AIIT PBL Method

ADVANCED INSTITUTE OF INDUSTRIAL TECHNOLOGY

AIIT PBL Method

– Implementation of an Innovative Education Curriculum –

*At the time the projects were conducted

Foreword

The Advanced Institute of Industrial Technology (AIIT) has implemented an innovative education curriculum known as PBL (Project Based Learning). PBL is an effective teaching method to develop human resources capable of becoming immediate assets in real life society. Several students form teams, set clear goals and complete a single project that contains operations as close to real life scenarios as possible. Through these experiences, they gain skills and know-how that will be useful in society. In a regular, research-based graduate school, graduation requirements are generally fulfilled by completing a master's thesis. However, with PBL education, there are several large differences, including the fact that activities are undertaken by teams consisting of multiple individuals; assessments are made not only on the deliverables but also the activities conducted during the process; and there are concrete final presentations on the projects' results. In order to practically acquire competency (job performance skills), the university makes it a graduation requirement for students to learn basic knowledge and skills in their first year, and mainly in the second year to engage in PBL education. No other university in Japan has adopted this sort of curriculum, making it worthy of being called an innovative education curriculum. The objective of this paper is to introduce, together with case study examples, the PBL education methodology (AIIT PBL Method) employed at this university, which has engaged in leading-edge initiatives as a frontrunner of PBL development.

1. Why AIIT PBL?

1.1 The chronology leading up to the implementation of PBL

In April 2005, the Public University Corporation Tokyo Metropolitan University was established, and a year later, the Advanced Institute of Industrial Technology (AIIT) was opened. When opening the AIIT, one of the largest issues was what sort of curriculum to establish in a professional graduate school. While the establishment of the AIIT was being considered, a widely discussed topic among many engineering universities was the implementation of a new graduate level major in the field of MOT (Management of Technology). In developing MOT programs, the one area that each university was largely focusing on was "what" to teach and "how" to teach it. Until then, universities used to follow the old style of education where studies were divided into three categories: lectures, seminars and practical training. However, universities endeavoring to implement innovative education programs were engaged in efforts to introduce what was then unconventional teaching approaches, such as case methods and PBL.

Under these circumstances, it was decided that the curriculum – "what" to teach – at this university would be structured around the objective of nurturing advanced IT human resources and advanced professional technicians to respond to the needs of the industry. In considering the "how," the aim was to implement an education method that would be most effective in making the most of the characteristics of a professional graduate school and targeting working graduate students. As a result, it was decided that PBL education would be fully implemented as an educational approach for students in their final year of the professional degree program. The following summarizes the processes that led to the implementation of PBL education.

1.1.1 Research

It became widely known that implementing PBL in engineering university studies produced highly effective results. A young faculty member in the mechanical engineering major at the Tokyo Metropolitan University Graduate School was granted the Fulbright scholarship and studied for a year as an exchange student at Stanford University. He conducted research on PBL education and obtained extensive knowledge on how to implement PBL in Japan. Separate from this, the Tokyo Metropolitan Institute of Technology was conducting remote PBL studies in a collaboration with Stanford University since 1998 using the internet. In this way, the two universities, which would eventually merge with Tokyo Metropolitan University, had each already begun independent investigative research and practical implementations of PBL education.

In particular, a visit to the Eindhoven University of Technology in Holland produced helpful results. The visit was prompted by the news that a new curriculum merging mechanical engineering and design had been established. The studies in that course are all conducted

through PBL education. Lecture classes do not exist in the curriculum. Students acquire all their knowledge, skills and competency by working on projects in project teams. Naturally, new students lack the knowledge necessary to complete projects, and they are helped by instructors who provide them with simple explanations. In order to acquire the body of knowledge necessary to complete a given project, they teach students the ability to study on their own, such as by explaining what sort of materials exist, what they are, and what sort of references to check in order to research them. Students acquire the knowledge required to resolve the problems they face on their own. Of course, the instructors carefully answer questions from the students, but the main part of the learning is done by the students. The instructors are only there to support them. In our two-day research, students in their final year helped us and I still remember what one of them said: "After I graduate, I will be working for a certain company. Thanks to studying at this university, I am confident that I will be able to identify and resolve problems in team activities through self-studies."

1.1.2 Advanced preparations

The university was opened following such research, but it was first necessary to identify a variety of issues prior to fully implementing PBL education at the graduate school. Under these circumstances, the "Experiential Studies Graduate Course" was held in the first year of the university's opening. In this course, PBL was conducted over 15 blocks in projects formed mainly by working students. Through this, they came up with the theme for the year-long PBL education to begin in the second year.

First, when the course was explained, one working student spoke up, saying, "I work for a company, so I cannot easily disclose ideas to other students. Even if this sort of class were to be held, I wouldn't be able to speak a word." The faculty asked, "What sort of conditions would allow you to participate in this class?" To which the response was, "If participating students were to sign a confidentiality obligation agreement, I would agree to take part." This exchange led to having PBL education participants sign an agreement of confidentiality obligation to reassure other students. Later, the university was registered at the Patent Office to protect the intellectual property rights at PBL results presentation. This meant the intellectual property rights of the results presented at the event would receive protection for half a year.

1.1.3 Education to acquire competency

While proceeding with such considerations, we took notice of Bloom's categorization of education (Taxonomy of Educational Objective: Benjamin Samuel Bloom). The categorization is as follows:

Table 1-1 Bloom's categorization of education

Domains	Type of learning	Final objective
Cognitive domain	Knowledge	Systemization: enhance decision making abilities
Affective domain	Attitude/self	Internalization: improve character
Psychomotor domain	Skills	Automation: be able to automatically perform tasks without conscious thought

As this table shows, curriculums centered around lectures mainly conduct education in the cognitive domain. It requires students to acquire knowledge and understand it. However, in a professional graduate school, one of its teaching objectives is to have students gain the abilities to resolve practical problems and identify issues. In particular, an emphasis is placed on teaching working students how to resolve issues they actually face in reality. It was for this reason that the university chose to implement PBL education. In regard to this, the university has released the following statement.

"The key point is that we provide education on both practical and experiential levels. The technical issues which we face in the real world are not exercises. Each problem requires a solution that comes from various technologies. Issues in the real world are not simple enough to be resolved only with the acquisition of the systematic knowledge provided by a traditional graduate school education. On the contrary, real issues are so cumbersome and complex that it is difficult even to understand their nature if one is only equipped with traditional knowledge. To equip students with the ability to solve these real issues, the school offers classes that feature a large number of case studies and project-based learning systems."

1.2 PBL education in the Information Systems Architecture major

The Information Systems Architecture major nurtures "information systems architects" who utilize their technical knowledge in information-related fields, namely in the upper processes that connect businesses and information technology. Not only that, they also balance the needs of various stakeholders – such as clients – and design information systems. Human resources on the level of "information systems architects" require advanced job performance skills (competency), and PBL education is most suitable for enhancing such abilities necessary for the job. This section explains PBL methods used in the Information Systems Architecture

major.

1.2.1 Nurturing information systems architects

It has been pointed out before that IT technicians nurtured by the country's universities and other institutes are not always equipped with the skills needed in the industry. When AIIT was first established, there were opinions saying it lacked IT-related personnel, and many projects involving large-scale software developments were reported to have failed. In the past, computer manufacturers did not expect students to acquire IT skills at university. Rather, it was normal for companies to nurture IT personnel through their own education after being employed. However, in the 21st century, companies lost the leeway of being able to conduct IT education on their own and began to strongly seek students who had already acquired IT skills at university. It brought to light the gap between the level of human resources sought by companies and those graduating from universities. The Japan Business Federation (Keidanren) therefore researched the situation at universities in Europe and the US, summarized the issues concerning Japanese university education in a report and made a proposal. (Keidanren: Improving the Education of Advanced Information Communication Human Resources through Partnerships between Industry, Academia, and Government) [Keidanren 2005].

The proposal in this report (Action Plan for Developing Advanced Information Communication Human Resources in Universities and Graduate Schools) clearly states the intention to "have students actively gain practical and real-life experience through project-based learning and others". Additionally, this was also a time when Europe and the US were standardizing the education of IT human resources with a curriculum called "Computing Curricula 2005 [CC2005]". Universities are generally seen as places to teach knowledge, but the importance of equipping students with the skills to work in society led the Information Systems Architecture major to implement PBL education and nurture job performance skills (competency).

The Information Systems Architecture major aims to develop "information systems architects" equipped with practical skills, which was difficult to achieve in traditional university educations. In the Information Systems Architecture major, the "information systems architects" being nurtured are defined in the following way.

"An Information systems architect is an advanced IT professional engineer who develops various information systems (a general term for the systems consisting of computers, networks and such utilized by companies). Thus, the term refers to a wide range of the following job types classified into "strategist", "system architect", "project manager", "technical specialist", and "service manager" specified in the Common Carrier/Skill Framework (CCSF) [IPA2014], and "global specialist" and "business architect" specified in AIIT.

1.2.2 Studies and education objectives in the Information Systems Architecture major

In nurturing such “information systems architects”, the Information Systems Architecture major holds the acquisition of A) knowledge and skills, and B) job performance skills (competency), detailed below, as the objective of its studies and education. The curriculum is designed to allow students to interconnect and acquire such skills.

(A) Acquisition of the knowledge and skills required of information systems architects
- (A1) IT-related knowledge and skills ranging from the basics to varied applications
- (A2) Knowledge of operations in applicable fields
- (A3) Management knowledge and skills
- (A4) Knowledge and skills related to information system development

(B) Acquisition of the job performance skills (competency) required of information systems architects
- (B1) Communication
- (B2) Continuous learning and research
- (B3) Team activities

Students are able to acquire (A) knowledge and skills by choosing from roughly 60 lectures offered in the first year. In order to ensure the comprehensiveness and quality of the knowledge and skills to be acquired, the courses in this major indicate Common Career Skill Framework (CCSF) knowledge elements (BOK) and levels proposed by the Information-technology Promotion Agency (IPA).

The acquired knowledge and skills will then be linked to PBL courses held in the second year. Students will engage in PBL activities geared toward producing ideal human resources as described above, through which they will be able to acquire the (B) job performance skills (competency) necessary to information systems architects. The meta-competencies (B1)(B2)(B3) form the baseline in this major and are common throughout the industrial technology research courses. Below them are seven core competencies (B1-1)(B1-2)(B2-1)(B2-2)(B2-3)(B3-1)(B3-2) unique to the Information Systems Architecture major. They are defined as the following.

- (B1) Communication
  - (B1-1) Systems proposal, negotiation, persuasion
  - (B1-2) Documentation
- (B2) Continuous learning and research
  - (B2-1) Innovative concepts and ideas
  - (B2-2) Needs, social and market perspectives

(B2-3) Problem solving

(B3) Team activities

(B3-1) Leadership and management

(B3-2) Facilitation and balance

In this way, universal meta-competencies and core competencies, comprised of job performance skills for information systems architects, are integrated. Setting these as the learning and education objectives also incorporates the goal of acquiring superior skills in integrated problem solving as well as setting up and resolving challenges.

1.2.3 Model course

The Information Systems Architecture major has determined model courses as shown in table 1-2 for each type of human resources that have been anticipated, together with recommended classes. Students are therefore able to select which classes to take according to their own objectives, and as a result are able to acquire the knowledge elements and levels required of that type of human resource. Each course lists 8 to 17 recommended classes. The recommended classes, sorted by ideal human resource types, are designed so students who take them can acquire the level of knowledge and skills required of each type of human resources. This will allow students to determine which classes to take in order to fulfill their learning and education objectives according to their future careers.

1.2.4 Skills acquisition

PBL is one of the important teaching methods in competency education. Many European universities have already implemented PBL into their curriculums and are producing results in developing efficient human resources. In PBL, students undertake projects using various methodologies to complete given tasks. The important thing is for each student to go through the process and be able to say, “I can now do what I wasn’t able to do before,” “I can apply this to different problems,” and “I was able to acquire competencies.” It is a big opportunity for motivated students to learn new things.

In recent years, the IT industry has shifted from manufacturing operations to service operations. The quality of business in the IT service is determined by the mutual relationship between the service users (clients) and the service providers. IT service providers are expected to demonstrate a high level of service that exceeds their clients’ expectations. In order to do so, employees must have an in-depth understanding of the clients’ business backgrounds. They must provide services that match the industry’s workings and business environments as well as the company’s business principles, culture and so on. The need for IT skills and knowledge is a given, but soft skills such as leadership, communication and negotiation skills are also essential. The Information Systems Architecture major offers a program that allows students

to acquire such competencies through PBL.

