PRODUCT, PROCESS, & SYSTEM BUILDING SKILLS EDUCATION by CONSTRUCTING A CITIZEN SUPPORT SYSTEM

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ABSTRACT

The difficulty of Product, Process, & System Building Skills education in regular lessons is that all techniques for developing products and systems must be taught in a limited time. In addition, it is impossible to teach students the requirements of analysis, architectural design, etc., in the limited time, as these cannot be learned without actually experiencing them. This paper introduces the educational method of product, process, and system-building skills involving collaboration with industry and community. The method is based on Project-Based Learning and is applied to students at the Kanazawa Institute of Technology and Kanazawa Technical College. Education was carried out under a curriculum involving a project for system construction supported as a Ministry of Internal Affairs and Communications IoT Service Creation Support Project. This paper explains in detail the practical project that was carried out in Nonoichi City. This was an educational project in which the students themselves thought about a given problem and methods of problem-solving by collaborating with companies and the city. In an effort to solve the given problem, we developed an information terminal bus stop and submitted proposals to Nonoichi City. Through active engagement with the project, students learned how to listen to individual requests, analyze the requests, and create the system. In addition, they also learned how to conduct the operational test, solve extraction problems, and improve the system. The project allowed students to receive hands-on education, and at the same time had favorable effects on the community. In fact, when using the prototype system for the citizens and conducting a questionnaire survey, we received numerous comments on its effectiveness in improving citizens' lives. Also, we confirmed students' growth from the student questionnaire survey.

KEYWORDS

Software engineering: Extracurricular activities: Regional collaboration: Project-Based learning:
STANDARD 5: Design-Implement Experiences:
STANDARD 7: Integrated Learning Experiences:

INTRODUCTION

An engineering education program that emphasizes the balance between knowledge and practice advocated in the CDIO syllabus is important in university education. We examined the program for education in "Conceiving, designing, implementing, and operating systems in the enterprise, societal, and environmental context" described in the CDIO syllabus（Edward F. Crawley, 2002, Edward F. Crawley, 2011）carried out at the same time as entrepreneurship education (QAA, 2012). In this paper, we will explain the conception, design, and implementation of the educational method and its effectiveness in citizen support system building.

The difficulty of Product, Process, & System Building Skills education in regular lessons is that all the techniques for developing products and systems must be taught in a limited time. In addition, it is impossible to teach students the requirements of analysis, architectural design, etc., in a limited time because these cannot be learned without actually experiencing them.

This paper introduces the educational method of product, process, and system-building skills involving collaboration with industry and the community. The method is based on Project-Based Learning (PBL)(Mikiko Sode Tanaka, 2017). It is applied to students at the Kanazawa Institute of Technology and Kanazawa Technical College. The educational effects of the method are explained.

The project was supported as a Ministry of Internal Affairs and Communications IoT Service Creation Support Project (Ministry of Public Management, 2017). The purpose of the IoT Service Creation Support Project is to identify specific problems that should be overcome when creating and deploying IoT services through demonstration projects, to build a reference model that will help solve the issues, and to promote data utilization. In addition, it is to play the leading role in the development and maintenance of the necessary rules for the IoT service. The group of Nonoichi City, NEC Solutions Innovator Co., Ltd., Yoshida Advertising Co., Ltd., Kanazawa Institute of Technology, and Kanazawa Technical College was selected for this project.

This paper explains in detail the practical project that was carried out in Nonoichi City. The city, located in Ishikawa Prefecture in Japan, requested the development of an ICT system for citizen support. We carried out an educational project in which the students themselves thought about the given problem and methods of problem-solving by collaborating with companies and the city. In the effort to solve the given problem, we developed an information terminal bus stop and submitted proposals to Nonoichi City. The developed system comprised five sub-systems: a Timetable and Transfer Guidance System, Children's and Elderly Observation System, Disaster Countermeasure System, Advertisement System, and City Public Relations System. This system features image recognition software and provides service matching for each individual.

