https://doi.org/10.20965/jrm.2011.p0811

Paper:

Enhancing Student Engineering, Personal, and Interpersonal Skills Through Yumekobo Projects

Kosei Demura*, **Takumi Sakamoto****, **Yasuki Asano****, **and Masakatsu Matsuishi****

*Department of Robotics, Kanazawa Institute of Technology
7-1 Ohgigaoka, Nonoichi, Ishikawa 921-8501, Japan
E-mail: demura@his.kanazawa-it.ac.jp
**Project Education Center, Kanazawa Institute of Technology
7-1 Ohgigaoka, Nonoichi, Ishikawa 921-8501, Japan
[Received February 24, 2011; accepted May 30, 2011]

The Kanazawa Institute of Technology (KIT) established Yumekobo (the Factory for Dreams and Ideas) in 1993 to give students a place to create things freely and safely in extracurricular activities. Yumekobo has come to impact strongly on domestic and overseas universities promoting educational reform. The Yumekobo project supporting creative student group activities is no longer just a place for extracurricular activities, but has come to symbolize KIT educational philosophy. Students even cite the Yumekobo project as why they apply to be admitted to KIT. The project both improves students' technical capability and helps develop their personal and interpersonal skills – skills not taught sufficiently in institutions of higher education. The program's core is developing personal and interpersonal skills through student-led group activities. This paper details and assesses the Yumekobo project and its educational effect based on questionnaires conducted over the last 10 years.

Keywords: Yumekobo projects, personal and interpersonal skills, engineering skills, extracurricular activities

1. Introduction

Yumekobo (the Factory for Dreams and Ideas) at the Kanazawa Institute of Technology (KIT) was established in 1993 as a place where students could enjoy creating things freely and safely – here, "creating things" means creating visible and invisible things through engineering. In the 1995 educational reform, Yumekobo played a major role as a base for creative activity outside the academic curriculum in a paradigm shift from "teachers educating students" to "students learning independently."

The Ministry of Education, Culture, Sports, Science, and Technology (MEXT) selected Yumekobo as a support program for unique university education project. The Ministry also chose Yumekobo to take part in the Science Partnership Program for 9 consecutive years and in the 2007 Human Resources Development Program through Cooperation of University and Business. Yumekobo won the Director-General Award of the Science and Technology Agency at the 1999 Science and Technology Film/Video Festival and the 2002 MEXT Minister's Award for the excellence in engineering education. In 2003, a Newsweek magazine university education feature introduced Yumekobo as a new type of education [1].

Yumekobo project teams have achieved excellent results as winning first and second prizes in international and domestic competition related to solar boat, solar car, robot contests, and the RoboCup robot soccer challenge. These have triggered visits by university representatives from within Japan and from countries such as Korea, China, Taiwan, Singapore, and Germany. Many institutions in Japan and abroad are modeled on Yumekobo.

Yumekobo has become an educational system for creating diverse activities and symbolizes educational reform at KIT.

This paper details the Yumekobo project intensively – Yumekobo's most unique function.

2. Yumekobo

Since the purpose of engineering is to create things, merely acquiring fragmentary theoretical knowledge through lectures is not sufficient. We believe that students can only learn engineering by actually creating and systematically linking theoretical knowledge to experience.

Universities have not provided an appropriate environment for students to create things freely and safely, which is why KIT established Yumekobo in 1993 as a place where students could create things and realize their ideas and dreams safely and freely as follows.

1) Providing a space for free, safe activities

To let students create things freely, Yumekobo is open 320 days a year from 08:45 to 21:00 on weekdays and to 17:00 on weekends. Students with permission use facilities until midnight, although not later than that for security reasons. Facilities consist of two buildings with a total floor space of 3000 m^2. With freedom and safety often contradictory, we work to ensure safety four ways – through:

i) lectures on safety and safety patrols,

ii) requiring that students be licensed to use machine tools,

iii) appointing 40 students as safety control staff to maintain and improve Yumekobo safety,

iv) preparing for the unexpected by automatically enrolling students in accident insurance plans using student IDs.

2) Providing knowledge and techniques

To provide students with knowledge and techniques needed for their activities, KIT employs 18 engineers who are experts in metallic processing, welding, sheet-metal work, woodworking, electricity/electronics, and mechatronics. Lectures are given on safe, correct machine tool operation basics.

3) Providing machine tools, materials, and parts

The facility provides machine tools, hand tools, printed circuit fabrication equipment, measuring devices, personal computers, printers, and copiers enabling students to create a wide variety of items, together with 1,600 types of wooden and metallic materials and parts, consumables such as screws and nails, and electronic parts sold at the parts shop, which is open only to KIT students and teaching staff.

4) Contributing to the regional community

Yumekobo gives opportunities to students to contribute regionally through volunteering and being responsible as members of the community. A summer science program, for example, is held for about 500 students from elementary school through senior high school.

5) Managing the Yumekobo project

The Yumekobo project is conducted to improve students' technical capability and personal and interpersonal skills as detailed in the sections that follow.

3. Yumekobo Project

Among Yumekobo functions, Yumekobo project management is unique. Since Yumekobo is a facility where students enjoy creating things independently, it is not used for practical class work alone. When the facility was first opened, it stayed nearly empty, so the Yumekobo project was set up to increase the number of student users and to promote a creative culture at KIT.

3.1. Purposes and Conditions

The Yumekobo project is defined as a student group in which participants experience the full creative process from planning, investigation, design, and fabrication to analysis and evaluation in team work, controlling the schedule and operating the organization on their own. Project objectives include collecting the abilities and knowledge of students from different departments and scholastic years into teams, taking up tasks that cannot be achieved by individual efforts alone, and, in doing so, enabling students to improve their technical capability and personal and interpersonal skills.