Table 1-2: The 7 courses in the Information Systems Architecture major and the skills that can be acquired in each course

Model course	Skills to be acquired
Strategist Course	・ Lead the growth of business value that utilizes IT. ・ Propose and formulate strategies that utilize IT based on the company's business strategy. ・ Propose solutions that conform to the company's management policy to resolve issues.
Systems Architect Course	・ Design a system that is most suited to the business strategy. ・ Receive IT strategies and create a solution, or determine the requirements necessary for the development of a built-in product and design the architecture to materialize it.
Project Manager Course	・ Supervise the construction of a system with high reliability under the given conditions of restraint (quality, cost, deadline, etc.). ・ As the one in charge of the system development project, create the project plan, obtain the necessary members and resources, and carry out the project while taking responsibility of the budget, deadline and required quality.
Technical Specialist Course	・ Be in charge of the implementation in technical domain, such as the database and network. ・ From the designed architecture, construct the most suitable system foundation by designing and structuring the desired system or by utilizing specific skills such as for the network, database, security, etc.
Service Manager Course	・ Maintain the system while ensuring a continuous and high level of reliability. ・ Ensure the stable operation of the constructed system or product and provide services with a high level of stability and reliability such as by keeping damages to a minimum if malfunctions occur. Also conduct checks on the desired function requirements, non-function requirements, reliability and stability of the constructed system or product.
Global Specialist Course	・ As companies go global, resolve the issues of the system users, system managers and stakeholders. ・ Perform operations (presentation of principles, strategy proposals, management, product development, etc.) in specialized fields in a global environment (multinational enterprises, international organizations, offshore, etc.)
Business Architect Course	・ Utilize IT, product development and management skills in next generation growth industry fields (those such as tourism, sales of goods, and medicine that have been pointed out as having low productivity and low value-added) to prompt business metabolism, and trigger innovation by undertaking business developments, reforms and renovations.

1.3 PBL education in the Innovation for Design and Engineering major

The vision of professional human resources in the Innovation for Design and Engineering major requires students to acquire a number of more skills in addition to knowledge. We believe PBL is the best learning method to acquire such skills effectively and efficiently. The

next sections will describe the vision of ideal human resources produced by the Innovation for Design and Engineering major and will explain the competencies and skills needed to fulfill that vision. According to theories of education, the acquisition of these skills has always required practice by repetition of both body and mind. From this viewpoint, it will be explained why PBL is the learning method most suited to accomplish this goal.

1.3.1 Type of human resources produced by the Innovation for Design and Engineering major

As published on the university's homepage, the vision of human resources produced by the Innovation for Design and Engineering major is described as the following [AIIT 2016].

- Engineers who are able to identify the latent expectations of the market, present the future vision to customers, and envision the ideal characteristics of next generation products and services (product planning managers).
- Engineers who are able to manage all processes from optimal design to manufacturing while actively using their expertise in sensitivity design and in functional design (product development managers).

This major aims to nurture human resources who possess both these occupational abilities and are able to organize manufacturing specialists, intuit the client's latent expectations, create mechanisms that realize functions by utilizing one's sensitivity, and provide new, material value to people. In other words, human resources who are capable of creatively and reasonably developing products or services that maximize the client's benefits.

The importance of producing this type of human resource has also been addressed from different perspectives [Nobeoka 2015] [Nobeoka 2016a] [Nobeoka 2016b]. This survey focused on and analyzed computer products, household electronic goods, automobiles, etc. to find examples of what is succeeding as businesses in this modern age. It found that, for products or manufactured goods to be a success, they must have an integrated value stemming from a combination of design and engineering. Companies that develop such products actively nurture and allocate personnel known as design engineers who possess new abilities founded on a solid understanding and mastery in both design and engineering. Furthermore, reports indicate that it is a requirement for management class employees to possess both these qualities. For this reason, England, which has demonstrated successes through innovation policies in recent years, is promoting, through policies, the creation of an educational program where students can study an integrated combination of engineering, design and business. However, it is still rare to be able to find an educational institute anywhere in the world where students can effectively study these three subjects in one compact department (curriculum, major, etc.).

The Innovation for Design and Engineering major further expands on the meaning of this sort of design and labels it sensitivity design, while engineering that leads marketing is defined as functional design. The major contributes to developing human resources who can effectively

combine the two types of designs and further add service value (usage value) to produce the sort of attractive products and manufactured goods that the market is looking for. Furthermore, the major also includes a significant number of technical management courses with the aim to produce human resources who are capable of becoming managers. An educational institute where students can effectively and efficiently study these three fields is rare even on a worldwide scale and adds to the attractiveness of the major. The next section explains the skills necessary to human resources who are active in these three fields.

1.3.2 Skills necessary for studies

The aforementioned skills acquired by human resources from the Innovation for Design and Engineering major enable them to oversee upper and lower processes while also designing and producing market acceptable products and goods. In order to nurture and produce human resources capable of this, the major holds the following five core competencies as requirements and provides a curriculum for students to acquire those skills.

The major measures the abilities of the human resources it nurtures according to the above-mentioned competencies. However, there is also a Tokyo original industrial design field standard [JDP2016] formulated in a joint effort by the faculty of AIIT and the Tokyo Metropolitan Government Bureau of Industrial and Labor Affairs. Interested readers are encouraged to look into it.

Table 1-3: The 5 core competencies determined by the Innovation for Design and Engineering major

1. Creative ability	1.1 Plan proposal skills 1.2 Requirement defining skills 1.3 Creativity
2. Expressive ability	2.1 Presentation skills 2.2 Lingual visualization skills 2.3 Non-lingual visualization skills
3. Design skills	3.1 Functional design skills 3.2 Sensitivity design skills 3.3 Functionality and sensitivity integration skills
4. Development skills	4.1 Development planning abilities 4.2 Realization abilities 4.3 Test and assessment skills
5. Analysis skills	5.1 Usability assessment skills 5.2 Market research skills 5.3 Work process analysis skills

In order to acquire the above competencies, theoretical knowledge is of course necessary, but skills acquisition is also essential. Below is a list of some of those necessary skills.

- Creative ability: Visualize ideas and share the understanding with others by moving one's hands and engaging the senses of sight and touch to the maximum. This skill is not limited to canvas drawings and creating clay models, but also includes 3D-CAD software, 3D-CG software and 3D printers.
- Expressive ability: Requires students to not only conduct presentations using projectors, but also to acquire skills utilizing the body and senses, such as body-storming and using models.
- Design skills: The above-mentioned skills are necessary when mastering design tools such as electrical, electronic and machine circuit software, construction simulation, and human psychoanalysis (satisfaction, eagerness to buy).
- Development skills: When theoretically or practically developing mockups, prototypes and models, it is oftentimes necessary to utilize tools and machines, necessitating physical and sensory skills.
- Analysis skills: Conversation skills and expression reading skills are necessary when interviewing clients.

All the above skills require joint work with other members, which necessitates a mutual sharing of understanding.

Furthermore, the following behavior points will be assessed as refined skills and the ability to demonstrate Japanese-like consideration toward others.

- An eye for judgement (evaluation)
- Planning arrangements, procedures
- Dexterous movements
- Consideration (plentiful functions, easy-to-use interface)
- Courteousness (stable production, easy communication, stable operation)

The above points are skills we would like students to acquire in the Innovation for Design and Engineering major. However, they are not theoretical information that can be learned at a desk. They require an appropriate environment, the use of tools, and repetitive practice that uses the body in some form. The next section explains the essentials of acquiring these skills.

1.3.3 Skills acquisition

Skill is one of the elements of Bloom's education objectives classification and belongs in the psychomotor domain [Kajita 2010]. It is an ability mainly tied to muscle and nervous system movements (anatomical body) and indicates abilities that can be acquired through repetitive

practice. In industrial education, it is regarded as one of the three types of learning alongside knowledge and attitude. The evaluation of skill levels is indicated in the following table by Bloom's student Dave.

What Bloom and Dave are saying is that a prerequisite for skill is the knowledge to undertake action and that repetitive practice is necessary until the body (mental movement) and head can coordinate as one. For example, just by having knowledge of tennis, if you are placed on a court and a ball comes your way, your body will not be able to instantly react to the ball's movement, make your feet move and swing the racket. This requires physical repetitive practice.

Among the skills necessary to acquire the competencies mentioned in the previous section, most require the full use of senses necessary to the body and mind, and to be able to do this, one needs to undertake repetitive practice as Bloom and Dave state. This cannot be accomplished at the desk only through lectures, and instead requires practical learning using tools and machines. Furthermore, creative contrivances are needed to come up with new ideas and develop new products. In other words, one needs to fully utilize one's body and senses to visualize and embody ones ideas through trial and error. This skill in originality is nurtured, not on one's own, but through cooperative and joint work with other team members.

Table 104: Evaluation of skill levels as indicated by Dave

6.0	Evaluation		
5.0	Synthesis	Characterization	Naturalization
4.0	Analysis	Organization	Articulation
3.0	Application	Valuing	Precision
2.0	Comprehension	Responding	Manipulation
1.0	Knowledge	Receiving	Imitation
	Cognitive Domain	Affective Domain	Psychomotor Domain

As explained so far, the competencies cultivated in the Innovation for Design and Engineering major require repetitive practice that fully utilizes the body and senses. Furthermore, sharing understanding between members and conducting joint operations are also requirement conditions. The university believes PBL is the most effective learning method to allow students to acquire these skills. The PBL offered in the Innovation for Design and Engineering major provides working environments in addition to embedding various tasks in the PBL process that allow members to discuss issues, creatively contrive solutions and share what each of them understand. By having members, who come from various backgrounds, work together on tasks in this way, the major aims to improve each of their competencies. In

other words, the competencies to be acquired in the Innovation for Design and Engineering major can be acquired most efficiently through PBL.

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2. AIIT PBL Initiatives

2.1 Development of advanced professional human resources through PBL

In Japan's university education, there is a gap between company needs and university curriculums (see fig. 2-1). In response, AIIT, as a professional graduate school, endeavors to develop human resources who match company needs and embody what companies are looking for. Normally, most work is done in projects, so companies seek personnel who have the skills to work in projects. Furthermore, the problems that are faced during work are often complex and have no right answer. AIIT conducts PBL education in order to nurture human resources equipped with the skills and competencies to resolve such problems with wide and cross-sectional views.

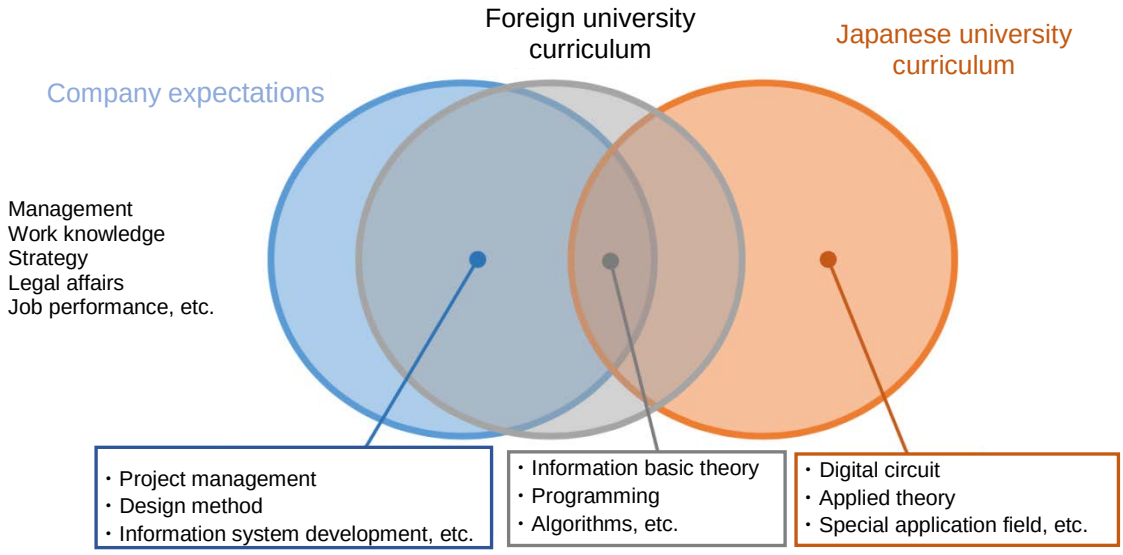


Figure 2-1: Gap between company needs and information science education in Japanese universities

Source: Keidanren "Improving the Education of Advanced Information Communication Human Resources through Partnerships between Industry, Academia, and Government" https://www.keidanren.or.jp/japanese/policy/2005/039/honbun.html

2.2 PBL as the core of diploma programs at AIIT

AIIT does not require students to write a master's thesis, which is usually necessary in research-based universities. Instead, the entire second year is devoted to PBL. In other words, regular research-based universities use master's theses to determine whether students were able to acquire advanced specialized knowledge, whereas AIIT uses PBL activities to determine whether students were able to acquire advanced job performance skills. Therefore, AIIT conducts PBL on a level of quality and quantity equal to that of master's degree schools.

As a professional graduate school, AIIT aims to nurture advanced specialist engineers who are able to contribute to the industry as professionals in their fields. For that reason, PBL

themes at AIIT are all practical and if they are chosen appropriately, students are able to conduct relatively large-scale projects. By engaging in a year-long project of a substance and scale equal to the level of real-life operations in their second year, students are able to acquire the knowledge, skills and know-how necessary to become advanced professional engineers.