From active engagement with the project, students learned how to listen to individual requests, analyze the requests, and create the system. In addition, they also learned how to conduct the operational tests, solve extraction problems, and improve the system. The project allowed students to receive hands-on education, and at the same time had favorable effects on the community. In fact, when citizens used the prototype system and completed a questionnaire survey, we received numerous comments on its effectiveness in improving citizen life.

This paper will be organized as follows: First we present the intended character of the Product, Process, & System Building Skills education with Nonoichi City and the companies. Second, the educational method based on PBL is discussed. Third, we describe a detailed practical example of the bus stop project, which was the system development project for citizen support chosen. Finally, we integrate the findings and provide directions for the future of such Product, Process, & System Building Skills education.

FEATURES OF PRODUCT, PROCESS, & SYSTEM BUILDING SKILLS EDUCATION

Purpose of the Project Activity

Society is constantly changing. In the information processing field, this is quite noticeable. We believe that the ability to respond flexibly to this change, the creation of new value, and the ability to lead society in a better direction are important. We believe that we should actively tackle social issues and focus on developing human resources able to improve society. Based on this philosophy, we are working on the development of regional innovation systems through community collaboration as extracurricular activities.

We posited that the three requirements for becoming a global leader are as follows and aimed at students acquiring these abilities.

A) Recognition / comprehension to cope with social change
B) Power to change one's own interests and abilities into actual behavior
C) Spirit and power to fully utilize one's own resources and solve social problems

We targeted Nonoichi City, in which the university is located, and tackled the matter of the improvement of civic life, because students who are citizens think that it is meaningful to solve their own civic problems themselves and to enrich the lives of other citizens. Another purpose of the project was to develop their software development capability by developing an ICT system for citizen support. By educating them in the system design method while actually creating the system, we aimed to improve students' skills as information processing engineers.

Flow of the Project Activity

We believe that by designing and implementing with an entrepreneurial spirit rather than designing and implementing the system as set out beforehand, we will acquire more useful skills in society. Therefore, our curriculum combines entrepreneurship education, such as the construction of a business model, and CDIO education: "Conceive, Design, Implement, and Operate." The flow of system development education in the bus stop project is as follows. We built the flow based on the system development flow carried out in this enterprise (Hirofumi Naito, 2006).

1) Planning: "Assembling the concept"
2) Planning: "Building a business model"
3) Proposal: "Create a business plan"
4) System design and construction
5) Introduction / deployment
6) Operation and maintenance

This is a mechanism to learn this process in a few years. For that reason, students cannot learn all of the flow in four years, and depending on the year of admission cannot learn it in order starting from Phase 1. The size of the project group is about five people in a general enterprise, and it is a project to be carried out over a period of half a year to a year. As the students are changing each year, it is structured to take place over about six years while various learning occurs in the activities carried out for three or four hours once a week. Currently in Phases 3 and 4, we are considering of the process of commercialization. In this paper, we describe the system development method education in Phase 4.

For software development, various indirect management tasks are required to create not only the work directly related to the development of software, such as request analysis, design, implementation, and testing, but other work as planned. As the scale increases, the importance and weight of such management work will also increase. In software engineering, a project is defined as periodic work carried out to create unique products, services, and products (Tomoji Kishi & Natuko Noda, 2006). The goal is to reach the deadline under the cost and resource constraints that the project is to achieve. We believe that developing the ability to develop software in limited time, cost, and resources is an important factor in education in the field, and in this activity we carried out activities involved in the project.

The major difference from regular lesson classes is that we must develop the practice of keeping pace with the citizens and city officials who are customers and with the cooperating companies. We have to manage the requirements, cost, and time constraints of customers at the company level. In order to make the project successful, we must plan and implement it

appropriately. For example, one must plan what to do day by day to achieve the final goal. In order to do so within the prescribed time period and cost, one must plan and implement properly by how much time and cost each factor should be multiplied. We must avoid time and cost overruns and ensure the project reaches its goal. In addition, as students execute the project, teachers must consider student human factors and develop members' abilities accordingly.