Personal and interpersonal skills are defined as the ability to adapt to society. All Yumekobo projects must meet four requirements.

1) Relationship to engineering and team activities

The Yumekobo project is premised on team activities related to engineering in the broad sense. A team must consist of students from different departments and scholastic years. Hopefully, first- and second-year students will experience trial and error in creating things, while third-year and older students will use their expertise and theoretical knowledge.

2) Student qualifications

All must be KIT students.

3) Rule compliance

Students must understand Yumekobo objectives and requirements and abide by rules on Yumekobo use and project implementation. Students become role models for other students using the facility.

4) Instructors and directors

All project teams must be supervised by a teaching staff member or an engineer instructor or director.

3.2. Launch, Continuation, and Termination

Applications for new projects are accepted year-round. Students must submit proposals and plans for new projects, and after undergoing assessment at KIT, launch these new Yumekobo projects.

Project proposals are classified into those by students, teachers, or companies. Initially, all Yumekobo projects already existing at KIT were upgraded to Yumekobo projects proposed by teachers. Most starting thereafter was proposed by students. Since student independence is respected in projects, it is important that students decide themes on their own. Project themes proposed by companies include embedded software, started as a project promoting cooperation with NEC Software Hokuriku, Ltd.

To continue projects, students must submit plans and budget applications each November. Budget applications are reviewed in meetings with project leaders, assistant leaders, accounting managers, and operating directors in December. Based on the previous year's achievements and plans for the next year, projects are considered for continuation.

The competition principle is required to develop an organization, so a project continuing too long inhibits development. Of the 27 projects launched thus far, 14 were terminated or suspended. To further accelerate development, short-term projects whose periods are preset were set up in 2006. In 2009, two short-term projects were launched and both have already ended.

Table 1. Years Yumekobo projects started.

Year	Project name (number of participants)
1993	Solar car (28)
1994	Human powered airplane (53)
1996	Robot (38)
1997	Fuel economizing car (31)
1999	RoboCup (62), Architectural design (45)
2000	Mechanical support (25)
2002	Formula car (33), Wind power plant (24)
2003	Welfare equipment (29)
2005	Small autonomous airplane (32)
2006	Autonomous car (19)
2009	Embedded software (17)

3.3. Organization and Management

3.3.1. Organization

A management committee promotes Yumekobo project activities, systematically planning, managing, and controlling activities conducted by the entire project. Members of the committee are selected from participating students.

Committee control is divided into 1) safety and environment, 2) personal computers, 3) batteries, 4) substrate fabrication, and 5) resin. The committee ensures a safe environment for activities, maintains tools and equipment, and provides information on safe and correct equipment use.

The management committee currently controls the 13 projects in **Table 1**.

3.3.2. Management

• Management policy

The Yumekobo project is conducted basically by students independently and voluntarily. Students set project targets and plans on their own and are responsible for management and decision-making. Instructors and directors, who are teaching staff, advise and support student efforts.

• Overall activities

To manage projects smoothly, monthly meetings are held among project leaders and management committee control division representatives. Monthly safety and anticrime patrols are conducted around the university to prevent crimes such as theft and intimidation and to maintain and promote safe environments. **Table 2** shows annual activities.

• Individual project activities

Each Yumekobo project has a student leader, an assistant leader, and a manager under whose leadership project participants create things from planning, investigation, and design to fabrication, analysis, and evaluation in team activities as shown in **Fig. 1**. Students manage tasks such as budgeting, ordering, and scheduling corresponding to corporate project work. Students thus experience project management throughout the Plan-Do-Check-Act (PDCA) cycle.

In project meetings of students including supervisors held every two weeks. Students confirm progress and plans, while reporting potential and actual accidents so that sharing this information helps prevent accident recurrence. Sharing space and information, activities are all conducted in the same big room and meeting materials and records meeting are stored in a common file server and posted on a bulletin board for everyone to access.

The yearly schedule includes the November submission of activity plans and budget applications for the next academic year. Individual projects are studied for whether they should be continued, taking into account the previous year's results, plan contents for the next year, and the number of participants. For continued projects, the next year's budgets are determined in negotiations with project leaders, assistant leaders, managers, and directors. Budgets are allocated based on achievements such as contest results to promote competition among projects.

Table 2. Annual schedules.

April	Project Management Orientation: An orientation session on project management is conducted for leaders, assistant leaders, and managers of each project, and representatives of each control division at the beginning of the academic year.
	Project Orientation: Orientation sessions for the entire project and individual projects are conducted for first-year and other students.
May	Project Activity Experience: Students experience activities in projects they are interested in, and decide whether they will participate.
June	Questionnaire Survey: Conducted to improve student activities.
July	Evacuation Drill, First-aid Training, Cleaning: Students take part in activities such as evacuation drills and emergency first-aid training.
August	Science School: Students work as assistants in science class experiments.
October	Intermediate Reporting: Each project team reports progress in activities, seeking advice from teachers, to promote activities.
November	Activity Plan, Budget Document, Evacuation Drill, First-aid Training: Activity plans and budget application are submitted.
December	Budget Negotiation, Cleaning: Students negotiate with teachers on budgets.
February	Supplementary Budget: Budget documentation is submitted to adjust excesses and deficiencies in budgets.
March	Public Meeting: Each project team makes presentations on annual activities to invited sponsoring companies, parents, and others concerned with the project.
	Activity Report: Each project team submits a report on the summary of annual activities.