2.3 Projects and educational objectives

Figure 2-2 outlines the educational objectives of PBL at AIIT. Within the projects, students undertake various activities to resolve issues, and as a result, are able to produce deliverables. PBL is a teaching method where students learn over the course of the project's flow. The educational objective of implementing PBL at AIIT is to allow students to learn how to resolve problems, be able to accomplish tasks they could not before, and be able to apply what they learn to other issues.

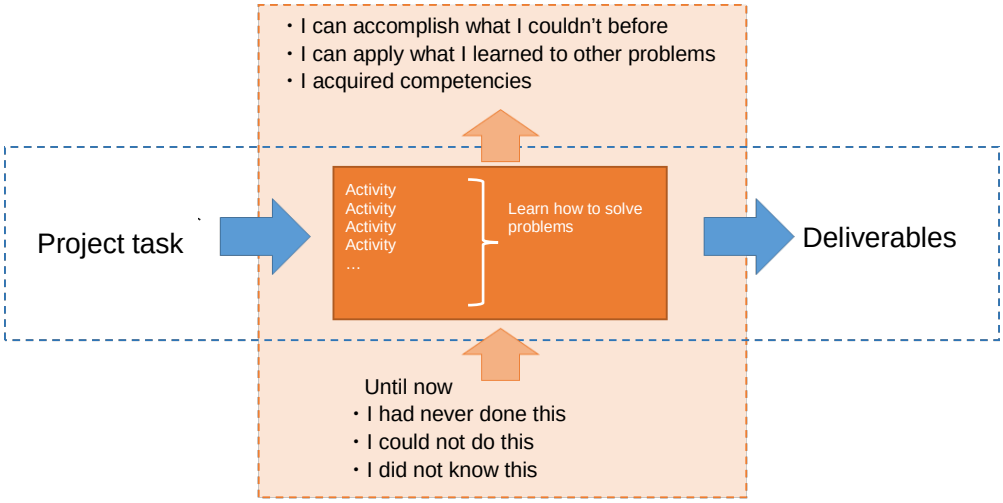


Figure 2-2: AIIT PBL educational objectives

2.4 What can be learned through AIIT PBL

Students can learn the following by engaging in AIIT PBL.

Table 2-1: What can be learned through AIIT PBL

Learn how to apply and accommodate knowledge to solve project tasks (conduct activities).	Think on your own instead of being told the answer (realization).
Learn how to solve problems (be able to apply solutions to similar problems).	(Characteristics of planning and design operations): various limitations, sense of value, trade-off decisions.
Independently study what you do not know but is required to fulfill your role in the project.	Nurture the ability to study continuously.
Aim for even higher quality by not only	Understanding of diversity.

thinking on your own, but asking for diverse opinions, values and perspectives from others.	
Learn how to proceed with and manage projects (comprised of multiple members).	Activity project management as a team (team member).
Learn what is necessary for “service”.	The correct way to understand “expectations”.

3. AIIT PBL Characteristics

AIIT PBL has unique characteristics that set it apart from other PBL programs – namely, its “education program”, “management system” and “performance assessment system”. This chapter introduces these characteristics.

3.1 Educational program

3.1.1 Outline of year 1 and year 2

The AIIT PBL is a compulsory course to be taken in the university’s final year of education and is a program equivalent to a regular graduate school’s master’s thesis. In other words, instead of requiring students to write a master’s thesis, the conditions of completing the university’s degree is to engage in PBL education. Out of the 40 units required for graduation, AIIT PBL takes up 12 units (6 in the first term and 6 in the second) and is the university’s most unique and crucial course.

The diagram below illustrates the standard flow from matriculation to graduation. The university is structured into a four semester quarterly system. Students in their first year acquire knowledge and skills by taking various general and specialized courses over four semesters. In the second year, PBL is conducted over the course of a year, which is split into the first half and second half. The problems faced in real-life society are not simple enough to be resolved just by acquiring the systematic knowledge taught in regular graduate school educations. If anything, they are so complex that such knowledge will not allow a person to even understand the real essence of the issue. AIIT implemented PBL education in order to nurture human resources capable of resolving such real-life issues. Participating in PBL will allow students to acquire practical job performance skills that utilize both knowledge and skills.

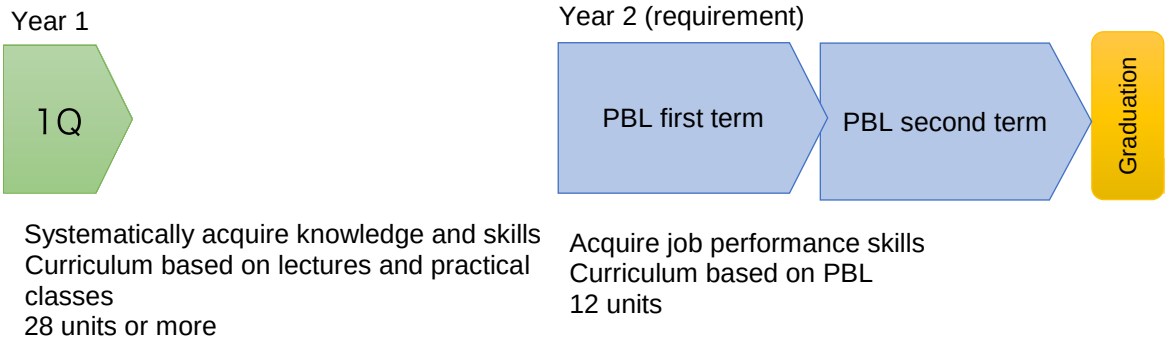


Figure 3-1: Standard flow from matriculation to graduation

3.1.2 Structure of competencies

The objective of AIIT PBL is to equip students with the systematic knowledge and skills needed for information systems development and manufacturing, as well as the practical abilities necessary to perform job operations. The university defines the job performance skills that students acquire through PBL as competencies. As shown in figure 3-2, competencies are constructed of three meta-competencies and the core competencies established by each major.

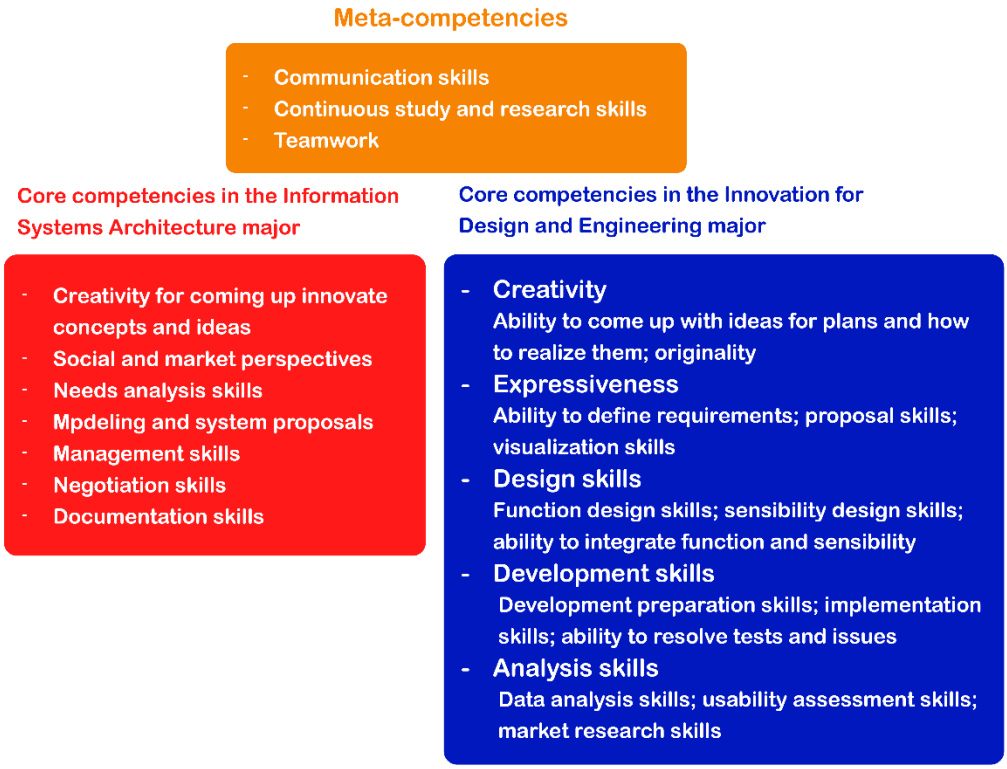


Figure 3-2: Three meta-competencies and the core competencies established by each major

3.1.3 Annual schedule

AIIT PBL is equivalent to the master's thesis of a research-based graduate school, requiring students in their second year to engage in a single project over the course of a year. As shown

in figure 3-3, preparations for PBL begin in January of the first year to assign teams and then activities start in earnest in April. In between, the Innovation for Design and Engineering major holds three mid-term results presentations, and the Information Systems Architecture major holds one. Additionally, in February, final results presentations are held in a venue outside the university, which is open to the public.

3.1.4 Team organization and guidance structure

Teams for AIIT PBL consist of multiple members, just like regular work operations. However, those members come from highly diverse backgrounds and comprise of students of different ages, occupations, positions, experiences, etc. On the one hand, conducting PBL within such an organization is difficult, but on the other, members will be able to gain knowledge and experiences they would otherwise never encounter with members who come from similar backgrounds.

Around five students make up a team. Each student acts as a member of the project within AIIT PBL team activities. Team members share a common goal, fulfill each of their given roles within the team and produce results as a team. They learn through this process of problem solving. There is also a lot they learn from their other team members, who, as mentioned above, come from diverse backgrounds.

One faculty in a primarily responsible role and two as vice supporters will be placed on each team. The faculty who assumes primary responsibility will guide the team as a whole on how to proceed with the project. He/she will also keep track of the students' activities and results, and based on those observations, will guide and assess each individual. It is difficult to evaluate individual team members in team learning activities, but the university has prepared a structure and assessment system that allows the three faculty to evaluate the students' performance as objectively as possible.

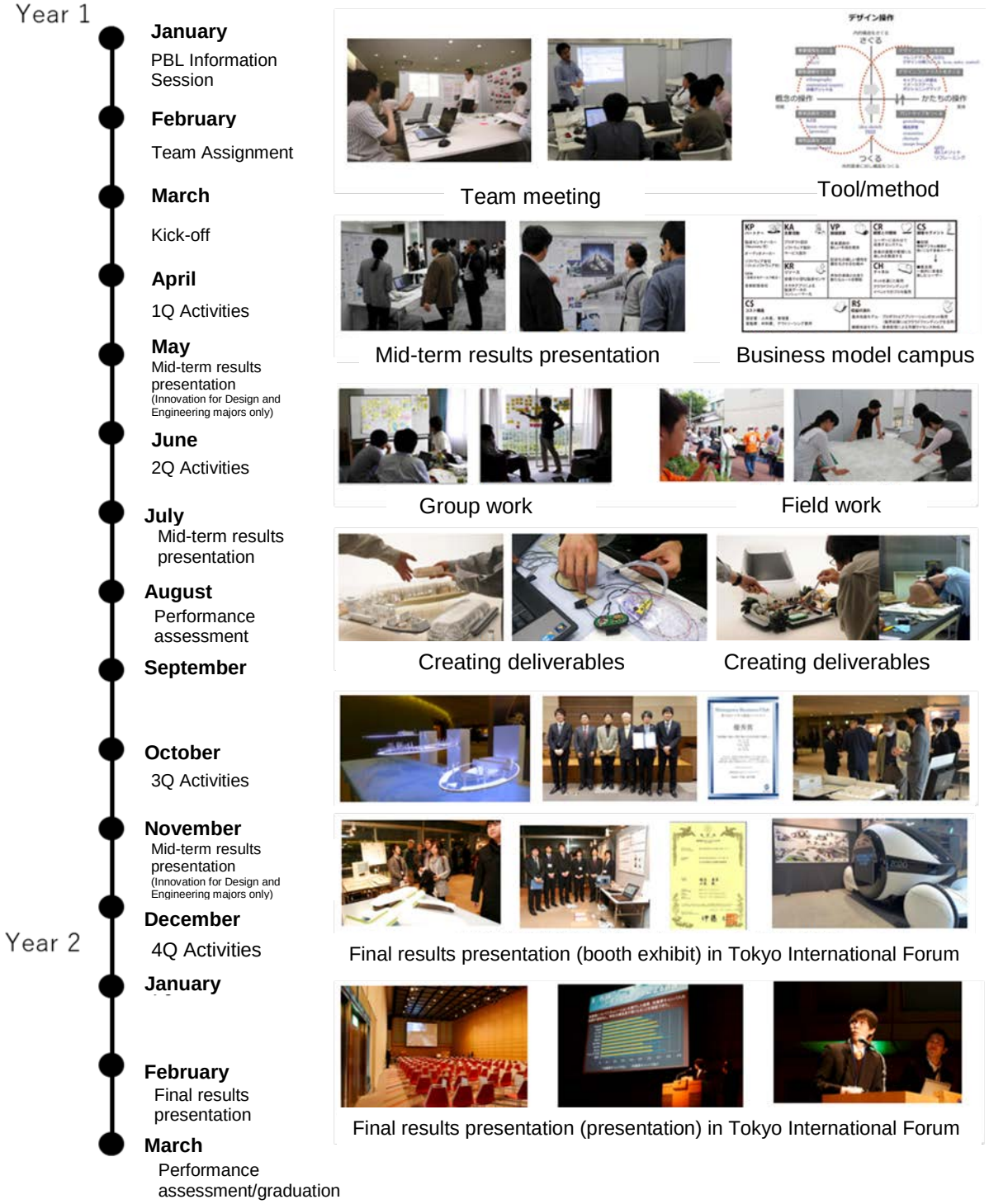


Figure 3-3: AIIT PBL annual schedule

3.1.5 PBL activities

AIIT PBL is a mandatory course split into first and second terms with a total of 12 units. Therefore, as a general principle, students are expected to spend nine hours a week (equal to six blocks of class time) on team activities and nine hours of out-of-class work per week over the course of 30 weeks. The out-of-class work should consist of acquiring knowledge necessary to team activities in advance and researching tasks assigned to each member during team activities. With this, in principle, the activity time totals 18 hours a week. AIIT PBL students are expected to produce deliverables that correspond to these hours.

