Paper:

Hands-on Education of Robotics Department for Four Years of College

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[Received February 19, 2011; accepted April 13, 2011]

In this paper, we introduce engineering education at the Department of Advanced Robotics, Chiba Institute of Technology. At the department, we try to teach useful knowledge and provide laboratory work leading to useful experience. One purpose of the curriculum is to enable students to design a system with a mechanism, control circuit, and computer programming. We then provide many lectures related to system design – control engineering, mechanics, mechanical dynamics, electronic circuits, information engineering, mechanical drawing, and so on – and provide laboratory work on related theory in the lectures. Laboratory work helps students understand abstract theories that are difficult to understand based on desk study alone. This laboratory work continues from the first to fourth years. In addition, we provide many project studies. Some students try to develop their own systems through extracurricular studies. Through the project, students obtain much knowledge and experience. After introducing our curriculum, we discuss the results of this curriculum.

Keywords: robotics education, practical skill, project-based learning, robot design, curriculum

1. Introduction

The target of the Department of Advanced Robotics, Chiba Institute of Technology is to provide students with useful knowledge and experience needed for modern engineers and scientists. The curriculum prepared will, for example, help students design systems, including control circuits, programs, and mechanisms, in such subjects as control engineering, mechanics, mechanical dynamics, structural dynamics, electrical and electronic circuits, information engineering, and mechanical drawing. To enable students to have an experience that cannot be gained through lectures and readings alone, lectures and laboratory work are closely related so that students can acquire both theoretical and practical abilities. As proven in cognitive psychology, existing knowledge acquired through actual experience is important in understanding abstract theory [1, 2].

One feature of the curriculum in this department is that many practical and specialized subjects are offered to first-year students. Classes on designing and creating robots continue for the four years until graduation, in particular, during which students deal with hardware and actual systems to improve their practical abilities. This curriculum started five years ago and produced the first graduates last year. Each scholastic year has about 130 students enrolled. There is, to our knowledge, no previous example of an educational program on designing and creating robots that continued for five years and targeted such a large number of students. In addition to classes in the curriculum, extracurricular project activities are aggressively undertaken. As stated later, one of the project activities launched by student and instructor volunteers developed into a class, eventually turning into to a project involving the entire university. This is an example of voluntary student activities changing the operation of extracurricular activities at the university.

This paper introduces the curriculum of this department as a fusion of theories and practices and examines its effects and problems. We emphasize two typical activities in the curriculum – Design and Construction of Robots with Laboratory Work 1, which is a practical course for first-year students in the second semester – and the development of autonomous electric-powered wheelchair robots as the first and most representative project activity.

2. Curriculum Outline

Table 1 shows the curriculum outline. All laboratory work is linked to lectures. Electronic circuits used in laboratory work are, for example, explained in detail in the lecture on Electronic Circuits for Robots. The main feature of these classes is that lecturers do not necessarily explain the basics before teaching applications, but first show applied examples, then explain the basics. There are five levels, 1 to 5, in practical courses on designing and constructing robots, and content become increasingly difficult with the rising level. Higher-level courses require, for example, that students develop an advanced system to control an inverted pendulum and manipulate objects using hands which they have designed and fabricated. In the last course, level 5, students work on individual topics to prepare for graduate study.

Table 1. Curriculum of Advanced Robotics Department.

Seme -ster	Laboratory Work	Related Lectures
1st	Adventures in Robotics	Mechanics of Robot, Mechanical Drawing, Computer Fundamentals for Robotics
2nd	Design and Construction of Robots, 1	Electronic Circuits for Robots, Robot Programming
3rd	Design and Construction of Robots, 2	Dynamics of Mechanical Systems, Control Engineering, Electrical and Electronic Circuits
4th	Design and Construction of Robots, 3	Biological Engineering, Robotic Sensing, Numerical Computing
5th	Design and Construction of Robots, 4	Dynamics of Multibody Systems, Actuator Driver Circuits, Robotics control, Pattern Recognition, Embedded Computer, Artificial Intelligence
6th	Design and Construction of Robots, 5	Robot Interface Design, Cognitive Science, Network Programming, Mechanics of Robot Materials and Structures, Robotics Systems, Robotic Intelligence
7th, 8th	Graduation Work	

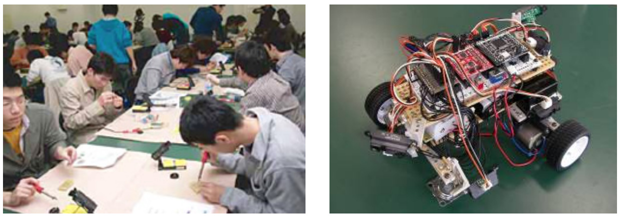


Fig. 1. Adventures in robotics.