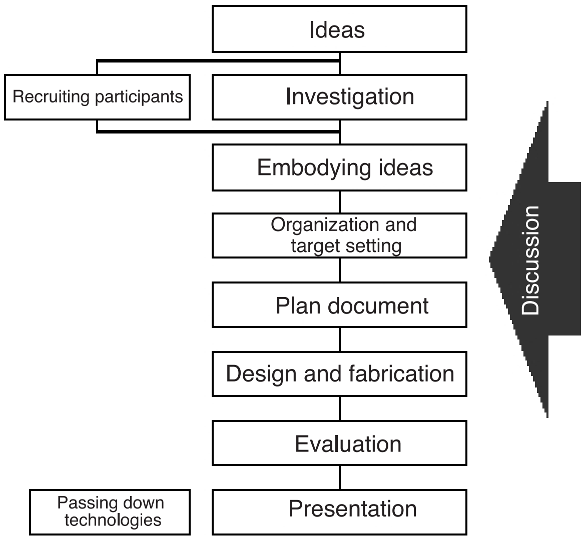


Fig. 1. Activity (excerpted from Yumekobo Operational Rulebook 2010).

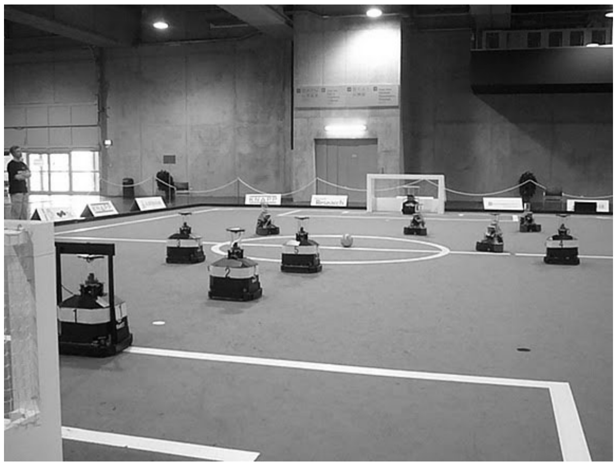


Fig. 2. Scenery from the RoboCup middle size league – KIT team on the near side.

Yumekobo project teams wanting to take part in a competition must submit plans at least one month ahead so that engineers can study the plan to determine whether the technical level is high enough to compete. This examination is strict, and teams that do not pass cannot compete. RoboCup project participants once cancelled to take part in the international contest because they failed the examination. This strictness helps ensure good results for teams in competition. After competitions, teams submit reports on results.

At the end of the academic year, students make presentations to those concerned in the project, including sponsoring companies. They also submit reports on annual activities, achievements, and reflections on what they have done. The Yumekobo project thus includes both creative technical work and organizational events such as meetings, presentations, documentation, and reporting fostering student abilities in adapting to society through personal and interpersonal skills.

3.3.3. Project Introduction

A number of robotics and mechatronics projects are introduced in the sections that follow.

• Robot project

The robot project was launched in 1996 to acquire robot manufacturing knowledge and techniques. Students are divided into a university robot contest group and a team Robot with Intelligence Development (RID) group, each designing, creating, and examining robots based on their own ideas. The university robot contest group targets wins in international robot competition such as the ABU Asia-Pacific Robot Contest and receiving the ABU Robocon Award – the contest's top prize. Team_RID develops self-contained pet robots able to communicate with people, targeting robot coexisting with human beings.

• RoboCup project

The RoboCup project was launched in 1999 targeting RoboCup. Its ultimate goal is for a team of autonomous robots to win in games with the 2050 FIFA World Cup champion team. Students develop 5 wheeled robots for the middle-size robot league (see **Fig. 2**), three 60 centimeter tall robots for the kid-size humanoid league, and one 150 centimeter tall robot for the adult-size humanoid league.

• Mechanical support project

Launched in 2001, the mechanical support project targets developing large-scale disaster rescue robots for use in occurrences such as the Great Hanshin Earthquake. The project team is divided into a group for developing practical devices and a group to take part in the Rescue Robot Contest for testing rescue systems.

• Welfare equipment project

The welfare equipment project was started in 2003 to develop machines and equipment technically supporting self-reliant efforts by those who are physically or mentally challenged in such areas as rehabilitation. Students are currently developing artificial myoelectric arms with multifingered hands similar to human hands that are easily adjusted and repaired through modularization.

• Autonomous car project

The autonomous car project was launched in 2006 to acquire specialized skills in mechanical engineering, control engineering, sensing engineering, electrical and electronic engineering, programming, and similar fields through autonomous vehicle control R&D. The original target was to participate in the DARPA Urban Challenge in the United States, but at present is to complete Real World Robot Challenge race in Tsukuba City.

3.4. New Initiative of Yumekobo Project: Collaboration with Companies

3.4.1. Background

To further improve education and research, KIT conducted a questionnaire on companies graduates had been hired by to clarify the relationship between the types of engineers that companies require and the actual capability of KIT graduates. Results showed that graduates must have high-level abilities to perceive things from different perspectives, to establish hypotheses, to communicate with others, to work cooperatively, etc. To further the Yumekobo project, KIT set up a new Yumekobo project in 2007 to collaborate with companies based on know-how from past projects.

3.4.2. Purposes and Features of Yumekobo Projects Collaborating with Companies

The project purposes remain the same for all Yumekobo projects. Most distinctively companies and KIT jointly educate students, making projects totally different from conventional joint research and internships. One of the projects' advantages is that students can acquire the latest knowledge and know-how from company engineers and use these in Yumekobo projects, thus passing techniques down. A further objective is to make Yumekobo projects technical state-of-the-art activities.

3.4.3. Project Contents and Implementation

In education for these projects, students experience and are involved in all corporate product development phases, including setting targets, design, fabrication, experiments, evaluation, improvement, and related work such as setting schedules and managing progress, budgets, and meetings. Program themes are set to cover many fields to enable students in different academic years, whether first-year or graduates, to take part in and actively manage projects.