When starting PBL, students first create a project plan. They plan how to use the 18 hours, which is the standard criterion for a week's activities, and how they will carry out the project. While conducting PBL, they will engage in project activities based on this plan. Project activities are reported and submitted using the AIIT PBL support system, to be explained later. By sharing these among all the faculty, the instructors will be able to grasp an understanding of each individual students' activities.

The following is what students submit in their PBL activity reports.

- Record all the details of the project activities and input the contents into Backlog, the AIIT PBL support system.
- Submit a weekly report recording individual activities to LMS (Learning Management System), the AIIT PBL support system.
- Submit a self-assessment to LMS at the end of each quarter.
- Submit a project activity report at the end of the first and second terms.
- Submit an annual activity report at the end of the second term (for public release).

3.1.6 Weekly reports and self-assessment

As stated above, students submit weekly reports on the activities and accomplishments of the week. The report covers not only team activities but also all the work that was done outside of class. Weekly reports are mainly used to gain an understanding of the contents and quantity of individual students' activities. Table 3-1 outlines the points of the weekly reports and what should be reported.

Table 3-1: Weekly report contents

Weekly Report Points	Details of Weekly Reports and Cautionary Points
This week's activities and results achievements	Report on your activities this week and the state of the deliverables that resulted from those efforts. Always create deliverables and make it available for other members and faculty to reference.
Next week's activities and planned results	Plan and write down goals for next week's activities and the expected deliverables.
Issues and solutions	Report on what sort of issues arose this week, what issues were resolved, and their solutions.
Occurrences and awareness	Report on memorable occurrences that happened involving the project as a whole, as well as anything you noticed.
Special notes	Write down anything else that should be reported or requests that you would like to make to other members or faculty.

Additionally, based on the records of activities and accomplishments in the weekly reports, students submit self-assessments four times a year to reflect on what they have learned. Self-assessments are a means for students to reflect on their project activities at the end of each quarter and write down what they are now capable of doing and the competencies they acquired. Self-assessments are mainly used for qualitative evaluations (to assess the quality of activities). Furthermore, at the end of the second quarter, students submit a project activity report on the first term consisting of roughly 2,000 characters. Then at the end of the fourth quarter (upon completion of the year-long PBL), they submit a project activity report of roughly 2,000 characters reflecting on the whole year. The activity report submitted at the end of the fourth quarter is made public.

3.1.7 AIIT PBL support system

Two systems have been introduced to support AIIT PBL activities. The first is Backlog (fig. 3-4), a system that was implemented to manage PBL projects and files. Its features include progress management functions, problem management functions, wiki, and file sharing functions. By using Backlog, students are able to proceed smoothly with PBL. In addition, instructors are also able to access Backlog to check on the project's state of progression and its deliverables. The second system that was implemented is an LMS called manaba (fig. 3-5), where students submit activity reports, which is then shared among the instructors. The aforementioned weekly reports and self-assessments are submitted through this system. Activity reports submitted here by students can be accessed by all instructors of the major. Every student's grades are decided at a Performance Assessment Conference, which is attended by all full-time instructors of the major, so this system was implemented as a way for all instructors to be able to see each of the students' activities. Details of how performance is evaluated will be addressed later.

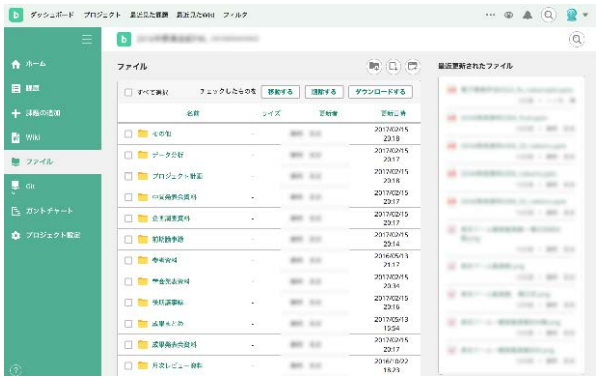


Figure 3-4: Backlog

Figure 3-5: LMS (manaba)

3.2 Management system

3.2.1 PBL theme selection

As shown in figure 3-6, to select the PBL theme, extramural delegates are invited from member companies of the Management Advisory Board established by AIIT. Together with university delegates centered around AIIT faculty, they form the PBL Review Committee, which was established in an effort to include opinions from industry. In this committee, extramural delegates discuss real life issues and university delegates base their proposals on such discussions and submit them to the committee. Then the opinions of the extramural delegates are once again considered and integrated before being solidified as themes for the next fiscal year. If the PBL themes were decided solely by the faculty in charge, it would produce the issue of being too concentrated on the research fields that the faculty are currently engaged in, which would lead to theme settings based on a deep but narrow point of view. This method ensures that this pitfall is avoided. The PBL themes for FY2016 are shown in table 3-2.

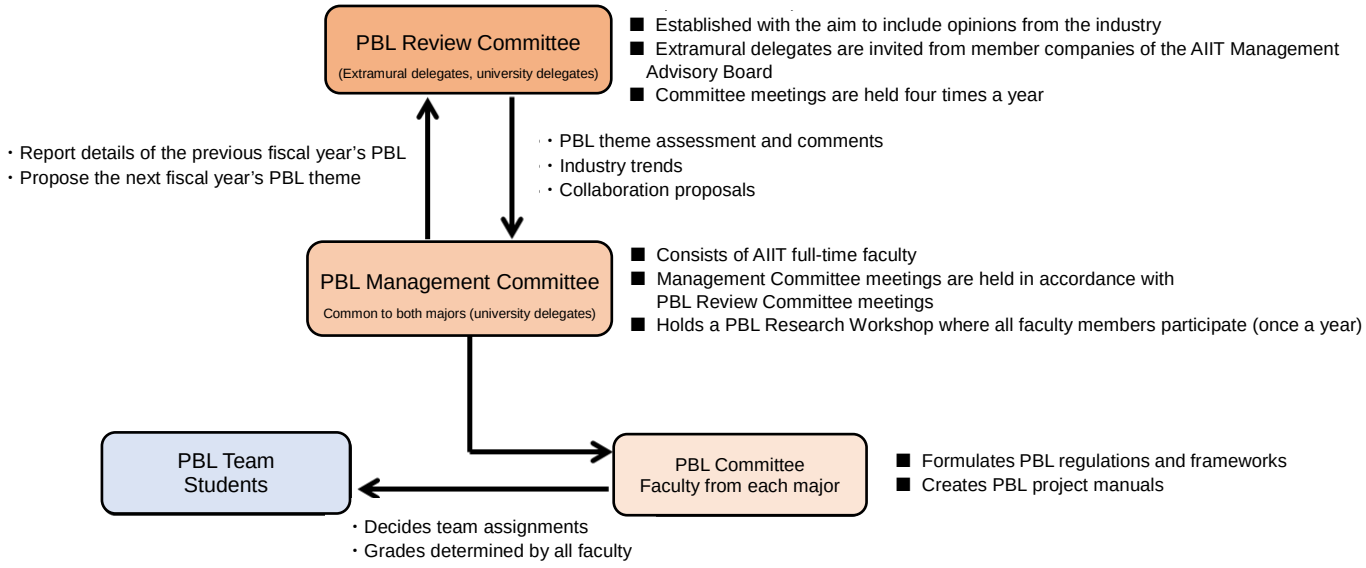


Figure 3-6: Organizational structure of PBL managements

3.2.2 Implementation of an External Assessment Committee system

AIIT PBL has implemented an External Assessment Committee system. In this system, faculty in charge of PBL select individuals who they believe are suited to be external evaluators and recommend them to the PBL Review Committee where they are approved. It is mandatory to conduct external assessments of PBL activities by external reviewers who are specialists in fields related to the PBL themes taking place. This ensures that activity assessments are made objectively.

Table 3-2: List of PBL themes for FY2016

Information Systems Architecture Major	Innovation for Design and Engineering Major
Development of software for parafoil autonomous control	Proposal of a service system utilizing the memories of experiences with “Karada ni Nihon Miyage”™
Execution of PIA with multipurpose cameras in a multi-stakeholder process	A comfortable flower chair that shifts to accommodate physical builds
Development of a traffic analysis and prediction system utilizing online data	Service design to improve time value in city life
Proposal and implementation of an ultrasonic wave communications protocol and its application to HCI	Forming Bonds Tokyo 2030 – mobile design as a means for regional interactions –
OAMMS - an open-source member management system for academic conferences	Innovation in urban cities – reconstructing interhuman relations –
Support of business strategy formulation for business innovations	Proposal for policies pertaining to the creation of Asian industry network platforms
Service system plan construction utilizing the internet and near-field communication	Communication services to improve quality of home nursing visits outside of visiting hours
Software development for providing value – practical implementation of scrum –	Proposal of tourism support tool "EEG TRAVELER" utilizing biological information
Development of information systems software for innovation	
Verification and proposal for the effectiveness of systemized knowledge of start-ups based on PMBOK	

3.3 Performance assessment system

3.3.1 What is being assessed

In AIIT PBL it is not the success or failure of the projects that is assessed, but each individual student. The grades of individual students are evaluated according to how much they contributed to PBL activities and the extent of competencies they were able to acquire. The former is an evaluation of the students’ level of participation in PBL activities on a daily basis, as well as the quantity and quality of the deliverables they produced. The latter is an evaluation of whether the competencies acquired by the student through PBL activities are of a professional master’s level. The assessment places an emphasis on what students learned through PBL over the course of the year and how much they improved.

3.3.2 Who makes the assessments

To assess performance, a Performance Assessment Conference is held twice a year, attended by all full-time instructors. Three faculty members (one in a primarily responsible role and two as vice supporters) create a performance assessment draft, which is reviewed by all full-time instructors in the PBL Performance Assessment Conference. Such contrivances are made to ensure the objectivity and appropriateness of PBL evaluations. Additionally, assessments also take into consideration the monthly reviews and opinions of external assessment members when they, for example, participate in project result presentations.

3.3.3 Assessment method

(1) Evaluation of the quality and quantity of PBL activities and its deliverables

Assessments are made according to the PBL assessment matrix shown below, based on the deliverables and reports from students (weekly reports and self-assessments). Based on this, students are assessed on the amount of time they spend engaging in PBL activities and whether their deliverables are worthy of the time that was spent.

Table 3-3: PBL assessment matrix

PBL Assessment Matrix	Qualitative Assessment	Quantitative Assessment
PBL Activity	Project management, roles, contribution, etc.	Activity time, tardiness, absence, etc.
PBL Deliverables	Quality of documents, software, hardware, academic paper, etc.	Standard fulfilling quantity of deliverables

(2) Evaluation of competency achievement levels

Competency skills levels are clearly defined in five stages for Meta Competency and Core Competencies established by each major as shown in the following table. Using those skill levels as assessment standards, students are assessed on how well they acquire competencies.