EDUCATIONAL METHOD BASED ON PBL

With the aim of improving citizen support, we investigated one problem of Nonoichi City. In Nonoichi City, a comprehensive planning document has been released which introduced the city policy and compiled the opinion of the citizens as to in which direction the city should go. We decided to focus on what we could do to enrich the lives of citizens within the comprehensive plan. The issues that we decided to solve are:

1) Improvement of transportation convenience
2) Child observation
3) Elder observation
4) Disaster countermeasures
5) Advertisement for city publicity and city revitalization.

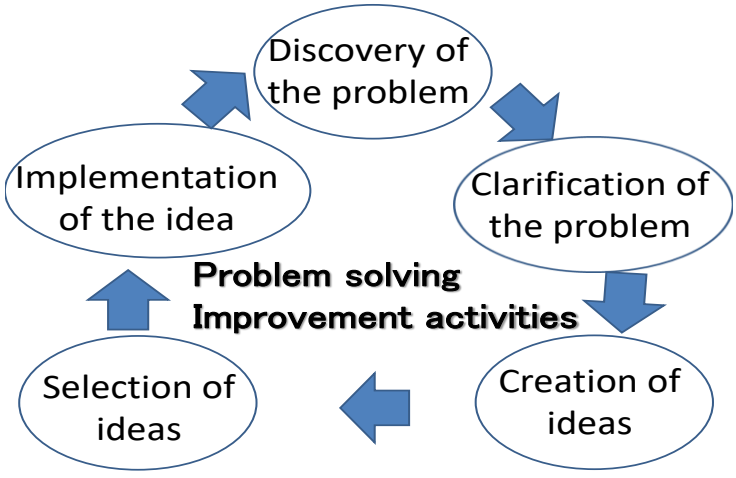

Figure 1. Flow of problem solving and improvement activities

Figure 2. Students explaining ideas to the Nonoichi City official

For the task selection, the flow of problem solving and improvement activities shown in Figure 1 was used. First of all, the students discovered and clarified the problem, create ideas, selected and realized the idea, and discussed it with a Nonoichi City official (Figure 2). This was repeated a number of times to bring the ideas of the Nonoichi City official and students' ideas into conformity and set the final task of the project.

DETAILED PRACTICAL EXAMPLE OF THE BUS STOP PROJECT

Our project was adopted by the Ministry of Internal Affairs' "IoT Service Creation Support Project", and it was decided to carry out a demonstration experiment of a smart bus stop in Nonoichi City. In order to make the project a success, we had to develop a system in collaboration with parties actually able to meet only a few times. Students must have the ability to develop programs without bugs according to a schedule set in collaboration with the company. Students were required to acquire skills that they had never had before.

Although the network of the system was built only on the Internet, we had to rebuild the main network using LoRa, which is the standard for IoT. As a result, hardware (printed circuit board design, development), embedded software, a transmission test, and network construction were also added as project tasks. Regarding human recognition, we worked on the assumption that a person was standing before, but had to be recognized walking. Sending an image of a person by using LoRa takes about 24 hours for one image. Since this is not realistic, we had to examine the image compression method. The project had a number of technical problems. Figure 3 shows an overview of the developed system.