The educational program is developed through discussions with teaching staff, company managers, and engineers. Contents are determined by transforming company engineers' ideas and methods in developing products into university education. In the program, company engineers must provide viewpoints and take part in student activities to realize cooperative industry-university education. Students take part in both corporate and campus activities to actually experience the tension company engineers feel in solving problems by creating new ideas based on knowledge and know-how accumulated over time. Such activities enable students to enhance their ability to judge situations.

3.4.4. Project Examples

Eight projects have been started working with companies, typified by the examples below related to robotics and mechatronics.

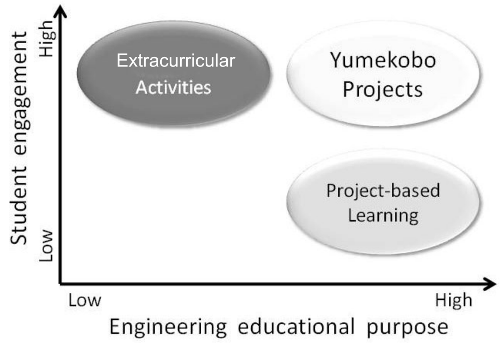


Fig. 3. Positions of Yumekobo projects.

- Laser sensor project

Working with Hokuyo Automatic Co., Ltd, the laser sensor project started in 2009 for students to learn laser sensor techniques. Yumekobo project students first suggest various ideas using laser sensors. They then actually develop systems based on their ideas and the advice and guidance of company engineers. This process lets students create things in an environment not experienced in campus activities alone.

- Embedded software project

Working with NEC Software Hokuriku, Ltd., the embedded software project started in 2009 for learning embedded software techniques, including Unified Modeling Language (UML) for software development. Students take part in the embedded technology software design robot contest in which participants experience and learn the entire software development process to evaluate embedded software created in the project.

3.5. Positioning of Yumekobo Project

Figure 3 shows the positioning of Yumekobo projects compared to Project-Based Learning (PBL) [2, 3] included in the curriculum and extracurricular student activities, e.g., club activities.

The most obvious difference between the two is the philosophy for establishment. Yumekobo was established to provide an environment for young engineers to realize their dreams and the Yumekobo project is a way to achieve this purpose.

Both Yumekobo projects and PBL operate systematically in education. They are similar in that specific tasks are set and students work independently over time on tasks through planning, investigating, solving problems, making decisions, designing, fabricating, evaluating, etc.

The Yumekobo project differs as an extracurricular activity whose achievement does not provide credits, e.g., toward graduation or a thesis. Students voluntarily take part in projects only because they like them, displaying active initiative in projects. Due to the difference in eagerness toward activities, for example, students spend much more time on Yumekobo projects than on PBL.

PBL involves group activities conducted by small numbers of students.

Yumekobo projects involve large number of students tackling difficult tasks, requiring participants to have higher management capability.

Yumekobo projects and extracurricular club activities differ in purpose and operation. The Yumekobo project objective involves engineering education in line with educational targets at KIT, so projects are included in educational programs. Most Yumekobo projects are operated systematically.

Most club activities are conducted similar to hobbies and individual clubs where targets and manage activities are set separately, with little club interaction.

Yumekobo projects become engineering education based on educational targets, so technical and operating support are provided systematically. Projects are also strongly interrelated. These advantages may lead to the excellent achievements projects are known for.

Educational systems such as the Yumekobo project use extracurricular time effectively to develop student personal and interpersonal skills and are introduced easily at universities. In the Yumekobo project, students develop deep relationships through opportunities to talk and eat with other students thanks to post-classroom group activities up to 21:00 on weekdays, 17:00 on weekends, and during long vacations. Students finding it difficult to develop such deep relationships can foster interpersonal abilities by experiencing these opportunities. The Yumekobo project thus encourages an educational effect resembling effects nurtured in dormitory life, such as Harvard University and MIT.

4. Educational Content

The sections below discuss the Yumekobo project from the perspective of educational content.

4.1. Education Improving Personal and Interpersonal Skills

We define personal and interpersonal skills as the ability to adapt to society, which includes five elements – autonomy, leadership, communication, presentation, and collaboration.

1) Autonomy

As stated, Yumekobo projects are mainly managed by students, thus enabling students to enhance autonomy through activity.

2) Leadership

Leaders, assistant leaders, manager, and group leaders in projects must lead other participants in achieving targets. They develop leadership through trial and error in daily group activities.

3) Communication

To enhance communication skills, students conduct discussions with other participants in the projects and with teachers in biweekly meetings and budget negotiations. In collaborative projects with companies, students improve interpersonal skills through close communication with company engineers, which is essential to projects. Yumekobo project teams take part in international competition yearly. Students therefore keenly feel pride in being Japanese when they won championship because they are a delegate of Japan. They realize the importance of being able to communicate and negotiate in English.

4) Presentation

Students must make presentations of reporting activity plans and progress in biweekly meetings. Other opportunities also arise for presentations, such as in intermediate reporting and in public meetings and demonstrations at campus open day. In public meetings, project teams make oral presentations, poster sessions or demonstrations to audiences including invited guests. Students carefully prepare and train for these through repeated practice with teachers, dramatically improving their presentation skills.

5) Collaboration

Yumekobo projects are based on team activities addressing tasks not achievable by individual efforts, so students develop the ability to cooperate with others daily. As stated, Yumekobo projects have a system and accumulated know-how to enhance student personal and interpersonal skills.

4.2. Technical Education

Succeeding in domestic and international technical competition requires a high level of technology and management skill. KIT conducts three types of education harbored in the Yumekobo project.

