Capstone Class of "Mechatronics Innovation Project" as STEM Educational Curriculum for Teacher Training Course

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Abstract

We have a set of STEM oriented special curriculum with name of "Mechatronics" in our teacher training course of "Program in Technology and Information Education, in School of Education, Hiroshima University". The mechatronics classes start from first grade, and they are eventually integrated in a capstone class of "Mechatronics Innovation Project" in third grade. We set a different theme in each year, in which the mechanical, electronic and programming elements are integrated, and students are going to solve it by making automatic "mechatronics" machines. The theme in 2021 was wood climbing robots.

Keywords: Technology education, STEM, Practical work, Robot making

1. Introduction

Importance of practical work class is well known in educational curriculums of engineering programs in universities and colleges. After graduation, engineers are expected to be a mastery of their knowledges in their daily job, that is, only knowing "passively" respective rules and formulae is almost useless, one has to utilize "actively" and "practically" their knowledges and skills to resolve real problems. Therefore, it becomes ordinal to involve several practical work classes in curriculums of specialized engineering courses [1] [2].

Our course in Hiroshima university is teacher training course of technology and information subjects, not a merely for engineering, but we believe that the same kind of practical works are quite effective to develop teaching skills of technology and information as well. Practical work classes must not be restricted to specialized educations. Actually, it is much easier to grab technological notions and/or mechanisms by touching and manipulating real machines for every people regardless of ages and study levels.

The remaining issue is how to adopt currently introduced practical woks, although many of which are specialized for engineering course, to our curriculum. Number of methods were proposed heretofore, On the Job Training (OJT), Project (or Problem) Based Learning (PBL) [3], Active Learning (AL), STEM/STEAM Educations [4], and so on, indicating that there had not be found a standardized method applicable for all curriculums. From other point of view, nonetheless, we get the chance to develop original teaching program, adopting, mixing and modifying above mentioned methods to tailor to our student needs. We are going to explain, in this work, STEM oriented practical work classes introduced in our course, focusing on the terminal capstone class of "Mechatronics Innovation Project".

2. Mechatronics Curriculum

Advantage of our course is that the students are going to study a wide variety of subjects in technology field, that is, all the mechanical, electronic, agricultural and information technologies are studied. In other words, it is involved many of STEM character in the curriculum. Therefore, for the purpose of integrating those elements, we introduced a set of STEM oriented special classes with name of “Mechatronics” in our teacher training course since 2010. There are in total of 4 mechatronics classes. First class starts from 1st semester just after the admission, with a simple theme of repairing bicycle, knowing forces act on the bicycle flame assembling simple models, and so on.

The theme of mechatronics classes becomes gradually complex ones, the 2nd one is focused on CAD/CAM, making small staff with free design. In the 3rd class, students design and fabricate hill-climbing remote-controlled cars in which the both mechanical and electrical elements, namely, all the STEM elements are contained and integrated into a real machine. After experiencing 3 classes of Mechatronics, they are eventually integrated into 4th capstone class of “Mechatronics Innovation Project (MIP)” in third grade.

3. Mechatronics Innovation Project (MIP)

For the MIP class, we set a different theme in each year which requires mechanical, electronics and programming elements with higher levels than previous classes, and students are going to resolve it by making automatic “mechatronics” machines. The theme in recent years are shown in Table 1. Recent trend in theme is that it contains

Table 1 Theme of Mechatronics Innovation Project in recent years.

Year	theme
2017	Wood climbing robot
2018	Anti-virus apparatus
2019	Step climbing rescue robot
2020	Automatic transfer robot
2021	Automatic cleaning robot

Z axis movements which requires more mechanical challenges.

We have to carefully choose the theme and set the level of it. The theme must not be too difficult nor too easy. Actually, the level of difficulty can be controlled the size and shape of the field, as we will see later.

We place the MIP class in the first semester of the third year, taking four periods of time per week. 18 students (including 3 transfer students from technology colleges) were participated in 2021th class, and they were divided into 6 groups, (3 students per group). In addition, a group of graduated students was also participated to the MIP. Each student was assigned to one of a mechanical, electrical, or information part according to his or her favorite, and was responsible for designing and manufacturing of designated part.

3.1. *Overall flow of the MIP class*

The overall flow of the class was as follows, (1) presentation of the assignment and overview of the class, (2) group discussion, (3) project presentation, (4) submission of design documents, (5) ordering of parts, (6) processing and assembly, (7) performance evaluation, (8) final presentation, and (9) submission of a final report. The flow was unchanged in every year.

3.2. *Theme in 2021*

We announced the theme for 2021 MIP class as "Automatic Wood Climbing Robot”, getting idea from commercially available wood climbing and branch cutting machines. The robots to be made were actually

Fig. 1 Appearance of field for the wood climbing robot.

mimic of such machines but, after considering the level of the robot mechanisms, we excluded the branch cutting apparatus.

