Однако учебная программа курсов не отвечает требованиям отрасли и рынка, и у студентов недостаточно знаний, если они проходят курс онлайн, где нет лабораторной работы. Учебная программа на основе

проектов для онлайн-курсов IoT разрабатывается, и оценки студенческих проектов сравниваются со знаниями студентов до реализации проекта. Результаты сравнения являются многообещающими, и обсуждаются будущие работы.

Ключевые слова: Интернет вещей (IoT), образование, учебный план, разработка проекта, онлайн-курс.

Introduction

The acronym IoT is one of the most often talked areas in the technological revolution so-called Industry 4.0 that is based on cyber physical systems. During the last decade, in the 2010s, universities started to include courses on the Internet of Things in their curriculum. First IoT course in the Computer Science department of Suleyman Demirel University (Almaty, Kazakhstan) was conducted in the 2018 fall semester as IoT in Industry for master's degree students. The topics covered in the curriculum of the course were related to the devices, networking, application, intermediary devices, fog and cloud computing, data analysis, etc. that are also found in the curriculum of the European and Asian universities [1], [2], [3]. When it comes to the practice and laboratory experiments, building IoT devices and systems is always arguable because of abundance of hardware tools and platforms and either minority or unavailability of online software and platforms for education. Some universities have collected hardware tools and devices in order to increase students' performance and to make them able to build their own IoT devices. In spite of this, the industry is asking for new tools and skills that are developing very quickly. Another problem is the global epidemic called COVID-19. Many educational institutes have changed to education from distance learning. It is still a very big challenge to mostly engineering specialties in university and colleges. They need to build laboratories for every student at home which is very expensive or develop online tools and platforms that are minority and do not cover everything. The course IoT in Industry was taught using available and free online development tools that allow students to build complete IoT systems. In this course we used the project based learning method. During the course, students learned the steps of creating successful IoT systems in industry and practiced their knowledge by making projects in various platforms that are either online or hardware they have. In order to learn how the course projects help them to improve their knowledge, we took a survey before starting the project. The project topic and tools and platform were for their choice. After students finish their projects we compare them with survey results.

The paper is organized as follows. Methods used by previous authors and this course are discussed in section 2. Section 3 discusses the results. Finally, in section 4 the work is concluded.

Methods

Aim of the project based learning approach is to develop student's knowledge and skills on some topics through making a project, solving challenges, and finding possibilities for real world problems. Since the IoT is a new opportunity to the organizations, manufactures, industries, etc., it allows students to think in a different way and develop their imagination and creativity in the world of information technologies. Many project based courses were developed for offline laboratories. For example, Nykyri et al [4] developed a curriculum with laboratory work in a break room of Finnish University based on Café IoT, where data collected from a coffee maker is used in the project. For the project development students create all parts of the project including sensor connection, network, edge computing, user interface, etc. Similar work was done by Bistak et al [1], where students develop RC-car projects using IoT sensors, actuators and microprocessors at the end of the course. The author concludes that it would be better to give the project in the earlier stages of the course. However, he says that students should have knowledge about some definite topics from the curriculum. This gap can be filled by the curriculum developed by Koo [3]. Assigning reading every week and industrial projects in between would give significant impact for their final works, such survey papers. Another work was proposed by Silvis-Cividjian [5] for systems engineering approach with laboratory works with pervasive computing and software testing. The ALIOT project by Kharchenko et al [6] is being tested in several European countries. The project includes a model and the analysis of requirements of modern IoT infrastructure that covers IoT curriculum for Industry and Human applications. In the project every detailed topic of IoT is included for different degrees in education. All approaches discussed above were successful according to the course evaluation by students' survey results. However, all of them were developed for offline classes and anything was not discussed about online courses.

Since the course IoT in Industry is conducted online, laboratory works must be prepared with online tools and platforms which can change hardware or cheap IoT hardware kit must be collected, so everyone can allow it to themselves. The curriculum of the course is combined from three parts: devices and networking, security, and project. In order to develop IoT devices, it is not enough to have knowledge from only one field like digital design, electronics, data analysis, etc. IoT is a combination of many subjects. So, one third topics of lectures are related to project development, where students learn steps of a successful IoT project that fits overall IoT system development and implementation. Lab works for each related topic were conducted using online platforms like Tinkercad from Autodesk [7], Arduino Create [8], and desktop application Packet Tracer [9]. Tinkercad allows electronics education. Instructors can plan their lessons and see students' works directly from the

platform. Very good only platform for designing and testing device parts of the project. Arduino Create from Arduino let users create 'things' and connect them to Arduino Cloud. The platform is very cheap and allows us to connect more than 200 students for one institution. Also desktop applications are available for creating devices and systems. Proteus [10] is used in electronics. Packet Tracer was developed by Cisco Networking Academy for networking courses and free for education. In the latest versions it includes tools for IoT systems. Creating devices with microcontroller, sensors and actuators, connecting them through various types of networking, including wireless connection, controlling the device remotely or automated are all covered in the application. During the course, detailed information and practice is done using the platforms described above.

Results

Students were given free topics for the course individual project. Their task was to develop a project that fits the overall IoT system. The projects done by students were in the topics: smart home, green house, access control, security, etc. Three projects out of eleven included only perception layer (device), other eight projects included all three parts from IoT architecture layer. As a platform, four students used Tinkercad, six students used Packet Tracer, and one student used an Arduino board (hardware). More than half of the students gave very good performance on their projects. The results of other students were between 50 and 80 out of 100. The reason is that they did not complete all requirements. One student did not develop a project.

The results of the project were very good compared to the survey results that were taken before project development. In the survey eleven students were asked how much they knew the topics that would be covered in the project. The results are out of five and less promising as shown on Table 1. Because it shows only three as median, 3.3 in average. The score of almost all topics are three. When they were asked whether offline lab is necessary, the average score was 3.8 (median: 4). Students think the course project is important for learning the course materials better (median: 4). However, some students thought it was not significant (minimum score: 2). Now we know that the course project is important. Because the students got better results after project implementation on certain topics. The comparison results say course projects can increase students' knowledge.

Table 1. Survey was taken before the course project development

Variable	Mean	Median	Min	Max
Knowledge in device part	3.6	3	2	5
Knowledge in networking	3.5	4	2	5
Knowledge in application	3	3	1	5
Knowledge in IoT security	2.9	3	1	
Overall topics	3.3	3	1	5

Can you apply IoT in industry	3.3	3	2	5
Significance of the course project	3.8	4	2	5
How much the course materials were useful?	3.8	4	1	5
Is a physical lab necessary?	3.8	4	2	5

Conclusion

The project based curriculum for IoT courses that is taught online is implemented and tested. Survey was taken before the project development, in order to learn students' knowledge. Students used online and desktop tools and platforms which are free for their projects. After project completion, the grades of the projects and the survey results were compared. The comparison results show that project implementation positively impacts on students' knowledge. However, the number of participants on survey and project implementation was very low. We can get another result if more people participate in the process. For future work, more detailed curriculum like ALIOT project [6] should be implemented for both online and offline courses considering industry requirements and the Kazakhstani market. Cheap hardware platforms must be collected that would be available for everyone, which increases students' performance on topics.

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