Table 3-4: Table of meta-competency skill levels

		Level 5	Level 4	Level 3	Level 2	Level 1
Communication skills		The student is able to independently perform the various tasks associated with proposing product plans, designing and manufacturing the goods, and is also able to lead other members.	The student is able to independently perform the various tasks associated with proposing product plans, designing and manufacturing the goods.	The student is able to independently perform the tasks of proposing product plans, designing and manufacturing the goods mainly in his/her area of expertise.	The student is able to assist in the tasks of proposing product plans, designing and manufacturing the goods under the guidance of a leader.	The student has the basic knowledge and skills necessary to the tasks of proposing product plans, designing and manufacturing the goods, but not on a working level.
	Communication	・The student is able to not only unilaterally adapt to constantly advancing technologies and dynamically changing environments, but is also prepared to actively take part in such changes (reciprocal interaction with technology and environment) while maintaining independence. The student is also able to lead other members.	・The student is able to not only unilaterally adapt to constantly advancing technologies and dynamically changing environments, but is also prepared to actively take part in such changes (reciprocal interaction with technology and environment) while maintaining independence.	・The student, depending on the field and situation, is able to not only unilaterally adapt to constantly advancing technologies and dynamically changing environments, but is also prepared to actively take part in such changes (reciprocal interaction with technology and environment) while maintaining independence.	・The student, under the guidance of a leader, is able to not only unilaterally adapt to constantly advancing technologies and dynamically changing environments, but also to support endeavors to actively take part in such changes (reciprocal interaction with technology and environment) while maintaining independence.	・The student is not able to demonstrate the following: the ability to not only unilaterally adapt to constantly advancing technologies and dynamically changing environments, but also be prepared to actively take part in such changes (reciprocal interaction with technology and environment) while maintaining independence.
		・In this advanced information society, the student does not make claims based on assumptions or fragmentary information, and instead is able to systematically gather information, reference existing research and case studies, and use appropriate methods to objectively analyze information, while also being able to lead other members.	・In this advanced information society, the student does not make claims based on assumptions or fragmentary information, and instead is able to systematically gather information, reference existing research and case studies, and use appropriate methods to objectively analyze information.	・In this advanced information society, the student, depending on the field and situation, does not make claims based on assumptions or fragmentary information, and instead is able to systematically gather information, reference existing research and case studies, and use appropriate methods to objectively analyze information.	・In this advanced information society, the student, under the guidance of a leader, does not make claims based on assumptions or fragmentary information, and instead is able support endeavors to systematically gather information, reference existing research and case studies, and use appropriate methods to objectively analyze information.	・The student is not able to demonstrate the following: the ability, in this advanced information society, not to make claims based on assumptions or fragmentary information, and instead be able to systematically gather information, reference existing research and case studies, and use appropriate methods to objectively analyze information.
	Leadership	・The student is able to appropriately report on his/her own conditions and problems during regular meetings, while also accurately understanding the situations and issues of other members. The student is also able to lead other members.	・The student is able to appropriately report on his/her own conditions and problems during regular meetings, while also accurately understanding the situations and issues of other members.	・The student, depending on the field and situation, is able to appropriately report on his/her own conditions and problems during regular meetings, while also accurately understanding the situations and issues of other members.	・The student, under the guidance of a leader, is able to partially report on his/her own conditions and problems during regular meetings, while also partially understanding the situations and issues of other members.	・The student is not able to demonstrate the following: the ability to appropriately report on his/her own conditions and problems during regular meetings, while also accurately understanding the situations and issues of other members.
		・In discussions, the student is able to selectively use appropriate methods such as divergent and convergent thinking strategies to constructively guide the discussion (facilitation) and maintain the project's efficiency as well as a suitable mental balance among the members. The student is also able to lead other members.	・In discussions, the student is able to selectively use appropriate methods such as divergent and convergent thinking strategies to constructively guide the discussion (facilitation) and maintain the project's efficiency as well as a suitable mental balance among the members.	・In discussions, the student, depending on the field and situation, is able to selectively use appropriate methods such as divergent and convergent thinking strategies to constructively guide the discussion (facilitation) and maintain the project's efficiency as well as a suitable mental balance among the members.	・In discussions, the student, under the guidance of a leader, is able to support endeavors to selectively use appropriate methods such as divergent and convergent thinking strategies to constructively guide the discussion (facilitation) and maintain the project's efficiency as well as a suitable mental balance among the members.	・The student is not able to demonstrate the following: the ability to, in discussions, selectively use appropriate methods such as divergent and convergent thinking strategies to constructively guide the discussion (facilitation) and maintain the project's efficiency as well as a suitable mental balance among the members.
		・In meetings and during work, the student is able to comment and act in ways that improve the quality of the project's deliverables or work efficiency. The student is also able to lead other members.	・In meetings and during work, the student is able to comment and act in ways that improve the quality of the project's deliverables or work efficiency.	・In meetings and during work, the student, depending on the field and situation, is able to comment and act in ways that improve the quality of the project's deliverables or work efficiency.	・In meetings and during work, the student, under the guidance of a leader, is able to support endeavors to improve the quality of the project's deliverables or work efficiency.	・The student is not able to demonstrate the following: the ability to, in meetings and during work, comment and act in ways that improve the quality of the project's deliverables or work efficiency.
		・The student is able to keep an eye out for his/her team member's mental stress levels and take	・The student is able to keep an eye out for his/her team member's mental stress levels and take	・Depending on the field and situation, the student is able to keep an eye out for his/her team member's	・Under the guidance of a leader, the student is able to support endeavors to keep an eye out for his/her	・The student in not able to demonstrate the following: the ability to keep an eye out for his/her

		selective measures according to the situation, such as making time to talk or taking steps to address risks. The student is also able to lead other members.	selective measures according to the situation, such as making time to talk or taking steps to address risks.	mental stress levels and take selective measures according to the situation, such as making time to talk or taking steps to address risks.	team member's mental stress levels and take selective measures according to the situation, such as making time to talk or taking steps to address risks.	team member's mental stress levels and take selective measures according to the situation, such as making time to talk or taking steps to address risks.
Continuous learning and research skills	Mid- to long-term plan	・The student is able to concretely estimate the challenges he/she or the research will face in five or ten years' time and is able to plan his/her current efforts to realize them. The student is also able to lead other members.	・The student is able to concretely estimate the challenges he/she or the research will face in five or ten years' time and is able to plan his/her current efforts to realize them.	・Depending on the field and situation, the student is able to concretely estimate the challenges he/she or the research will face in five or ten years' time and is able to plan his/her current efforts to realize them.	・Under the guidance of a leader, the student is able to concretely estimate the challenges he/she or the research will face in five or ten years' time and is able to partly plan his/her current efforts to realize them.	・The student is not able to demonstrate the following: the ability to concretely estimate the challenges he/she or the research will face in five or ten years' time and be able to plan his/her current efforts to realize them.
		・Even if the research fails or falls into a stalemate, the student possesses both the logical mind and perseverance needed not to easily change the objective of the study or project and instead to generate, through analyses, a means to realize the goal. The student is also able to lead other members.	・Even if the research fails or falls into a stalemate, the student possesses both the logical mind and perseverance needed not to easily change the objective of the study or project and instead to generate, through analyses, a means to realize the goal.	・Depending on the field and situation, even if the research fails or falls into a stalemate, the student possesses both the logical mind and perseverance needed not to easily change the objective of the study or project and instead to generate, through analyses, a means to realize the goal.	・Under the guidance of a leader, even if the research fails or falls into a stalemate, the student is able to support endeavors not to easily change the objective of the study or project and instead to generate, through analyses, a means to realize the goal.	・The student is not able to demonstrate the following: a possession of both the logical mind and perseverance needed not to easily change the objective of the study or project even if the research fails or falls into a stalemate, and instead to generate, through analyses, a means to realize the goal.
	Problem identification and resolution	・The student is able to assess him/herself, other members, the project's results, and their efforts objectively from multiple angles with the perspective of gaining meaningful knowledge from it in the future, not just taking away the superficial successes and failures of the experience. The student is also able to lead other members.	・The student is able to assess him/herself, other members, the project's results, and their efforts objectively from multiple angles with the perspective of gaining meaningful knowledge from it in the future, not just taking away the superficial successes and failures of the experience.	・Depending on the field and situation, the student is able to assess him/herself, other members, the project's results, and their efforts objectively from multiple angles with the perspective of gaining meaningful knowledge from it in the future, not just taking away the superficial successes and failures of the experience.	・Under the guidance of a leader, the student is able to support endeavors to assess him/herself, other members, the project's results, and their efforts objectively from multiple angles with the perspective of gaining meaningful knowledge from it in the future, not just taking away the superficial successes and failures of the experience.	・The student is not able to demonstrate the following: the ability to assess him/herself, other members, the project's results, and their efforts objectively from multiple angles with the perspective of gaining meaningful knowledge from it in the future, not just taking away the superficial successes and failures of the experience.
		・The student is able to discover the seeds of issues from various fields and phenomena, such as existing research and case studies, daily life occurrences and experiences in his/her vicinity, and is able to clearly define it as an issue. The student is also able to lead other members.	・The student is able to discover the seeds of issues from various fields and phenomena, such as existing research and case studies, daily life occurrences and experiences in his/her vicinity, and is able to clearly define it as an issue.	・Depending on the field and situation, the student is able to discover the seeds of issues from various fields and phenomena, such as existing research and case studies, daily life occurrences and experiences in his/her vicinity, and is able to clearly define it as an issue.	・Under the guidance of a leader, the student is able to support endeavors to discover the seeds of issues from various fields and phenomena, such as existing research and case studies, daily life occurrences and experiences in his/her vicinity, and is able to clearly define it as an issue.	・The student is not able to demonstrate the following: the ability to discover the seeds of issues from various fields and phenomena, such as existing research and case studies, daily life occurrences and experiences in his/her vicinity, and be able to clearly define it as an issue.
		・The student is able to discover clues to solve problems (analysis), such as through classifications, pursuing the cause or by comparison with similar cases. The student is also able to lead other members.	・The student is able to discover clues to solve problems (analysis), such as through classifications, pursuing the cause or by comparison with similar cases.	・Depending on the field and situation, the student is able to discover clues to solve problems (analysis), such as through classifications, pursuing the cause or by comparison with similar cases.	・Under the guidance of a leader, the student is able to support endeavors to discover clues to solve problems (analysis), such as through classifications, pursuing the cause or by comparison with similar cases.	・The student is not able to demonstrate the following: the ability to discover clues to solve problems (analysis), such as through classifications, pursuing the cause or by comparison with similar cases.
		・The student is able to propose several concrete ways of solving problems, assess each of them objectively, choose the best method and possess the skills to carry it out. The student is also able to lead other members.	・The student is able to propose several concrete ways of solving problems, assess each of them objectively, choose the best method and possess the skills to carry it out.	・Depending on the field and situation, the student is able to propose several concrete ways of solving problems, assess each of them objectively, choose the best method and possess the skills to carry it out.	・Under the guidance of a leader, the student is able to support endeavors to propose several concrete ways of solving problems, assess each of them objectively, choose the best method and possess the skills to carry it out.	・The student is not able to demonstrate the following: the ability to propose several concrete ways of solving problems, assess each of them objectively, choose the best method and possess the skills to carry it out.
Team activities	Interdisciplinary	・The student is able to avoid being fixated on past experiences and expertise in given fields, and instead is able to learn constantly in an appropriate way and actively participate in the work of foreign fields, thereby contributing to the	・The student is able to avoid being fixated on past experiences and expertise in given fields, and instead is able to learn constantly in an appropriate way and actively participate in the work of foreign fields,	・Depending on the field and situation, the student is able to avoid being fixated on past experiences and expertise in given fields, and instead is able to learn constantly in an appropriate way and	・Under the guidance of a leader, the student is able to avoid being fixated on past experiences and expertise in given fields, and instead is able to learn constantly in an appropriate way and actively participate in the	・The student is not able to demonstrate the following: the ability to avoid being fixated on past experiences and expertise in given fields, and instead be able to learn constantly in an appropriate way and