1) Specialized education by teachers

The Yumekobo project has two types of training courses – Yumekobo licensing and skill improvement. Licensing consists of 11 regular courses based on creating safety education, appropriate machine tool use, printed substrate fabrication, and circuit design. Skill improvement consists of 15 courses for upgrading students' skills in nonferrous metal welding, H8 microcomputers use, structural analysis and probabilistic robotics, each course being held annually.

2) Management education by teachers from companies

In skill-improvement courses, management know-how is taught based on the experience of teachers from companies.

3) Education by students among project participants

According to William Glasser, a person can acquire 50% of content in conventional lecture-based education, 70% in discussions with others, 80% experiencing learning, and 95% in teaching others. In Yumekobo projects, education among students is promoted to enhance educational effects.

In the RoboCup project, for example, fourth-year students teach C++, a computer language required to use intelligent robots, and Linux, a basic computer system, to first-year students in the first semester. These subjects are not included in the Robotics Department curriculum. During summer vacations, fourth-year students teach first -year students intensively through lectures and practice using machine tools and design software such as CAD, enabling first-year students to acquire at least minimum knowledge and techniques required for creating robots half a year later. In the autonomous car project, a collaborative project with companies, students review source code weekly as instructed by company engineers. In the robot and mechanical support projects, competitions among project participants are held to increase first-year student skills. After acquiring basic skills, both third- and fourth-year students jointly undertake projects through On-the-Job Training (OJT). Voluntary education among students is not limited to subjects related to projects, and third-year students can ask fourth-year students about lectures at the university.

5. Results and Evaluation

This section evaluates Yumekobo project educational effects by reviewing results in competitions and questionnaires on education.

5.1. Results

Yumekobo project teams have achieved remarkable results both in domestic and international competition, as shown in **Table 3**. The solar boat project team won the Solar Splash world championship four times. The solar car project team won the overall 1997 Solar Car Suzuka championship and 5th place overall in the 1999 World Solar Challenge – top among Japanese teams.

Since 2002, robotics and mechatronics projects have achieved excellent results. The robot project team took part in the international ABU Asia-Pacific Robot Contest four times and won the top ABU Robocon Award once, and the Best Engineering Award twice. The team also won the NHK Robot Contest first and second prizes twice, becoming one of Japan's strongest teams.

The RoboCup project won second prize three times in the Middle-Size League in the RoboCup World Championships and first prize once and second prize three times in the same league in the RoboCup Japan Open. The team also won second prize in the Humanoid League in the 2010 RoboCup Japan Open and took part in international competition.

The mechanical support project team won the Fire and Disaster Management Agency Award of Commissioner twice, the Robotics Society of Japan's Best Robot Award once, and the Rescue Robot Contest Best Teamwork Award once. The team was invited to help demonstrate the Rescue Robot Contest at the SICE Annual Conference 2010 in Taiwan.

Table 3. Main project achievements.

Projects	Results
Solar boat	1994–1996, 1999: Solar Splash, Collegiate world champion
Solar car	1997: Solar car race SUZUKA (Champion) 1999: World Solar Challenge (5th place)
Robot	2002: NHK robot contest (Vice champion), ABU Asia-pacific robot contest (ABU Robot contest award) 2007: NHK robot contest (Champion), ABU Robot contest (Best Engineering award) 2009: NHK robot contest (Vice champion) 2010: NHK robot contest (Champion), ABU robot contest (Best Engineering award)
RoboCup	2002–2004: RoboCup world competition, Middle-size league (Vice champion) 2003: RoboCup Japan Open, Middle-size league (Champion) 2009, 2010: RoboCup Japan Open, Middle-size league (Vice Champion) 2010: RoboCup Japan Open, Humanoid league (Vice Champion)
Mechanical support	2009: Rescue robot contest (Best robot award) 2010: Rescue robot contest (Best teamwork award)
Autonomous car	2007: Tsukuba challenge (Completed the race, Tsukuba mayor award)

The autonomous car project team became one of three teams completing the 2007 Tsukuba Challenge in Tsukuba City, which the remaining teams did not finish. The team was awarded the Mayor of Tsukuba Award.

These achievements underscore Yumekobo project education effectiveness.

5.2. Evaluation

5.2.1. Methods

To determine student awareness of the Yumekobo project, annual surveys – called Survey A – have been conducted since 2002 for all students taking part in these projects. In 2010, the survey was conducted in June and 285 students responded. A further survey – called Survey B – for students taking part in projects related to robotics and mechatronics, projects for robots, RoboCup, mechanical support, and autonomous cars, was conducted in February 2011 to monitor personal and interpersonal skills, technical capability and time devoted to activities. Survey B was answered by 86 students.

5.2.2. Participant Numbers

The undergraduate program student quota is 5,920. For academic 2010, 6,675 students were enrolled in undergraduate programs. Including graduate students, this became 7,143. **Fig. 4** shows trends in participant numbers in Yumekobo projects and the number of projects. In 1994, solar cars and solar boats, originally developed as part of the university curriculum, were incorporated into the Yumekobo project, and new projects for human-powered

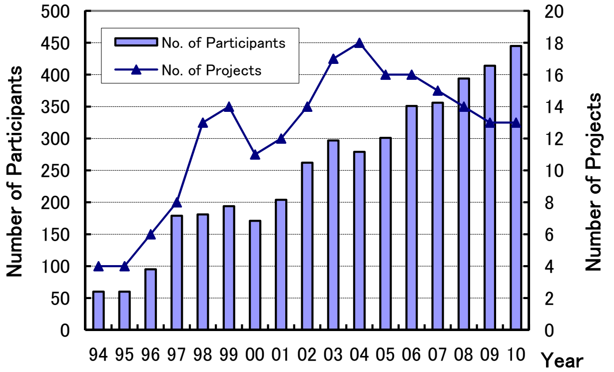


Fig. 4. Trends in numbers of project participants.