Basic technique for adjusting the level of the theme we used was changing the size and shape of the field. We usually called it “the Field”, although 2021th field was merely vertically standing pipe (Figure 1). The size and complexity of the fields were most considerable point for the theme setting in every year.

We eventually made the field using vinyl chloride pipe (100 in diameter). In the midst of the pipe, a step was inserted as obstacles. The pipe was painted to black color. On the other hand, step and curve parts were remained original gray color to be noticed by sensors.

4. Results and Discussions

4.1. *Design plan until project presentation*

Until the idea presentation day, several unique mechanisms, for example a mimic of scale insect mechanism that would climb up a tree by extending and retracting the distance between two rings, were proposed. After the presentation and coming into concrete design process, in contrast, all groups eventually chose climbing mechanisms with tires or crawlers. The bodies of the robots were divided into two- or three-parts tied with springs or rubber bands. The divided bodies were expected to be enable to expand and contract when the robot pass through at the step.

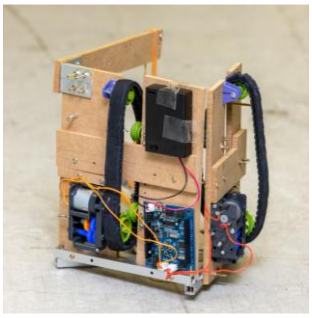

Fig. 3 Appearance of robot made by graduated student group.

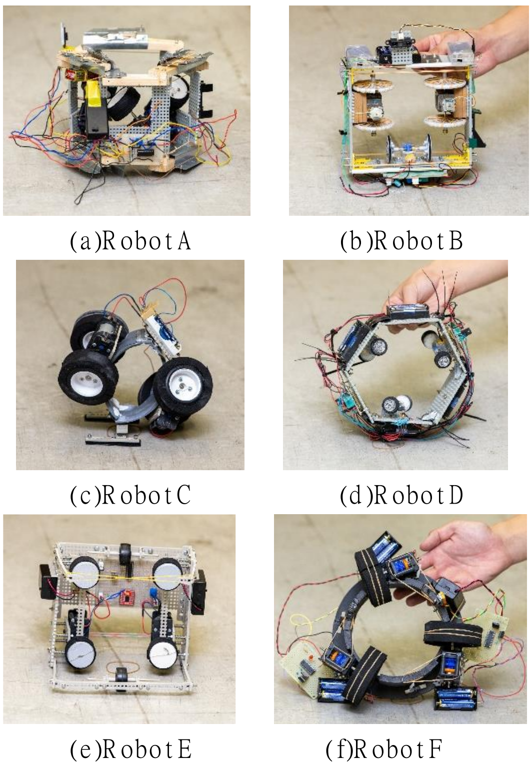

Fig. 2 Robots made by undergraduate student group (main participants of the MIP class).

4.2. *Designing and fabrication of robots*

Appearances the robots made by students are shown in Figure 2. Another robot was also made (Figure 3) made by a group of graduated students (1st grade in master course, experienced the MIP class two years ago). Design specifications of the robots are summarized in Table 2.

For designing process, each group considered the climbing mechanism and calculated traction power needed. Then, they were going to select body materials, actuators, gear boxes, and so on. Furthermore, control system with PIC, electric circuits and programming were designed and made. Each group could to put some of originality so that the robots got different appearances.

Table 2 Design specifications of robots.

Robot	Number of actuators	Traction parts	Setting angle of traction parts [deg]
A	3	tires	45
B	2	tires	0
C	2	tires	45
D	3	tires	45
E	2	tires	0
F	3	tires	0
G	2	crawler	0

Five robots used plastic, and other two used lumber for body construction, both of which were easy to be cut, shaped and assembled. For traction parts, undergraduate student groups chose rubber tires, whereas master students selected crawler. Size and number of tires were different among them.

Installation angle of tire or crawler were varied from 0deg. (4 group) to 45deg. (3 group). With 0deg. the robot climbed vertically straight, which requires more power in actuator so that those robots equipped stronger actuators of brushed DC motor with miniature gear box. In contrast, spiral climbing was realized with 45deg. robots, with relatively smaller motors, as we see in the model D, which equipped the smallest motors. The model D also equipped with the smallest tires which compensated the traction, at the expense of climbing speed.

One of disappointed point was the robots of undergraduate students could not to open, therefore they had to be put from top of the pipe, which was definitely useless in real situation. Only graduated students resolved that problem. Their robot could put the robot at the bottom of the pipe from the side.

5. Summary

STEM oriented practical work class suitable for teacher training course of technology and information was performed. The theme of the class was making wood climbing robot which contained all the mechanical, electrical and information elements. By controlling the level of the field, students could fabricate unique robots putting their own ideas in them. We believe that this kind of "active experiences" will be quite fruitful for their future job.

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