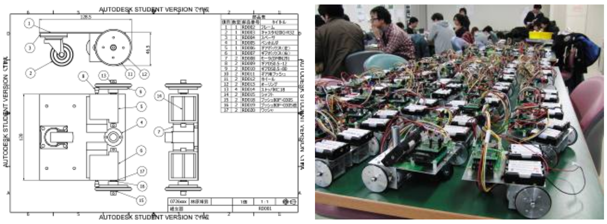


Fig. 2. Design and Construction of Robots with Laboratory Work, 1.

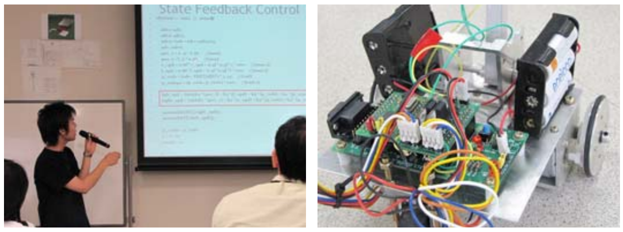


Fig. 3. Design and Construction of Robots with Laboratory Work, 2.

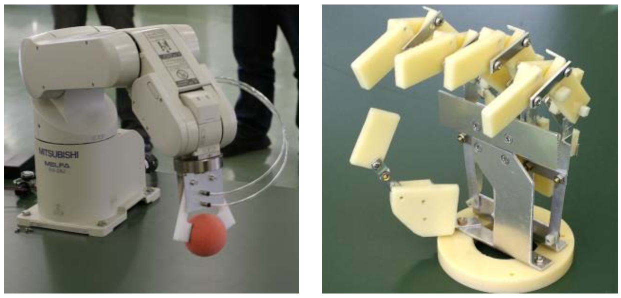


Fig. 4. Design and Construction of Robots with Laboratory Work, 3.

3. Designing and Constructing Robot

Laboratory work on designing and constructing robots continues from the first first-year semester to the second third-year semester. This section describes the targets of courses. Each course consists of 15 classes held for half a year.

First First-Year Semester: Adventures in Robotics (1 class, 90 minutes)

The aim of this course is to have students experience designing and constructing robots (**Fig. 1**). Students accumulate technical experience through the creation of robots with single-board computers. This course raises student awareness of robotics and helps them understand part of the system. The Future Robotics Technology Center plays the central role in managing the course [3].

Second First-Year Semester: Design and Construction of Robots with Laboratory Work, 1 (2 classes)

While the first semester focuses on experience, the target of the second semester is to have students design robots based on theory (**Fig. 2**). Specifically, students acquire the basics of robotics by designing and constructing autonomous mobile robots. To understand that design is based on theory, students are required to conduct research and make presentations. They are also required to fabricate parts to create robots. This course program is detailed later [4].

First Second-Year Semester: Design and Construction of Robots with Laboratory Work, 2 (2 classes)

While the course for first-year second-semester students covers overall robotics technologies, this course focuses on electronic circuits and control systems. Students design the control system for an inverted pendulum using MATLAB, etc., then control actual machines through their designed systems to confirm operability (**Fig. 3**).

Second Second-Year Semester: Design and Construction of Robots with Laboratory Work, 3 (2 classes)

This course focuses on mechanism design and system construction. While the previous course only required students to append a pendulum onto the previously constructed mechanism, students must design and fabricate completely original hands from scratch. Each student also connects his/her hand to the provided manipulator and write a program for an integrated system to accomplish such tasks as moving objects and writing letters (**Fig. 4**).

Third-Year Design and Construction of Robots with Laboratory Work, 4 & 5 (2 classes)

From the first third-year semester, students work in groups on themes of their choice. Since students are assigned to laboratories in this semester for specialized education, they set their own themes for this course in

Fig. 5. Design and Construction of Robots with Laboratory Work, 4&5.