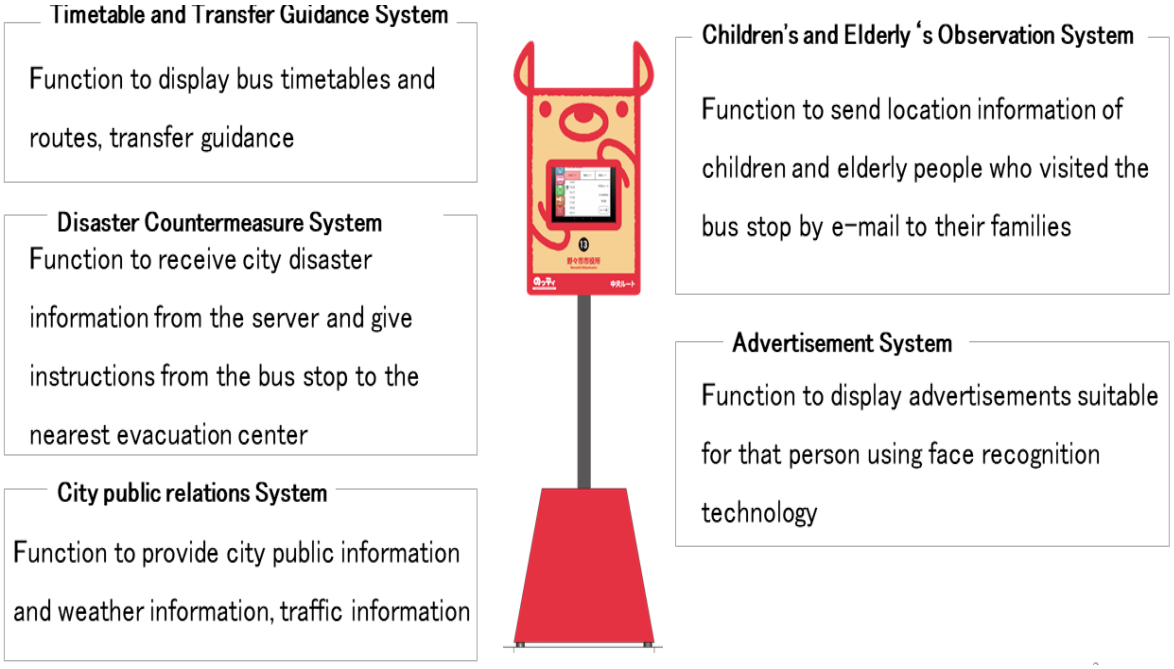

Figure 3. Citizen support system for Nonoichi City

Figure 4. Demonstration experiment carried out in Nonoichi City

At the time they participated in the project, students who had not even written a program carried out research and development and conducted demonstration experiments. It became a harsh, onerous project that had to be completed in about six months. Students sometimes worked overnight, as did the teachers. In the end all this work paid off and we were able to carry out demonstration experiments with no accident (see Figure 4). In addition, students were able to publish papers through IEEE, etc. (Ryoma Aburano et al., 2016, Taku Kuribayashi et al., 2017, Hiroki Nishino et al., 2017). Presentations in English seemed to put the presenters into a panic, but we think that this was also a good learning opportunity.

Although the system operated without bugs in the demonstration experiment, several problems have been revealed in processing speed and usability. We collaborated with the company, created a major system, carried out demonstration experiments, and completed the project successfully, but from the system point of view there are still problems, and we learned there are high technical walls. “If you can speed up the system, you can get it used not only in Nonoichi City but also in the downtown area,” was gently pointed out. We do not know how far students understand the meaning of the word, but we think that they learned that there is much work to complete a system so it operates without bugs.

EDUCATIONAL EFFECTS OF THE BUS STOP PROJECT

Citizen Questionnaire Survey Results

We actually set up the information terminal bus stop that we created at the bus waiting area of the Nonoichi City Hall and conducted a survey of citizens (Roma Aburano et al., 2016). Figure 5 shows the questionnaire survey image. To the question, “Is it necessary to convert the bus stop to an information terminal?” the answer that it was necessary was given by 84% of the respondents (Figure 6). To the question, “How do you think the information terminal bus stop will be of help?” 50% answered the improvement of the convenience of the transportation system of the city, 26% the safety of the city or contributions to safety, and 24% greater effectiveness in revitalizing the area by disseminating city information (Figure 7). From the results of the questionnaire survey, we confirmed the effectiveness of the system that the students planned and developed.