		team and improving his/her own abilities. The student is also able to lead other members.	thereby contributing to the team and improving his/her own abilities.	actively participate in the work of foreign fields, thereby contributing to the team and improving his/her own abilities.	work of foreign fields, thereby supporting the team and improving his/her own abilities.	actively participate in the work of foreign fields, thereby contributing to the team and improving his/her own abilities.
		・The student is able to propose role assignments and task plans and put them into action by distinguishing the members' characteristics and making sure the human resources can function to the best of their abilities. The student is also able to lead other members.	・The student is able to propose role assignments and task plans and put them into action by distinguishing the members' characteristics and making sure the human resources can function to the best of their abilities.	・Depending on the field and situation, the student is able to propose role assignments and task plans and put them into action by distinguishing the members' characteristics and making sure the human resources can function to the best of their abilities.	・Under the guidance of a leader, the student is able to support role assignment proposals and task planning and putting them into action by distinguishing the members' characteristics and making sure the human resources can function to the best of their abilities.	・The student is not able to demonstrate the following: the ability to propose role assignments and task plans and put them into action by distinguishing the members' characteristics and making sure the human resources can function to the best of their abilities.
		・The student makes an effort to acquire new knowledge by flexibly interacting with members who have different experiences and fields of expertise (synergy effect). The student is also able to lead other members.	・The student makes an effort to acquire new knowledge by flexibly interacting with members who have different experiences and fields of expertise (synergy effect).	・Depending on the field and situation, the student makes an effort to acquire new knowledge by flexibly interacting with members who have different experiences and fields of expertise (synergy effect).	・Under the guidance of a leader, the student supports efforts to acquire new knowledge by flexibly interacting with members who have different experiences and fields of expertise (synergy effect).	・The student is not able to demonstrate the following: the ability to make an effort to acquire new knowledge by flexibly interacting with members who have different experiences and fields of expertise (synergy effect).
	Understanding of diversity and engineering ethics	・The student is able to avoid being misled by superficial differences regarding decisions based on historical, environmental, global and cultural diversity and technical ethics, and makes an effort to correctly understand the mutual differences by considering their situations, positions, backgrounds and origins. The student is also able to lead other members.	・The student is able to avoid being misled by superficial differences regarding decisions based on historical, environmental, global and cultural diversity and technical ethics, and makes an effort to correctly understand the mutual differences by considering their situations, positions, backgrounds and origins.	・Depending on the field and situation, the student is able to avoid being misled by superficial differences regarding decisions based on historical, environmental, global and cultural diversity and technical ethics, and makes an effort to correctly understand the mutual differences by considering their situations, positions, backgrounds and origins.	・Under the guidance of a leader, the student is able to support endeavors to avoid being misled by superficial differences regarding decisions based on historical, environmental, global and cultural diversity and technical ethics, and makes an effort to correctly understand the mutual differences by considering their situations, positions, backgrounds and origins.	・The student is not able to demonstrate the following: the ability to avoid being misled by superficial differences regarding decisions based on historical, environmental, global and cultural diversity and technical ethics, and making an effort to correctly understand the mutual differences by considering their situations, positions, backgrounds and origins.
		・The student avoids agreeing/disagreeing with certain perceptions or ethical perspectives, and instead takes in the "good" of both and challenges him/herself to create new perceptions and ethical perspectives. The student is also able to lead other members.	・The student avoids agreeing/disagreeing with certain perceptions or ethical perspectives, and instead takes in the "good" of both and challenges him/herself to create new perceptions and ethical perspectives.	・Depending on the field and situation, the student avoids agreeing/disagreeing with certain perceptions or ethical perspectives, and instead takes in the "good" of both and challenges him/herself to create new perceptions and ethical perspectives.	・Under the guidance of a leader, the student avoids agreeing/disagreeing with certain perceptions or ethical perspectives, and instead takes in the "good" of both and supports endeavors to create new perceptions and ethical perspectives.	・The student is not able to demonstrate the following: the ability to avoid agreeing/disagreeing with certain perceptions or ethical perspectives, and instead take in the "good" of both and challenge him/herself to create new perceptions and ethical perspectives.
		・The student is able to define the significance of the project through team discussions on perceptions and ethical perspectives and thereby raise team motivation. The student is also able to lead other members.	・The student is able to define the significance of the project through team discussions on perceptions and ethical perspectives and thereby raise team motivation.	・Depending on the field and situation, the student is able to define the significance of the project through team discussions on perceptions and ethical perspectives and thereby raise team motivation.	・Under the guidance of a leader, the student is able to support defining the significance of the project through team discussions on perceptions and ethical perspectives and thereby raise team motivation.	・The student is not able to demonstrate the following: the ability to define the significance of the project through team discussions on perceptions and ethical perspectives and thereby raise team motivation.

4. AIIT PBL Case Study Collection

This chapter will introduce actual PBL case studies that were held according to the AIIT PBL method, which has been explained in the previous sections. Projects from the Innovation for Design and Engineering major will be introduced, including summaries of each of the projects, what sort of projects were conducted, as well as how they were carried out.

- PBL case study 1 (instructor: Prof. Noboru Koyama, Innovation for Design and Engineering*)
- PBL case study 2 (instructor: Assoc. Prof. Toshitake Tateno, Innovation for Design and Engineering*)
- PBL case study 3 (instructor: Prof. Tetsuo Fukuda, Innovation for Design and Engineering*)
- PBL case study 4 (instructor: Prof. Hiroshi Hashimoto, Innovation for Design and Engineering)
- PBL case study 5 (instructor: Prof. Mitsuhiro Maeda, Innovation for Design and Engineering)
- PBL case study 6 (instructor: Prof. Hideki Murakoshi, Innovation for Design and Engineering)
- PBL case study 7 (instructor: Prof. Shigeomi Koshimizu, Innovation for Design and Engineering)

*At the time the projects were conducted

4.1 PBL case study 1 (instructor: Prof. Noboru Koyama, Innovation for Design and Engineering*at the time the project was conducted)

Research of Full-size (Full-scale) Clay Model Production Methods in Facility-less Environments

Summary: We engaged in the development of full-size (full-scale) designs as a means to propose designs with even greater appeal and substance. This report details the development and research results of such full-size clay model production process methods in environments that lack full-size model facilities. In truth, there are few design schools (universities, professional schools, etc.) both in Japan and worldwide that are equipped with full-size facilities, and there are hardly any schools with the environments (instructors and financial aspects) necessary for students to produce full-size models. Under these circumstances, the students and I tackled new production methods to easily create full-size models with enhanced appeal.

1. Project overview

The initiative to produce a full-size clay model in a facility-less environment was based on the FY2014 PBL project theme “Omotenashi (Hospitality) Mobility in Tokyo Olympics 2020.” This project revolved around the development of a design for compact mobility vehicles aimed to allow visitors and athletes from countries worldwide to experience the Japanese “omotenashi spirit” at the 2020 Tokyo Olympics. We believed that in order for more realistic proposals to be made, producing a full-size model with enhanced appeal and substance would be most effective.

2. Model development in a facility-less environment

2.1 About the facility and time period needed for the production of a full-size model

The type of tools for model productions found in many design schools, including our own, are shown in figure 1. They include a simple surface plate for scale models and a simple layout machine to determine the coordinates of X-Y-X axis points on scale models. They are relatively low cost, can be fully utilized even by designers after a certain level of training, and therefore can contribute to the production of a fairly high-quality scale model.

Figure 1: Scale model production facility

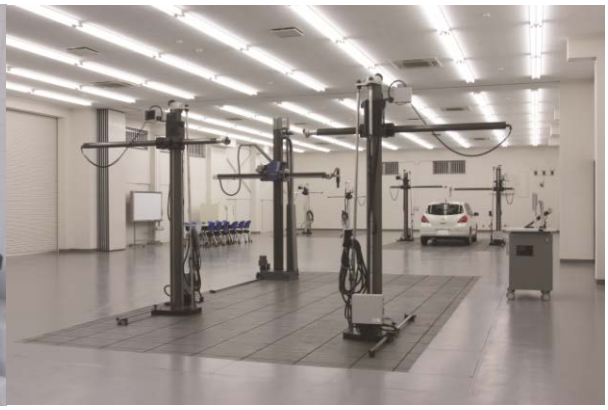


Figure 2: Full-size model production facility

On the other hand, facilities such as that shown in figure 2 can be found at automobile manufacturers. They include a 4m x 8m surface plate for the production of full-size models and multiple layout machines (this is only a basic facility; in actuality, facilities contain many other equipment, such as full-size 3D measuring machines and processors). Using this sort of facility, models are developed over a period of roughly three months.

In order to produce full-size models, a full-size model making facility is usually necessary, but our university does not have one. As for mobility vehicles, full-scale models are usually most suitable for making proposals, which makes having a full-size model crucial to make highly appealing proposals. In this research, a full-size clay model was created in a facility-less environment by contriving alternative production methods and making the model more simplified and lightweight.

2.2 Production process of a full-size (full-scale) model

2.2.1 Process (Step 1)

First, the design was refined by keeping original ideas while also making the shape as simple and as attractive as possible.

Next, efforts were made to reduce the amount of clay to lighten the model. Usually, over 50mm of clay is applied, with the reckoning that the shape will be corrected, but this time, a minimum amount of 5mm or so was used by designing the shape of the styrofoam core as accurately as possible using CAD. The limitation caused by this was the inability to change the shape, but it was determined that the merits were even greater, such as becoming lightweight and reducing cracks. (See figures 3 and 4)

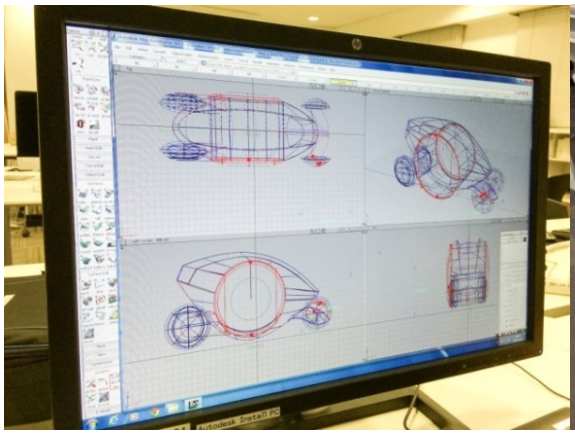


Figure 3: CAD data close to the final shape

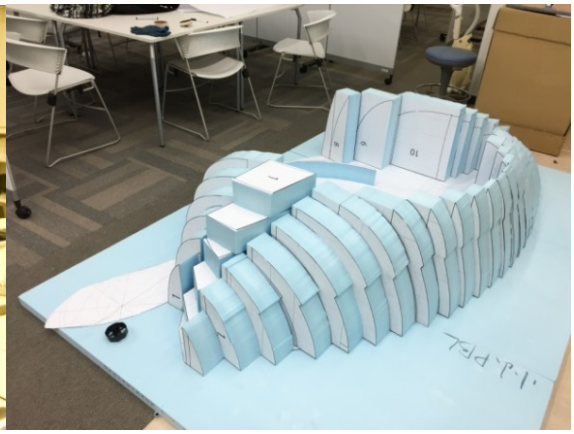


Figure 4: Completed styrofoam core

2.2.2 Process (Step 2)

The next step involved dimensional accuracy, which is crucial to model productions. A wooden mullion was created to determine measurements for the surface plate, which took on the role of determining coordinates, thereby increasing the accuracy of measurements. The inside was also made hollow, and these both contributed to reducing the weight of the model. This simultaneously allowed the vehicle user's posture to be checked and easily adjusted. As a result, the styrofoam core for the clay turned out to be a lot lighter than expected. (See figures 5 and 6)

Figure 5: Installing the wooden mullion and checking the vehicle user's posture (left)

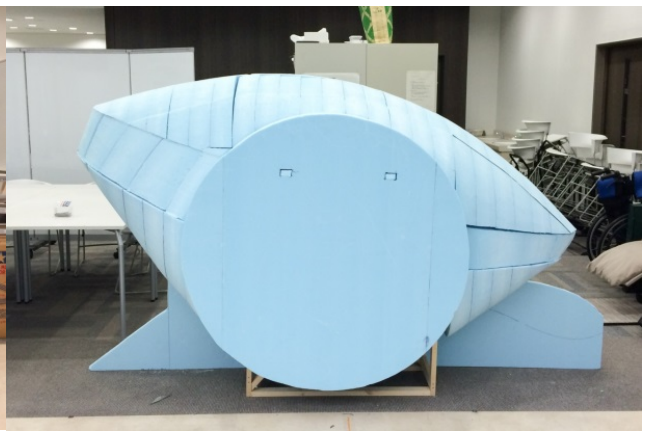


Figure 6: Completed core for the clay model (right)

2.2.3 Process (Step 3)

In this step, clay was applied to the styrofoam core, but as stated in 2.2.1, it was applied as thinly as possible (about 5mm) to keep the model lightweight, whereas in usual cases, over 50mm is applied. Incidentally, this allowed the clay to be applied evenly, which prevented cracks from appearing after completion. (See figures 7 and 8)

Figure 7: Applying clay

Figure 8: Clay application completed

2.2.4 Process (Step 4)

This process involved painting the completed clay model, but as can be seen in the photo, this model is made of only one side. It was decided from the start to only create one side and to ultimately complete it as a full model by using a mirror (mirroring). This was done to solve a measurement problem, where a full body model would not have fit through the school's painting booth door, and also to shorten the work time.

Later, the painted model was fitted using tape and completed as a final product. (See figures 9 and 10)

Figure 9: Mirroring

Figure 10: Completed full-size model

3. Summary of results

From starting the idea sketch, after the selection of the concept, to completing the full-size model, this project took approximately six months to develop. In particular, the full-size clay model was completed within a period of less than two months. This was the result of various

contrivances to the model production.

In addition, a full-size (full-scale) model made a large impact during the presentation and exhibit, just as we had expected at the start. The model effect it produced was far greater than anticipated.

This made us realize anew that cars are products that humans get into and ride, so when assessing design, the model should be full-size (full-scale) and not a scale model.

I believe there was a great significance in producing a full-size clay model in an environment that lacked the facilities to create full-size models by being creative with its production and display methods. I hope to present these results during various opportunities in the future.

Furthermore, I hope this will lead to being able to create full-scale interior models. In addition, I hope it will also extend to the development of an integrated interior-exterior model.

References:

(1) Noboru Koyama, Toshiyuki Murao, Keita Murata, Toshiaki Soma, Amane Oya, Takefumi Imagi, Kazuya Matsumoto: "Study for Developing Design Process through Making of Running Prototype Model Super Cell", *Bulletin of the Advanced Institute of Industrial Technology,* No. 7, December 2013.