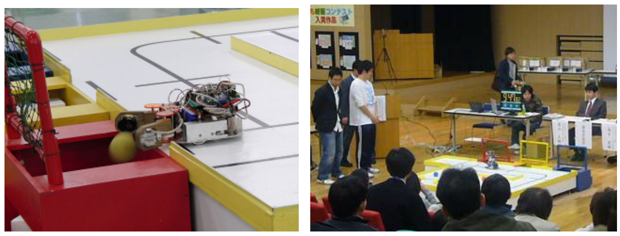


Fig. 6. Intelligent robot study group.

Fig. 7. RoboCup project.

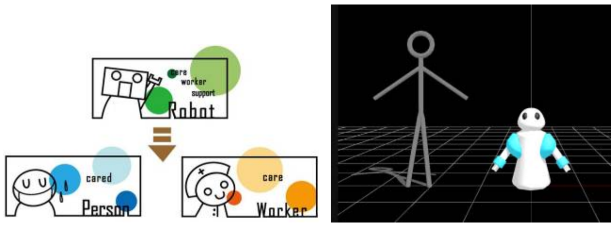


Fig. 8. aba project.

each laboratory. Some groups conclude their work in a semester, but most continue working on the same theme throughout the year. At the end of the course, students make presentations (**Fig. 5**) and mutually evaluate results. Laboratory work content changes to include new fields such as robot cognition and intelligence, depending on student intention, from work centering on hardware and control using motors and CPUs. To acquire knowledge and techniques in preparing graduate work, students address specialized tasks with the support of laboratories.

4. Robotics Project

In addition to the above laboratory work on creating robots under educational programs, the department also promotes project-centered education in which students propose and address tasks with advice from instructors. In this type of class, students present their achievements after half a year, and those who have accomplished tasks receive credits. The Oyakudachi (Valuable) Robot Contest, introduced later, is an example of these projects. The contest initially started as a voluntary student activity, but thanks to its excellent achievements, it developed into a project as the first example of this education. This section introduces examples of projects that have continued until this writing.

Intelligent Robot Study Group

This project has students design and construct robots for the Intelligent Robot Contest held annually in June in Sendai, Japan (**Fig. 6**). This contest requires high-level techniques to enable robots to autonomously search for and transport balls. Thanks to the support of the Chamber of Commerce and Industry in Narashino City, this competition is also held at our university every December.

RoboCup Project

This is a project involving soccer competition among autonomous humanoid robots (**Fig. 7**). The project team participates in an international competition annually. Since participants are required to develop a wide range of techniques, students have received support from outside engineers. In RoboCup 2010 Singapore, the team won first prize in the Technical Challenge for Teen Size (more than 1 meter) Humanoid Robots [5–7].

Awakened Bunch Activity (aba)

aba is a student project having students realize robotics to support elderly care workers (**Fig. 8**). The project focuses on depression, which has drawn the most attention, to introduce robotics technologies in developing new treatment [8, 9]. Although this project is managed by students, members collaborate with outside hospitals treating depression patients and special nursing homes to research and develop robots. They also intend to commercialize developed technologies in the future.

Including other projects stated later, diverse projects are managed by students. Although many projects are suspended before completion, some have continued with increasing numbers of participants during the five years since this program started.

5. Design and Construction of Robots with Laboratory Work, 1

This section details the Design and Construction of Robots with Laboratory Work 1 course (DCR 1), an introductory course on designing and constructing robots. This course mainly targets the following:

1. acquiring the basics of autonomous mobile robot design and construction,
2. understanding that design is based on theory.

Since the target of the laboratory work in the first semester is to experience robot creation, DCR1 is the first opportunity for students to design and construct robots based on theory, so this course is designed to have students investigate design methods and experience the gamut of robot design and construction, from drawing, machining, and assembly to circuit fabrication and computer programming. This course targets first-year students, so participants include students with a wide range of experience, ranging from those who have created robots to those who do not have any experience even in machining. The program for this course should thus be designed to enable all students to undergo hardship to some extent while finally achieving the target. It should also be considered that up to 130 students simultaneously undertake the same laboratory work. We describe the course program, which was established based on the above ideas, and its results.