Figure 5. Questionnaire survey about the information terminal bus stop

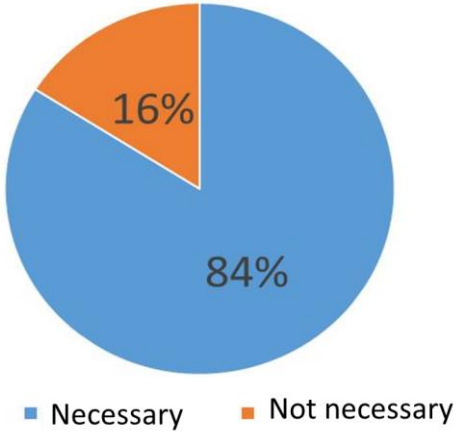

Figure 6. Questionnaire survey on the effectiveness of the information terminal bus stop

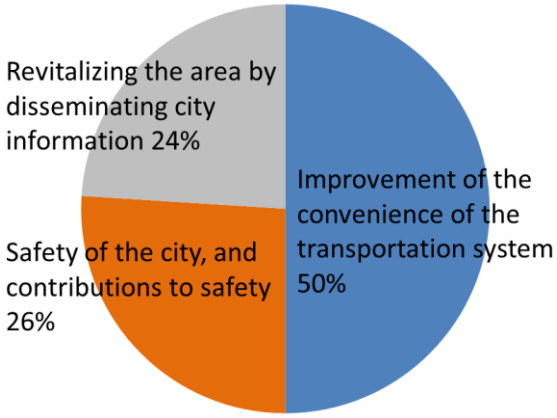

Figure 7. Questionnaire survey on the effectiveness of the information terminal bus stop

Student Questionnaire Survey Results

We conducted a questionnaire survey on participants' abilities to acquire the skills required for system design by participating in the project. In response to the question as to whether their programming ability improved, 89% of the students responded that they improved. Also, 38% of the students said that their progress management abilities used in the project improved. Moreover, 50% of the students listened to the client's request and answered that the ability to build a better trust relationship improved, while 68% of the students responded that the ability to work smoothly with project members improved. We received good feedback from students that they were able to learn practical contents and were able to participate well in the project. From the results of the questionnaire survey, we confirmed the effectiveness of our education system.

FUTURE DIRECTIONS OF THIS PROJECT

We gave an explanation about the extracurricular lesson learning how to build a system in the project. This activity conforms to the CDIO syllabus, which consists of four parts (Edward F. & Crawley, 2002, Crawley & Edward F., 2011) as follows.

1. Disciplinary knowledge and reasoning
2. Personal and professional skills and attributes
3. Interpersonal skills: Teamwork and communication
4. Conceiving, designing, implementing, and operating systems in the enterprise, societal, and environmental contexts

In order to make it a stronger education system in the future, we think that it is necessary to add system maintenance education. It is important not only that the software system can be constructed, but also that it can operate without money and adds systems according to the users' requests. Programming techniques that are easy to maintain and facilitate the addition of new functions are important and cannot be learned without experience. In the future we would like to devote efforts to creating a curriculum for this part.

CONCLUSION

The difficulty of Product, Process & System Building Skills education in regular lessons is that all the techniques for developing products and systems must be taught in a limited time. This paper introduced the educational method of product, process, and system building skills in collaboration with industry and community. Education was carried out using the curriculum of a system construction project supported as a Ministry of Internal Affairs and Communications IoT Service Creation Support Project. We carried out an educational project in which the students themselves thought about a given problem and methods of problem-solving by collaborating with companies and the city. In an effort to solve the given problem, students developed an information terminal bus stop and submitted proposals to Nonoichi City. From active engagement with the project, students learned how to listen to individual requests, analyze the requests, and create the system. In addition, they also learned how to conduct the operational tests, solve extraction problems, and improve the system. The project allowed students to receive hands-on education, and at the same time had favorable effects on the community. In fact, when and conducting a questionnaire survey of citizens using the prototype system, we received numerous comments on its effectiveness in improving citizens' lives. Also, we confirmed students' skills growth with a questionnaire survey for students.

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