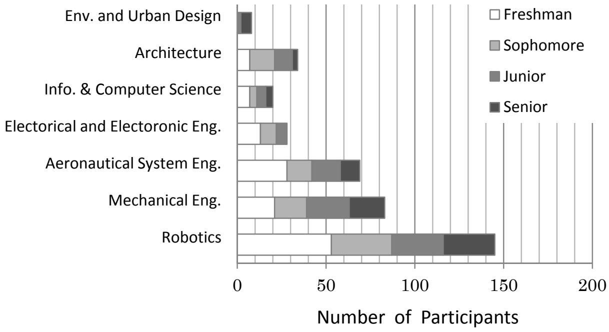


Fig. 5. Numbers of participants by department and scholastic year.

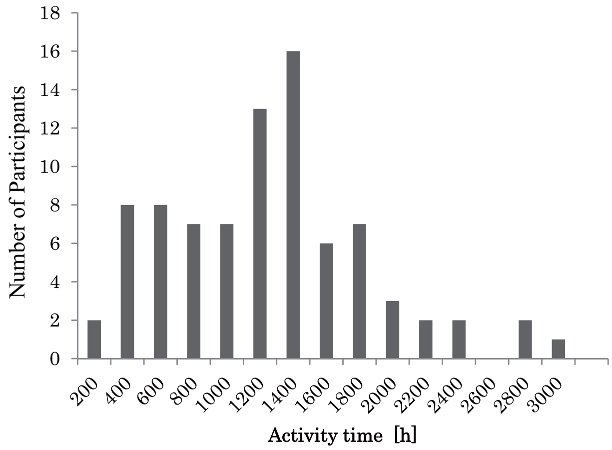


Fig. 6. Histogram of annual activity time.

Table 4. Activity time.

Projects	Per Week		Annual Activity Time
	During Semesters	During Vacation	
Robot	38.3	63.7	1990
RoboCup	19.1	34.0	1019
Mechanical Support	23.1	30.1	1100
Autonomous Car	9.4	18.4	522

aircraft and human-powered boat started. The number of projects increased yearly, peaking in 2004 at 18 and decreased to 13 thereafter as the number of participants in projects decreased. Participant numbers steadily grew annually from 60 in 1994 to 445 in 2010 – accounting for 6.2% of all KIT students.

Figure 5 shows participants by department and scholastic year, most belonging to the three mechanical departments of Robotics, Mechanical Engineering, and Aeronautical System Engineering. The Department of Robotics had the largest number of participants at 145 and also the top participation rate (28%) vs. the department's student quota. Department of Aeronautical System Engineering participation peaked at 25% and the Department of Mechanical Engineering's at 8%. Overall department participation was 6.2%. Since the names of the Department of Robotics and the Department of Aeronautical System Engineering indicate specific research targets, most students entering these departments may have a strong sense of purpose leading them to participate actively in the Yumekobo project. Students of these three departments accounted for 74% of all participants in 2005, which decreased to 61% in 2010 – indicating that more students belonging to other departments are now taking part in Yumekobo projects.

By scholastic year in 2005, graduate students accounted for 3%, fourth-year students for 10%, third-year students for 22%, second-year students for 28%, and first-year students for 37%. In 2010, corresponding numbers were 9%, 16%, 21%, 20%, and 34% – results showing that differences among ratios by scholastic year had decreased from five years earlier.

In summary, the number of participants in Yumekobo projects has increased yearly – particularly in departments other than mechanical engineering departments. A rising participation rate among graduate students indicates that the range of participants in Yumekobo projects has broadened to include students in all scholastic years at KIT – showing how projects have achieved steady development.

5.2.3. Activity by Hours of Time

Participants in Yumekobo projects are active after class until 21:00 on weekdays and from 09:00 until 17:00 on Saturdays during the semester. Except for mealtimes, they are active 22 hours per week, or 660 hours annually (22 hours $\times$ 30 weeks). During vacations, they work 42 hours per week, or 504 hours annually (42 hours $\times$ 12 weeks). In total, 1,160 hours are available per year for students' activities.

Figure 6 and **Table 4** show Survey B results. In the RoboCup and mechanical support projects, annual activity was about 1,000 hours – almost the same as the above calculated time. The robot project team is particularly hardworking, spending up to 2,000 hours yearly in activities. Students working over 2,000 hours, as shown in **Fig. 6**, took part in the robot project. Students apply to extend activity time, as shown in **Table 5** for 2010. Results show that robot and RoboCup project participants often took extended time in addition to regular activity time.

Since figures in these tables are averages, students working over 2,500 hours accounted for 3.5% and for

Table 5. Extended time from January to December 2010.

Projects	Extended Time	Total Number of Applicants
Robot	526	2121
RoboCup	423	741
Mechanical Support	119	488
Autonomous Car	62	96

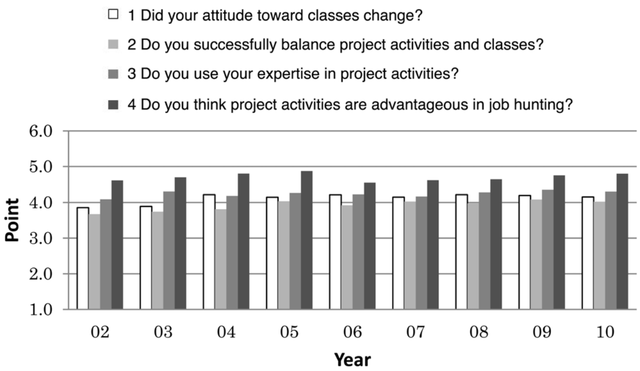


Fig. 7. Relationship between project activities and classes.