5.1. Outline

The robot to be created is an autonomous mobile robot that moves based on odometry. It was chosen as a target to help students understand the servomechanism system and the significance of geometry. After the goal was set, the program was determined taking into account time and cost required for design and fabrication. In determining the program, we first focused on linking drawing and machining. We organized the program to have students use their own drawings to do the machining work, not conducting drawing and machining separately, because we thought this would enable students to understand the relationship and significance of these two processes better. Drawing used a 3DCAD Autodesk Inventor. To raise student awareness of the relationship between theory and design, students were provided with themes for each group at an early program stage and were required to make presentations two months later. By investigating theories to be used in designing robots they actually created, students could understand that design is based on theory – one of the purposes of this course. Since students research on their own and make presentations only twice, they cannot learn theory adequately, but they are expected to start thinking about the significance of theory in design and how to apply theory to design by researching on their own. In machining and fabricating electronic circuits, students learn the theoretical background and design methods in lectures, but imitate prepared designs in practical work. This helps them acquire basic theories and techniques first, since they are not accustomed to robot development. In computer programming, we left ample room for students to work on improvement through trial and error. After lectures on feedback control and odometry acquisition, students individually create programs and actually operate robots to accumulate experience. Although the basic program is provided, students make various efforts to improve the program. Theoretical background is explained in lectures for first-year students, e.g., Mechanics of Robots and Electronic Circuits for Robots. Theory and practical work are thus closely linked for subjects in the curriculum.

Fig. 9. Robot.

5.2. Robot Creation

Figure 9 shows the robot to be created. It has a cylindrical hole at the center into which a pen is inserted to draw its trajectory. This has two purposes – (i) facilitating evaluation by the trajectory and (ii) providing an entertaining robot feature for writing letters and drawing pictures.

Since the program includes a wide variety of content, the robot mechanism was simplified as much as possible, while students were required to machine materials such as square aluminum pipes. The robot includes both parts requiring high accuracy in machining, e.g., distance between shafts, and parts not requiring accuracy, e.g., mounting part of motor units, so students could use diverse materials and machining methods. Initially, the process included the machining of gears, but it was often difficult to verify the control program due to low accuracy of machining tools, and gears were changed to ready-made ones.

The motor is equipped with a magnetic rotary encoder of 12 ppm. Although 12 ppm may be low, it is difficult to increase the pulse number since the CPU is H8/Tiny without a counter of the phase coefficient mode. When the pulse number is quadrupled, the pulse corresponds to 0.5 mm/count of the wheel circumference. For motor driver circuits, circuits distributed in the first semester are reused after partial adjustment. Although this robot is equipped only with basic parts for autonomous move-

Table 2. Program content.

	Category	Content
1		Guidance, Install Software
2	Mechanism	Workshop Practice (Safety Training)
3		Drawing
4		Basic of 3D CAD
5		Drawing by 3D CAD (Parts)
6		Drawing by 3D CAD (Assemble)
7		Machining
8,9		Discussion of Design
10	Electronics	Fablication of Electrical Circuit
11		Experiment of Motor
12	Control Programming	Trajectory Control by Odometory
13		Programming of Hardware
14		Programming of Feedback Control
15		Programming of Trajectory Control

ment, it is suitable as a platform for students developing and improving the system, because the structure can be changed with relative ease.

5.3. Program Content

Table 2 shows the content of the program. Each subject is taught in two classes (three hours), and also has three extra hours, so the maximum number of hours is six in total. For some subjects, students are required to spend much more time, so extra work is needed. Machining work in particular is often conducted in extracurricular time under the guidance of staff staying at the laboratory at all times. Each subject has one theme, and students step up to the next subject after accomplishing the task in line with the theme. We established this system because we think that a sense of accomplishment in every class raises student motivation. Regarding time for each subject, we allocated longer hours for designing and fabricating machines, in which most students have no experience. The time allocated for electrical circuits was shortened, since the class in the first semester also included this subject.