(2) Noboru Koyama, Keita Murata, Yusuke Shimazaki, Sadamu Sudo, Hiroaki Oobayashi, Shinichi Tanaka, Mou Nan: "Design Development of Full Size Design and Developing Full Size Clay Model without Facilities and Equipment for Full Size Model", *Bulletin of the Advanced Institute of Industrial Technology,* No. 9, December 2015.

4.2 PBL case study 2 (instructor: Assoc. Prof. Toshitake Tateno, Innovation for Design and Engineering*at the time the project was conducted)

PBL on Product Development Process Methods

Summary: It is difficult to explicitly explain product development processes and is therefore said to require a lot of time and experience to master it. However, in a master's degree program, students are expected to demonstrate a certain level of skill improvement in two years. Therefore, while teaching at AIIT, I placed an emphasis on what is known as "process methods" – extracting areas of problem solving that can be systemized, which we come across now and again in product development. The procedures for "process methods" are clear, so by undertaking product development based on these methods, I believed students would be able to acquire concrete, if partial, skill improvements over a short period of time. This chapter will introduce the educational case study and examples of its results.

1. Learning based on process methods

I structured the PBL course for which I was the main supervisor so that its learning system was not separated from the "Advanced Exercises: Innovation for Design and Engineering" courses held in the second year of the master's program and consistent to the lectures and seminars that I taught. In their first year, students learn about methods in conceptual design, from the creation of a product concept to its trial manufacture, in the lecture "Design Engineering". In "Prototyping" and "Computer Aided Product", students learn about methods using computer support in all the stages from detailed design to the product trial manufacture. Next, in the "Advanced Exercises: Team Design and Prototyping" seminar, students design and manufacture a product experimentally in teams using the methods that they learned. After completing those courses, students undertake the creation of a product over the course of a year in "Advanced Exercises: Innovation for Design and Engineering".

Students began with acquiring knowledge in lectures, then conducting small exercises within lecture hours, then conducting exercises over a quarter-long course to finally conducting exercises over a year-long course. In this way, I had students repeatedly undertake "process methods" and gradually move closer to practical applications by having them handle products with complex and large-scale systems.

2. Shopping vehicle case study

In Tateno's PT, all six projects from FY2008 to 2014 were centered around "moving objects". The reason is because the faculty specializes in mechanical engineering. In order to create movement, an entity and a moving mechanism are necessary, which naturally requires the design and development of machines and mechanical systems. This chapter explains the PBL

process by using the “Shopping HPV” project conducted in Tateno’s PT in FY2013 as an example. Figure 1 is part of the panel exhibited at the project’s presentation for that year and outlines the process overview.

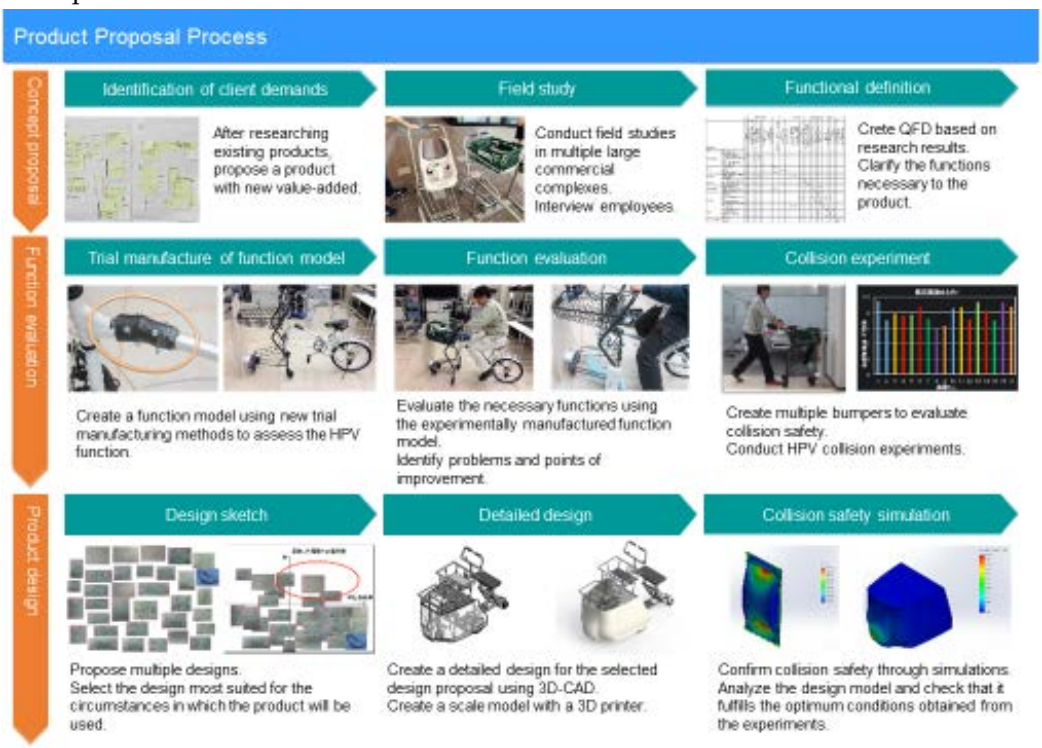


Figure 1: Overview of the product development process

2.1 Conceptual design

In Tateno’s PT, it was mandatory for students to conduct out-of-school surveys to clarify the product’s requirements for a conceptual design. The methods for conducting out-of-school surveys differ by year, with some examples including visits, interviews or inviting people from related companies as guest speakers. This year, after the development product was chosen to be a shopping cart, students visited large commercial complexes and conducted on-site interviews. Then the KJ method was used to create the concept for a new product.

2.2 Creating the specifications

Quality Function Deployment (QFD) was used to determine the product’s specifications. QFD was utilized to detail the points that characterized the product and to check there was nothing left unconsidered for the specifications. This project defined its new function as the “function for people to ride and safely maneuver the shopping cart”.

2.3 Trial manufacturing and evaluation of basic functions

Generally, the realization of new functions requires technological developments. This project

narrowed the functions down to two: the ability for people to ride and move around on the shopping cart and to ensure collision safety. Developments and evaluations were conducted on this.

To realize the mobility function, students came up with as many proposals as possible for structures that would fulfill functional requirements, such as the shopping cart maintaining stability when loaded with the same amount of baggage as regular carts, and also being able to make small turns. By organizing such ideas on a positioning map, we arrived at a structure that combined a regular shopping cart and a bicycle. For the trial manufacture, we created the necessary parts from resin material using a 3D printer. However, due to a lack of strength, it was supplemented by carbon fiber to ensure a level of sturdiness that would allow humans to ride it. Using the test product, we evaluated how it feels to ride and its mobility functions such as its minimum turning radius.

For collision safety, we focused on collision bumpers and discussed appropriate three-dimensional forms and hardness. A geometric model was created using 3D-CAD and we conducted collision analyses using FEM (Finite Element Method). As a result, we discovered it was best to create a bumper made of a thin, soft resin board slightly rounded near the bottom. So we designed and created models for several types of shapes, created the resin board using a vacuum forming machine and conducted a trial manufacture of the bumper. To evaluate it, we conducted a slow-speed collision experiment, then evaluated safety from the acceleration speeds, etc. that were measured during the experiment.

2.4 Detailed design and presentation

A final detailed design was made for the product based on the basic structure and the results of its functions' evaluation. In addition to making a geometric model using 3D-CAD and manufacturing an actual model using a 3D printer, computer graphics (CG) images were also produced. Creating CG still images of the product allowed us to evaluate its design, and CG videos were also created to allow regular people to understand the purpose and usefulness of the product being used in the three different environments that were anticipated during the planning stages (fig. 2).

(a) Shop while hand-pushing (b) Ride and move around (c) Sit and take a break

Figure 2: CG videos produced by using the 3D-CAD model

3. Examples of deliverables

This section briefly introduces the deliverables from Tateno's PBL projects conducted between FY2009 and 2014.

In FY2009, students proposed and manufactured a personal machine called "Medicine Helper" experimentally, which would notify users and prepare prescribed medicine at a given time. Its objective is to prevent users from forgetting to take their medicine and making it easier to extract pills from their sheets. Figure 3 shows its inner machinery structure. Its mechanism involves extracting designated medicine from PTP sheets (packaging sheets) at designated times by utilizing computer controls. Many components of the mechanism were created with a 3D printer and we were able to conduct a trial manufacture of an advanced machine in a short period of time.

In FY2010, an electronic wind chime called "Windchime Tidings" was proposed. It is a product that allows users living in cities to experience seasonal feelings while being indoors and to receive notifications of sudden weather changes. Based on weather information acquired from a sensor placed outside, the product in the room produces sounds according to the season and weather. A small radio wave communications machine was used in its implementation. Here, we were able to create a prototype model with a compact structure and appealing design.

In FY2011, we made a proposal to create a "machine and service that will produce a sense of uniqueness using chocolate bars and pixel art". An idea was developed to produce something special by drawing pixel art using the grids of chocolate bars. We constructed a device that would take a picture drawn on a computer software and apply it to create a colored chocolate bar. During this project, we produced innovative deliverables in all the areas of service, software and hardware.

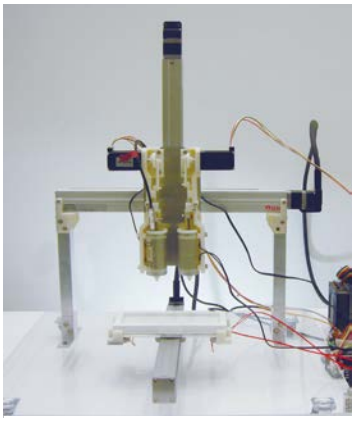
In FY2012, we created the "Shopping HPV" introduced in the previous section. With it, we were able to obtain technologically advanced deliverables.

In 2013, we proposed a "walking support tool," which would help elderly people with weak leg muscles to broaden their area of activities and live more active lifestyles. We conducted a trial manufacture of a device that uses a spring at the bottom of the foot to accumulate power from the shin guard and convert it into a propulsive force. Through this project, we were able to obtain advanced deliverables that included a lot of specialized knowledge and technologies.

In FY2014, we made a proposal to provide a mobile manufacturing service called "Fab Circus". We focused on the 3D printer as a new manufacturing technology and proposed a service to visit clients and provide lessons and advice on design to spread the fun of crafting. We set up the project presentation event itself as an example of the service and exhibited sample services such as in the categories of toys and utility items.

(a) Medicine Helper (mechanical part)

(b) Windchime Tidings



(c) Chocolate bar manufacturing device (mechanical part)

(d) Walking support tool

(e) Fab Circus

Figure 3: Tateno's PT deliverables

4. Results of PBL education

As this shows, we were able to produce excellent deliverables from all the projects. However, we were not only fixated on the deliverables but also conducted PBL activities as a practical application of "process methods". It is difficult to see the skills acquired during PBL as a team activity, but in Tateno's PT, work was divided based on the methods, so every member was able to understand the essence of the method they were in charge of. By applying them on a practical level, I believe they were able to acquire concrete skill improvements.

4.3 PBL case study 3 (instructor: Prof. Tetsuo Fukuda, Innovation for Design and Engineering* at the time the project was conducted)

Fukuda's PT Recollections

1. The future of lifestyles begins with a dream

Fukuda's Project Team (Fukuda's PT) is a design manufacturing project. To realize "a rich lifestyle through beautiful and attractive manufacturing," we research the ideal state of transport in large metropolitan areas where people, things and information flow.

First-generation students made a proposal to prevent traffic congestion between Haneda Airport and Tokyo Station by directly connecting the two using ship transportation and reducing the transit time.

Second-generation students made a proposal for a transit mall with the aim to create new value-added for an attractive Ginza town by making the new "Yurikamome" transit into a loop line and introducing autonomous driving.

Third-generation students focused on the Toyosu district and made a proposal for small-scale water transit lines, which will prove useful as a form of transportation in a spacious district with a concentration of large resident complexes.

Fourth-generation students made a proposal for a form of transoceanic transportation at a speed in between airline and sea travel – airships. The proposal includes the installation of a small mooring device, making it an environmentally friendly form of transport.

Fifth-generation students focused on alleviating traffic congestion during rush hour and proposed a water bus based on the Nihonbashi river model.

Sixth-generation students proposed a business model that includes a land utilization measure to grow Tokyo style food ingredients by integrating container wharfs and then opening a restaurant boat that minimizes the influence of transverse waves.

Seventh-generation students predicted a new station opening on the Yamanote line and made a proposal that would allow the lights on the hydrophilic pavement to act as emergency guidance lights during a natural disaster.

Eighth-generation students focused on the future of the city where social instability is increasing, and the population is aging. They believe communication is crucial to removing anxiety and selected "bonds" as their theme. Each student is preparing for the final results presentation, such as with proposals for multi-purpose transport that would circulate around town.

2. Discovering new value between problem solving types and hypothetical proposal types

Each year, members of the project team (PT) discuss abstract propositions given by the main supervisor to decide on a theme. The main theme and concept are formulated during the first

quarter of the year's curriculum, while the stage for laying down concrete ideas is scheduled for the second quarter. To proceed with a project according to schedule is difficult even in actual real-life operations, so it can be said that the work to make adjustments is the real essence of PBL education.