over 2,000 hours accounted for 7%. Such total student activity, including the four-year undergraduate program and graduate program, may reach 10,000 hours – equal to the time worked by a top professional engineer. Cognitive psychologist K. Ericsson et al. compared the practice time of violin students at Berlin University of the Arts between those expected to become professional violinists and those who at the level of music teachers. Total professional violinists practiced 10,000 hours, plus on their own time, which averaged over 24 hours per week. Music teacher, in contrast, practiced an average 9 hours per week [4]. One report held that practicing 10,000 hours is required not only for musicians but for professional athletes, writers, and chess players hoping to achieve the world's highest level [5]. Among participants in Yumekobo projects, some reached 10,000 hours. The abundance in activities is believed to prove the excellent results of Yumekobo projects.

5.2.4. Classes and Employment

Figure 7 shows Survey A questions and answers on the relationship between project activities and classes. Answers were classified into six items, from 1.0, completely disagree, to 6.0, completely agree. Points for answers to the question "Did your attitude toward classes change?" averaged 4.2 and to "Do you successfully balance project activities and classes?" averaged 4.0. These results show that Yumekobo projects benefit students' attitudes toward classes and that students think they maintain a good balance between project activities and classes. **Fig. 7** shows that answers to the question on advantages in employment marked the highest points, averaging (4.7). This means that students find project activities an advantage in job hunting.

Figure 8 shows courses after graduation of fourth-years taking part in Yumekobo projects and those of other fourth-years students in academic year 2010. Among participants in Yumekobo projects, 40% enrolled in graduate school, while 24% entered major companies. Some 20% of nonparticipants enrolled in graduate school and 13% entered major companies. The ratio of Yumekobo project participants was twice that of nonparticipants, both in graduate school and major companies. Despite the recent harsh situation for graduates seeking jobs with major companies, Yumekobo project participants achieved better results.

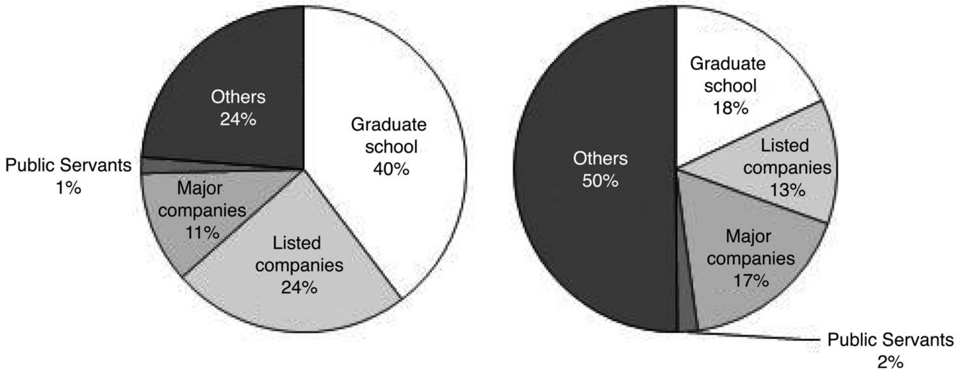
This achievement was not necessarily due to better grades of Yumekobo project participants than those of nonparticipants. When comparing Quality Point Average (QPA) – the average grade point in all subjects – between 55 participants in Yumekobo projects and 272 nonparticipants out of 327 fourth-year students in mechanical engineering departments, no significant difference was seen between the two, with participants scoring 2.63 and nonparticipants 2.51. In short, the large gap in employment may be due to personal and interpersonal skills of Yumekobo project participants highly evaluated by major companies. Students taking part in Yumekobo projects achieved higher employment than nonparticipants.

5.2.5. Technical Capability and Personal/Interpersonal Skills

Survey B asked students whether Yumekobo projects were useful in improving technical capability and personal and interpersonal skills. Answers were classified into six from 1.0 to 6.0 – 4.0 or more points meaning useful and 3.0 or fewer meaning not useful. Points for technical capability and personal/interpersonal skills averaged 4.6 and 4.4, indicating that projects effectively improved both skills.

The survey asked the same questions on compositional elements of the above two skills. **Fig. 9** shows that Yumekobo projects were useful in improving all elements. Viewed by overall trends, the average point for elements among first-year students and second-year students was 4.2, while that for third- and fourth-year students was 4.8, indicating that students in higher scholastic years thought projects were useful. Fourth-year students stated that projects were useful for improving personal and presentation abilities, which is because more opportunities existed for fourth-year than third-year students to use these abilities.

When students were asked which system or process improved their personal and interpersonal skills, they mentioned team activities, meetings with teachers, project management by students, creation of documents for plans and budgets, budget management, presentations at meetings and school festivals, etc. The system or process students thought useful for improving their technical capability included license courses, skill-improvement courses, education among project participants, and support by engineers.



(a) Participants in Yumekobo projects (b) Nonparticipants in Yumekobo projects

Fig. 8. Comparison of courses after graduation.

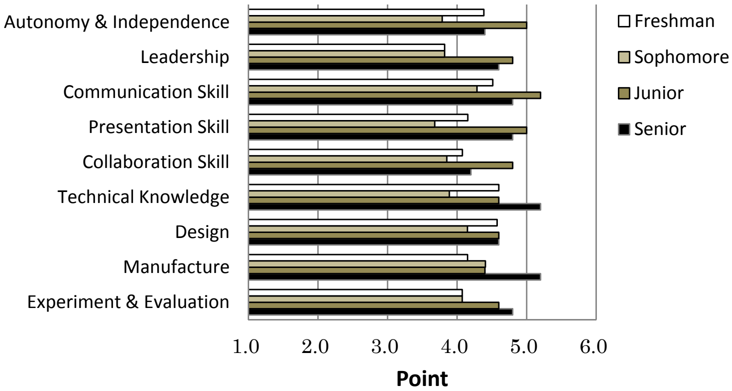


Fig. 9. Evaluation by elements of personal/interpersonal skills and technical capability.