One feature of this program is that students design robots based on their own ideas. Each student group is given a task in guidance, and is required to make presentations in classes 8 and 9. The themes of tasks are motors, gears, bearings, steering, wheels and tires, chassis materials, shaft materials, determinants of maximum velocity and maximum acceleration, the center of gravity, rotary encoders, odometry, batteries, motor drivers, cables, connectors, substrates, CPUs, velocity control, and communication. Each group selects one theme from the above to investigate. For drawing, students reaffirm the basics of drawing by handwriting before practicing the use of 3D CAD. In laboratory work, students are provided with information on model numbers of parts and typical dimensions of parts to be machined, but are not provided with information on dimensions related to the position of the hole. The purpose of this is to foster student abilities to obtain the necessary data from the datasheet when making designs. Students are initially perplexed by work they have never experienced, but after three weeks, most of them complete their drawings. This may be partly because 3D CAD is easy to use. Students thereafter undertake machining work based on their own drawings. Although tasks for drawing must be performed by each student separately, machining can be conducted by two students working together.

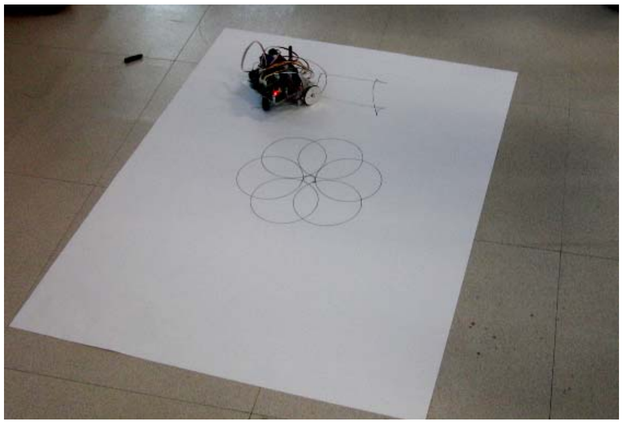


Fig. 10. Example of a figure drawn by a robot.

Students thereafter fabricate electronic circuits and conduct experiments on motors. In experiments, to learn the system of the rotary encoder, they investigate the relationship between input voltage and rotation frequency using oscilloscopes, and submit reports. Students finally learn feedback control and odometry, then actually create control programs. While sample programs are provided, students are required to create programs on their own by trial and error so that they can learn the relationship between control and actual movement through experiments.

5.4. Results

This program has been held four times, and nearly all students have completed robots and received final evaluations. **Fig. 10** shows a robot performing its ultimate task of automatically drawing pictures. Most students achieved a level enabling robots to write letters or draw pictures after a process of trial and error.

Although this program includes relatively difficult tasks such as drawing and machining, students successfully created robots by teaching each other among group members. There were some students who had to repeat machining about 10 times, but most students seemed to enjoy the laboratory work. In fact, based on the results of the questionnaire, most students thought that laboratory work was enjoyable. **Fig. 11** shows the results of the questionnaire conducted in 2009. The survey was conducted on all students on an anonymous basis, at the end of the class, and 112 students responded. Questions are as shown in **Fig. 11** in a bubble chart in which the size of circles is proportional to the number of students.

We think students were able to achieve the target of acquiring the basics of designing and constructing au-

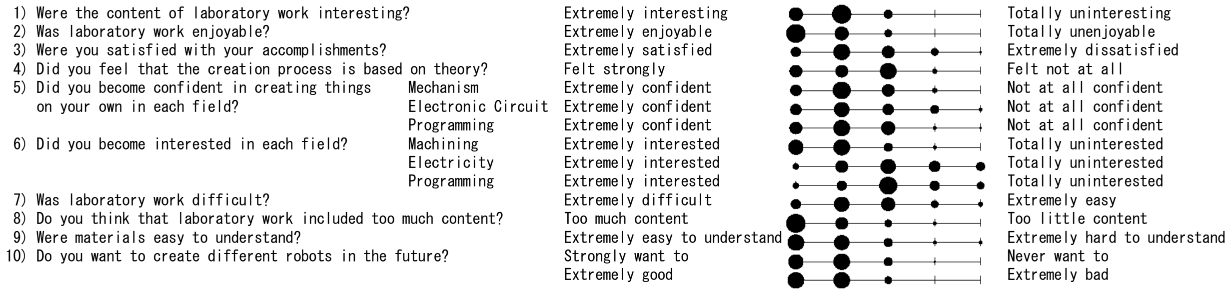


Fig. 11. Questionnaire results.

tonomous mobile robots to some extent, since they accumulated diverse experience through design and construction of robots, and their achievements were confirmed in their presentations. This has been proven by the result of the questionnaire, in which most students answered that they became confident, although the evaluation was subjective. Regarding the other target of understanding that creation is based on theory, only 30% of students answered that they strongly felt that creating was indeed based on theory, while no students answered that they did not feel that. We therefore think that the program was effective to a certain extent, but some room is left for improvement. As for the degree of difficulty, many students thought the program included too much content. Although we think a slightly difficult program is appropriate, there may be room for improvement.

6. Project Education

Laboratory work conducted based on preset programs, as stated in the previous section, effectively enhance student abilities to a certain extent. It is, however, also true that a large gap between students' academic abilities, technical capabilities, and eagerness.

For student education, it has been pointed out that practical and voluntary learning activities are as important as lectures. One example of effective educational programs for students with high motivation and abilities is a project-oriented education.

With the keyword "robot," we therefore provided students with opportunities to execute projects proactively and practically through robot development and planning and robot contest management. This attempt became the base for a class called the robotics project. It was later expanded into a "project for creating things" involving the entire university. This section introduces robot project education for 2006 and 2007 as part of a support program for engineering career study in collaboration with regional societies, which was adopted as the Modern Good Practice Program by the Ministry of Education, Culture, Sports, Science and Technology of Japan. We will show that a robot with a moderate level of technology enables students to gain an overview of the entire creation process and to enjoy a sense of accomplishment.

Fig. 12. Oyakudachi robot contest.

6.1. Robot Project Education

The purpose of this project was to develop an autonomous electric-powered wheelchair robot for participating in the newly organized Oyakudachi (Valuable) Robot Contest. Project members were 25 first-year students and 18 second-year students from the Department of Advanced Robotics and three other departments. The main two activities were developing robots and planning and managing the robot contest.

The aim of robot development is to encourage students to organically connect theories and practices through the overall process of creating robots. The aim of planning and managing the robot contest is to enhance students' abilities to implement plans so that developed technologies can actually be used. Since both are collaborations among group members, the project also aims to improve students' communication ability as a fundamental skill to become a member of society. The sections below outline the Oyakudachi (Valuable) Robot Contest, then introduce the developed robots.

6.1.1. Oyakudachi (Valuable) Robot Contest

In this contest, participants actually ride the autonomous electric-powered wheelchairs they developed in the simulated environment of a hospital. The floor has color-coded tape pasted on it based on destinations. Robots are evaluated, in automated operation, for riding comfort, judgment accuracy, and speed in arriving at destinations. **Fig. 12** shows scenes from the first contest.

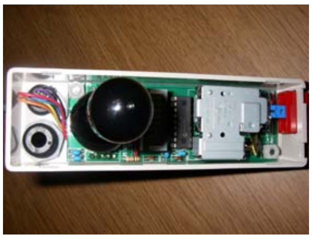
Based on the idea that actual use should be taken into consideration in the contest to increase the effectiveness of practical education, the following rules were set:

1. From the viewpoint of practical use, the robot must be ridable.

(a) Wheelchair.

(b) Motor.

(c) Control circuit.



(d) Joystick.

Fig. 13. Electric wheelchair unit.

(a) Seminar.

(b) Construction in group.

Fig. 14. Development work with team mates.

Fig. 15. Science museum demonstration robot LILI-ON.

2. Riding comfort must be evaluated.
3. The competition field must be close to a real environment.

Social significance is also important in practical education, so the target of this contest was set to realizing wheelchairs that autonomously support the transport of disabled subjects in hospitals or at nursing-care sites. Robotics technologies must contribute to improving quality in the field of medical welfare and nursing care.

The first contest, held on March 21, 2007, drew 14 teams, including two from other universities, one from a company, two from technical colleges, one from a high school, and one from a university club.

The second, on December 12, 2007, drew 9 teams, including one company team, one technical-college team, one high-school team, and three tie-up teams with companies.

The best results of teams belonging to the project were third prize in the first contest and first prize in the second. Planning and managing the contest involved a total of 19 meetings of three to four hours each held to establish rules, make flyers and Web pages, prepare for necessities, determine the evaluation method, prepare for trial runs, and simulate the contest.

6.1.2. Robot Development

To enable students with little knowledge of robots to participate in the project, a unit was prepared to convert ordinary manual wheelchairs into electric wheelchairs that can trace lines (**Fig. 13**). The basic hardware is completed by assembling the kit. Students then improve the hardware and develop control software.