Regarding requests for further improvement, many students mentioned facility developments such as expanding common workrooms to accommodate increased numbers of participants and the installation of new machine tools. For systems, students requested the development of a system promoting technical interaction with other projects and support for specialized techniques.

Figure 10 shows the degree of overall satisfaction with Yumekobo projects based on Survey A. With a maximum 6.0, higher points meant higher degrees of satisfaction, with the target of points for satisfaction 5.0. The degree of satisfaction has risen yearly, and projects may be said to have been managed effectively.

The target point of 5.0 was never achieved, incidentally. We are working to further enhance satisfaction by improving activity environments and reviewing opinions in leaders' meetings, project meetings, and questionnaire surveys.

In short, in the 18 years since Yumekobo was set up, Yumekobo project education is nearly completed and mature. The project has achieved consistent results and high satisfaction among participants. We now plan to respond to the increased number of participants. Due to physical limitations in facilities and the number of engineers supporting students, measures are needed to make this possible. One solution to these problems lies in collaborating with companies – an element expected to further grow in the future.

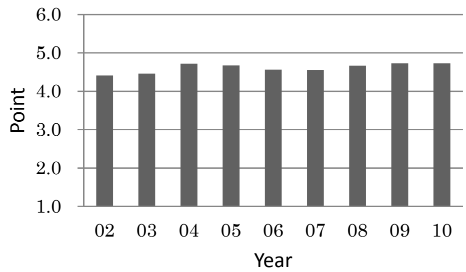


Fig. 10. Degree of overall satisfaction.

6. Conclusions

We have detailed the Yumekobo project – the most creative and unique function of Yumekobo as a symbol of education at KIT. The essence of Yumekobo projects is education in which students play a central role and voluntarily work to improve technical capability and personal and interpersonal skills. Many project teams have achieved their dreams, such as winning championships in international or domestic competition, and project participants continue to be active in the front lines after graduation.

Yumekobo is a place to acquire both the knowledge and technology needed to create things. It is also a place for fostering student personal and interpersonal skills not taught well enough in current high school education. Yumekobo thus serves as a model for engineering education in the 21st century.

References:

[1] B. Kantrowitz, "Learning the hard way," Newsweek International Edition, September, 2003.

[2] B. Barron, "Doing with understanding: Lessons from research on problem- and project-based learning," J. of the Learning Sciences, Vol.7, pp. 271-311, 1998.

[3] J. Mergendoller, "Project Based Learning Handbook," 2nd edition, Buck Institute for Education, 2006.

[4] K. Ericsson et al., "The role of deliberate practice in the acquisition of expert performance," Psychological Review, Vol.100, No.3, pp. 363-406, 1993.

[5] D. Levitin, "This Is Your Brain on Music," Plume-Penguin, 2007.

Name:
Kosei Demura

Affiliation:
Professor, Department of Robotics, Kanazawa Institute of Technology

Address:
7-1 Ohgigaoka, Nonoichi, Ishikawa 921-8501, Japan

Brief Biographical History:

1996 Ph.D. from Keio University
1996 Research Fellow, the Japan Society for the Promotion of Science
1997- Assistant Professor, Kanazawa Institute of Technology
2003-2004 Visiting Scholar, Massachusetts Institute of Technology
2007- Professor, Department of Robotics, Kanazawa Institute of Technology

Main Works:

• "Robot Simulation – A Robot Programming by Open Dynamics Engine –," Morikita Publishing Co., Ltd., 2007.

Membership in Academic Societies:

• The Robotics Society of Japan (RSJ)
• The RoboCup Japanese National Committee

Name:
Takumi Sakamoto

Affiliation:
Chief Technical Staff, Project Education Center, Kanazawa Institute of Technology

Address:
7-1 Ohgigaoka, Nonoichi, Ishikawa 921-8501, Japan

Brief Biographical History:

2001 Bachelor from Kanazawa Institute of Technology
2002- Chief Technical Staff, Project Education Center, Kanazawa Institute of Technology

Membership in Academic Societies:

• The Japan Society of Mechanical Engineers (JSME)

Name:
Yasuki Asano

Affiliation:
Chief Technical Staff, Project Education Center, Kanazawa Institute of Technology

Address:
7-1 Ohgigaoka, Nonoichi, Ishikawa 921-8501, Japan

Brief Biographical History:

1985- NEC Scientific Information System Development, Ltd.
1996- Engineer, Factory for Dreams and Ideas, Kanazawa Institute of Technology

Membership in Academic Societies:

• The RoboCup Japanese National Committee

Name:
Masakatsu Matsuishi

Affiliation:
Professor, Academic Foundations Programs, Kanazawa Institute of Technology

Address:
7-1 Ohgigaoka, Nonoichi, Ishikawa 921-8501, Japan

Brief Biographical History:

1969 Dr. Eng. from Osaka University
1966-1998 Director, Electronics & information Laboratory, Hitachi Zosen Co.
1984-1985 Visiting Research Scientist, University of Iowa
1999- Professor, Dean of Engineering Practice Education, Kanazawa Institute of Technology

Main Works:

• "The Finite Element Method for Designers of Ship Structures," Shueisha Publishing Co., Ltd., 2004.

Membership in Academic Societies:

• The Japan Society of Mechanical Engineers (JSME)
• American Society for Engineering Education (ASEE)