For the first contest, since it was the first experience for all participants, study sessions of two to three hours for all participating students were held 25 times from late July 2006 to mid-March 2007, in addition to group activities to develop mechanisms, electric circuits, control software, etc (**Fig. 14**).

For the second contest, study sessions for all were held 10 times, in addition to individual group activities, from April 2007 to December 2007. Since there were some students participating in the previous contest, the number of study sessions was fewer. Both in the first and second year, some students dropped out of the project.

Based on a questionnaire filled out by students who completed the project, students strongly recognized the difficulty in operating robots, the degree of their own abilities, and the importance of schedule control.

6.1.3. Development of Demonstration Robot LILI-ON in Science Museum

In the second year of this project, the development of a wheelchair robot called LILI-ON was added. LILI-ON was to be regularly exhibited and demonstrated at the Chiba City Museum of Science, which opened in October 2007. Since the robot was required to operate properly for a long period of time at a high level of technology, seven selected students and an instructor developed the robot from April to September 2007. **Fig. 15** shows the developed robot. This autonomous wheelchair robot can trace lines in various colors on the floor to arrive at destinations distinguished by color [10].

6.2. Project Examination and Evaluation

Participating students wanted to undertake the project as volunteers, so their responses to the questionnaire would be basically positive. We therefore investigated whether activities related either directly or indirectly to this project could actually be maintained for three years after the project had been concluded.

1. In the framework of project-style education, the classes of Robotics Project 1 to 4 were started in 2007 to support challenging activities of highly motivated students, for a purpose similar to the above activities. A university-wide CIT Monozukuri project to support students' project activities was launched last year to promote and increase student interest in creating things and to foster their practical abilities.

2. For the robot contest, Sentan Monozukuri Challenge in Narashino – a competition for advanced creative technologies in Narashino City – has been held since 2008 with the participation of large numbers of students.

3. LILI-ON, the demonstration robot at the science museum, continues in operation 3.5 years since it was developed. Members of the development team currently play a central role in regular maintenance once every two months and occasionally in repairing the robot.

4. In 2009 and 2010, robot project education targeting students of technical high schools was conducted in collaboration with all technical high schools in Chiba Prefecture within the framework of the Science Partnership Project (SPP) of the Japan Science and Technology Agency.

As seen in 1. to 4. above, activities related to this project have continued, although managing organizations have changed. This project can be assessed as significant as an educational program using robots. In concluding this section, we would like to mention the following points reaffirmed through this project.

- Students in project education often participate in projects as volunteers, not for required credits, so the content should thus be designed so that participating students can feel a sense of fulfillment. By creating robots with a moderate level of difficulty in development, students gain a sense of fulfillment through experience in the process of developing and completing the robot. Education using robots is therefore effective.

- Student motivation increases dramatically if content includes activities contributing to society, such as developing a demonstration robot at the science museum.

7. Curriculum Evaluation and Problems

As stated above, this department has conducted an educational program with varied content covering everything from the basics to applications, and further expanding in line with student interests. Lectures follow a style unique to Japanese universities in first teaching theories that are used in robot creation by students in the laboratory work, instead of first teaching theories not linked to any particular laboratory work. At our university, questionnaires are conducted at the end of all classes to gauge student satisfaction. The superiority of this curriculum is showed in the results of the survey. Below, for example, are average scores by students evaluating the Design and Construction of Robots with Laboratory Work 1 course (DCR 1), introduced earlier in this paper. The course rated the maximum of 5.0 points. Scores following the slashes (/) are overall averages for all lectures.

1. Was this class effective in improving your ideas, ability, knowledge, and techniques?

   Average 4.4 / Overall Average 3.9

2. Did you actively participate in this class?

   Average 4.4 / Overall Average 3.8

3. Comprehensively judged, are you satisfied with this class?

   Average 4.2 / Overall Average 3.8

The remaining 10 questions all drew higher average scores than overall averages. For the above three questions, about half of the students put down full scores.

The following summarizes our findings in conducting the curriculum in the five years since it started.

Advantages

1. The curriculum fosters students with high abilities in design and fabrication of mechanisms and electronic circuits. As an obvious example, students won first prize in the RoboCup by fully exercising their abilities in developing and maintaining robots. Most students acquire abilities to design, fabricate, and control robots with built-in CPUs.

2. The curriculum requires students to consider principles for practical work, so they are encouraged to study theory. Most students become interested in theory when they learn how theory is applied in actual work.

3. To explain abstract theory in lectures, instructors show specific examples familiar to students. The robot to be created in the laboratory work includes many technical elements, and it is thus appropriate as a specific example in lectures.

4. By dealing with much practical work, students reduce their resistance to experiments using robot hardware. As a result, most students can apply advanced theories to practical work in the process of their graduate studies.

5. Since educational programs for first-year and second-year students include theory and practical work that are closely linked, students can be smoothly assigned to laboratories in their third year. In other words, it is possible for third-year students to start specialized research.

Problems

1. Unless students actively participate in lectures with laboratory work, they cannot achieve the level needed to organically connect theory and practical work.

2. To enhance educational effects on many students, administrative costs for instructors increase, so measures must be found to adapt programs for small-group education to mass education. The administrative policy of the university strongly affects cost performance.

The above findings may be applicable to other educational programs to promote creative activities.

8. Conclusions

This paper has introduced the curriculum at the Department of Advanced Robotics, Chiba Institute of Technology as a fusion of theory and practice, and has examined both its advantages and problems. As typical educational activities, the contents of Design and Construction of Robots with Laboratory Work 1 course (DCR 1) and project-oriented education have been introduced. We hope that the results of this study will prove to be a useful reference for future education centered on creative activities.

References:

[1] J. Bransford, A. Brown, and R. Cocking, "How People Learn: Brain, Mind, Experience, and School," Washington, DC: National Academy Press, 2000.

[2] Y. Saeki and S. Watabe, "A Companion to the Cognitive Science of Learning," TAISHUKAN Publishing Co., Ltd., pp. 459-478, 2010 (in Japanese).

[3] Y. Okumura and T. Furuta, "Development of Microcomputer Educational Kit with Enhancing Modules and Practical Curriculum for Making Original Robot," Proc. of the 28th Annual Conf. of the Robotics Society of Japan, 1L2-1, 2010 (in Japanese).

[4] Y. Hayashibara, Z. Wang, S. Okawa, and E. Nakano, "Education through design and manufacture of self-propelled drawing robot," Proc. of JSME Robotics and Mechatronics Conf. 2009, 1A2-A17, 2009 (in Japanese).

[5] Y. Hayashibara, H. Minakata, and H. Sakamoto, "Autonomous Soccer Humanoid System "CIT Brains"," Design Engineering, Vol.44, No.6, 2010 (in Japanese).

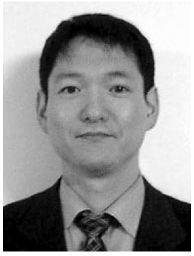
[6] H. Minakata, Y. Hayashibara, K. Ichizawa, T. Horiuchi, M. Fukuta, S. Fujita, H. Kaminaga, K. Irie, and H. Sakamoto, "A Method of Single Camera Robocup Humanoid Robot Localization Using Cooperation with Walking Control," The 10th Int. Workshop on Advanced Motion Control, TF-000787, 2008.

[7] Y. Hayashibara, H. Minakata, K. Irie, and H. Sakamoto, "Development of Humanoid "Dynamo" for RoboCup," Proc. of the 28th Annual Conf. of the Robotics Society of Japan, 1L2-1, 1A3-5, 2010 (in Japanese).

[8] Y. Wie, M. Oya, M. Komori, K. Takamatsu, T. Baba, K. Machi, K. Matayoshi, and K. Tomiyama,"The Role of Care-Taker Support Robot in Caring Depression," The 51th Japan Joint Automatic Control Conf., Vol.51, 2008 (in Japanese).

[9] S. Endo, Y. Wie, M. Ohya, Y. Ishikawa, A. Fukuda, T. Baba, K. Tomiyama, "Caregiver Support System GCSS and Avatar-agent," The 53th Japan Joint Automatic Control Conf., Vol.53, 2010 (in Japanese).

[10] S. Nakajima, "Development of the Robot for Chiba City Museum of Science and Its Educational Effectiveness," IPEJ Journal, Vol.20, No.4, pp. 8-11, 2008 (in Japanese).



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- "Light Weight Quadruped with Nine Actuators," J. of Robotics and Mechatronics, Vol.19, No.2, pp. 160-165, 2007.

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