Generally, when taking a problem solving approach to a proposition, problems are identified based on knowledge from observations and research data. It risks proceeding without a clear future outlook. On the other hand, a hypothetical proposal project is a research that has a vision of an ideal future and aims for an eco-design based on a social system that is considerate of a safe and comfortable environment.

Using a back-casting approach, problems are identified in the difference between the ideal and reality to proceed with creative reforms.

Therefore, Fukuda's PT members, as hypothetical proposal types, are instructed to imagine the near future in 10 to 20 years' time, around 2030, and to share their dreams. This hypothetical proposal type project may seem like a dream tale, but students strive to improve their proposal contents by repeating PDCA (plan–do–check–act) such as by: reading technical roadmaps in various fields; interviewing professors, personnel from metropolitan offices and producers from multiple companies in those fields; and furthermore by participating in exhibits, etc.

3. Efforts by the PM to avoid isolating members

Even if each individual is highly skilled, it does not mean they can demonstrate it in group work.

The teamwork necessary in continuous research is mutual awareness among members and consideration of role distributions.

The PM's role ranges from external negotiations to taking care of team members, but it is no easy job. There appears to be several patterns of failures.

Case one: the PM does too much on his own. Even though the project may appear to be moving forward smoothly, all the members except the PM have lost motivation.

Case two: the PM changes every term, and the resulting negative chain reaction makes it impossible to control the project.

Case three: the PM is a student newly out of undergraduate with no real-life experience in working society. The lack of trust isolates him/her and the project strays off course.

In the first case, it depends on how well the PM can put him/herself in the shoes of the other team members and think from their perspective. In a conscious effort to get members to relax, PMs make plans to gather everyone together with food dishes from each of our hometowns, hold birthday parties, invite graduated students for opinion exchange sessions, and go to social get-togethers in accordance to the season. These are all efforts by the PM to avoid isolating members. In the past, there were even cases where an out-of-school survey resulted in

becoming a field trip vacation.

It is important to find out about the members' personalities and dispositions at an early stage and build smooth human relations. Otherwise, no matter who the PM is, members will see him/her as running a one-man show with a project where the situation is apt to change from one minute to the next, giving the impression that the PM is forcing the project alone.

4. Visual information is the project's propeller

In the second case, it is important to ensure that design concepts and information sharing do not fluctuate even if PMs change by term. The project will be able to stay its course if visual information is handled well and information is organized.

Communication methods in a project include verbal information from conversations as well as written information from documents. However, it goes without saying that compared to a document with a massive word count, visual information that takes just one look to understand is more effective in recognizing forms. Among them, sketches excel at helping the members form a mutual understanding, whether it be a memo or thumbnail drawn for a meeting or the rendering of a conceptual drawing.

Additionally, 3D models that are created to develop understanding allow members to visualize the process, from exchanging opinions on details to reaching an agreement. This 3D model becomes the springboard for reflecting third party opinions and, by being repeatedly updated at weekly core meetings, allows it to act as the project's propeller.

As this shows, the verification process using a 3D model is essential to discussing the ideas conjured by the members, who all have diverse values. Therefore, in Fukuda's PT, it is considered a crucial process.

Regarding quality improvement, as was mentioned above, we aim to reach the highest possible level of quality by producing the model repeatedly at least three times to ensure it can withstand external assessment.

5. Have multiple people engage in a role and understand one another

The third case results from the PM being overenthusiastic due to a sense of responsibility and yet going nowhere due to a lack of experience.

In Fukuda's PT, if a student fresh out of undergraduate with no work experience volunteers to become PM, I instruct him/her to take on the role together with another person. Having a student with work experience act as a behind-the-scene PM in an assistant role helps to keep the project running smoothly. Additionally, it is a complementary measure to prevent the project from coming to a standstill if some members are absent due to certain circumstances. The PM also needs to have an unadorned quality that allows him/her to repeatedly and modestly reflect on oneself, or else building mutual trust among the members will be difficult, making it impossible to move forward.

In actual working environments, PMs are not often changed. Practical job performance skills require the ability to act resourcefully to recover the situation no matter what happens. However, since this takes a significant amount of time, I do not think it pertinent to change PMs partway through on a short-term basis. The success of a project also depends on whether there are team leaders capable of connecting the four quarters of the year.

6. The key is the existence of team leaders separate from PMs

PMs cannot always be a leader from the start and, in fact, do not have to be a leader at all. When a problem occurs in the project, sometimes a student rises with a quality that allows him/her to convert the issue into a vision of the future. When that happens, and all the other members are able to come together as one, it is the sign of a leader. It is necessary to understand the difference between the PM and the leader.

The role of a project's PM can be decided based on one's likes and dislikes. However, volunteering doesn't make a person a leader, and neither is it a quality that can be acquired by reading textbooks. A leader cannot function as a leader unless he/she is recommended and acknowledged by the surrounding people. Generally, leadership qualities are more about virtue than talent and depend on an individual's personality, such as how popular he/she is.

The job performance skills aimed to be acquired in PBL education naturally include interviews and appropriate guidance along the way, but I believe it is also important to build an environment where students can learn naturally through such trial and error within the team.

Therefore, a leader is not born from a simple role assignment or through self-recommendation. Even though there may not be a specialist in that area in PBL-PT teams with randomly chosen members, I often see certain individuals stand out at every mid-term results presentation as someone who organizes the team as a whole. In the first quarter, that person usually excels in communication and negotiation skills or concept building and creating proposal documents. In the second and third quarters, the person is usually adept at producing models. As one sort of example, there was an engineering student who had mostly refrained from speaking out due to his age and low confidence stemming from lack of experience. However, he realized he had specialized skills that differed from others and by supplementing what they lacked, his team members began to admire him. This led to him building confidence and he eventually guided the entire project. Some students have grown significantly due to this sort of small leadership experience in role assignment. This is the best result of PBL-PT and its biggest attraction.

Whether they can become future leaders depends on repeating this kind of experience, so I hope they continue to refine and cultivate themselves as individuals.

7. PT bonds of successive generations are passed down even after graduating

Meta-competency, which is a characteristic of PBL at AIIT, is a leading concept in the curriculum and essential to completing projects. It requires communication skills, which are crucial to teamwork, as well as the ability to take action that leads to one's continuous research.

Over the course of a year, some students achieve genuine growth and others gain confidence by realizing they possess specialized skills that they were unable to fully utilize until now. Reflecting on themselves and learning from the actions of other members, they build a natural, mutual relationship of leader and follower. Furthermore, there are students who used their experiences from the PT to identify operational issues in their companies and made significant contributions as middle managers. Even among students who did not have confidence upon completing their master's degree, some went on to demonstrate admirable skill changes several years later. These are all reflections of the educational outcomes at AIIT.

On a final note, I would like to convey that the bond between Fukuda's PT members from successive generations continues to deepen, not only through mid-term and final result presentations, but even at various opportunities after graduation where they provide guidance and cooperation.

I hope this contributes even a little to the PBL-PT benchmark, which will be developed in the future with the aim to combine the sensibility and functional fields.

4.4 PBL case study 4 (instructor: Prof. Hiroshi Hashimoto, Innovation for Design and Engineering)

Research Development Based PBL on Skill Learning Services

Summary: Skill learning services have been drawing much attention in recent years in the field of service studies as one that supports our country's sustainable development. This service requires knowledge and skills from a wide range of fields including social sciences and humanities, engineering, bioengineering, and business. Students in charge of each field think of ways to identify new challenges and resolve problems, then undertake work to effectively combine the knowledge and results from each field. This PBL implements a process whereby the students either present their results at a domestic or international academic conference or utilize the results in a field business to confirm the assessment of their outcomes.

1. What is a skill learning service

Skills involve body movements and require not only knowledge but also the repetitive practice of muscles and the nervous system. Furthermore, anatomically speaking, there are approximately 200 bones and some 400 skeletal muscles, and the bones' sizes and joints' ranges of motion are different for each person [Kapandji 1983]. Therefore, it is believed that creating a model movement is impossible. Next, somatic senses based on sensory organs differ between individuals, so even if you feel like you are moving correctly, it could be that your perception of multiple skeletal muscles is incorrect, and several parts may be moving incorrectly. Therefore, if you try to move by cognitively understanding what you want to learn, it may result in a discrepancy between cognition and actual body movements. This is known as the issue of discrepancy between a learner's cognition and movement [Hashimoto 2016]. Figure 1 illustrates this way of thinking.

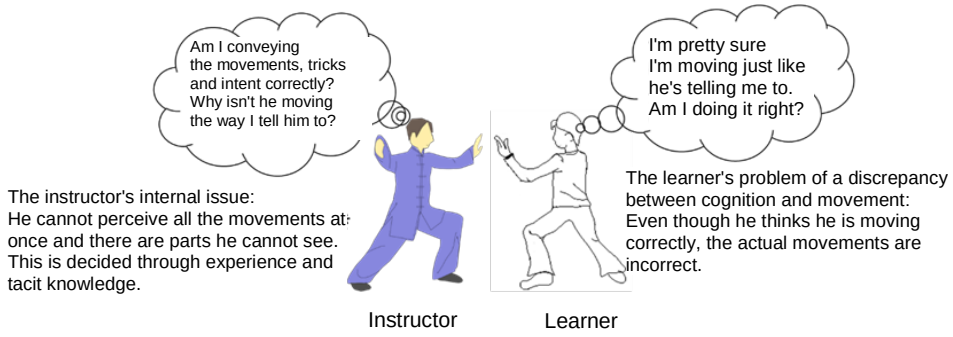


Figure 1: Illustrated explanation of internal problems and a discrepancy between a learner's cognition and movement

On the other hand, skills are at the core of fields that characterize our country, such as

manufacturing, sports, nursing, and cultural etiquette. However, the following issues can be seen in the ways skills were traditionally passed down.

- A lot of it was passed down verbally (oral instructions) and through imitation (such as learning through observation), which lacked communication, giving rise to the existence of tacit knowledge and being inefficient.
- Methods of passing down skills and developing human resource skills that aimed to be more efficient focused mostly on procedures and schemes without including what education refers to as ARCS (Attention, Relevance, Confidence, Satisfaction) or attempting to maintain or improve continuity.

Skill learning services aim to resolve these problems from some sort of perspective to allow both instructors and learners to feel a sense of satisfaction while also co-creating value in the teaching service [Asama 2016].

2. Skills for designing skill learning services

The following technologies are needed to design, develop and implement new skill learning services:

A) Service engineering: the understanding of systematic details involved in the quality, value, process, recovery and satisfaction level assessment related to services.
B) Human behavioral science: the understanding of biokinetics, which discerns the characteristics of humans as organisms, and of the context of movements, which occur based on environment, tools and culture.
C) Artificial operating technology: CG technology capable of representing robots, avatars and characters as the service media that delivers the service.
D) 3D measurement of humans: technology that can measure the three-dimensional movements of humans, then produce, record and display skeletal models of it.
E) Psychological analysis: technology capable of measuring and analyzing satisfaction levels and psychological changes recorded in the service value assessment.
F) Media representation: technology to represent the developed service.

3. PBL method and process

As PBL is founded on group work, the best method to utilize this mainly involves the sharing of concepts among members and the sharing of knowledge and skills that each member is responsible for. Situations that require the sharing of concepts include when members decide on the theme, as well as when they decide on how and in which direction to move forward with the project. Sharing concepts is a high order meta-level, so discussions that simply verbalize or visualize ideas is insufficient in representing the meta-level. Therefore, I have students search for every possible approach. For example, hypothetical and authentication theories, verification methods conducted in the field, and conducting hearings from outside intellectuals

are all effective approaches.

At the start of the PBL process, all the members begin discussions to decide on a theme. Discussions begin at first with research on the definition, characteristics and contents of the service. As long as the service is targeted at humans, all the members take part in investigating prior research on a wide range of topics, such as human characteristics, the process and conditions of achieving satisfaction, and the specifications for the man-made product, which will act as the service medium. However, when students come across situations that require understanding of academic or technical contents during the research or study for choosing a theme, some students will have difficulty in comprehending it.

Since students have reservations toward each other at the beginning of the project, when discussions are held between students with different levels of understanding, no one will press questions on those who are having difficulty keeping up, which often results in slowing down the discussion. However, since discussions require the ability to understand each other's standings, a key challenge is how to help students achieve the same level of understanding. In this case, by having instructors act as supervisors, or at times mentors, they can effectively guide the student members and give suggestions, thus creating opportunities for the students to ask each other questions and mutually recognize the progress they make on understanding each other. By being able to share that recognition, students who understand the topic are able to come up with ways to explain it to those who don't understand. Then, those with low-level understanding will gradually be able to gain an understanding and ask questions and participate in the discussion.

The role assignments based on technical skills outlined in the previous section are assigned regardless of personal strengths and weaknesses, and instead because they are what the student wishes to acquire or believes will allow him/her to meaningfully contribute to the company or society. In this PBL, students are also expected to share what each of them researched or the knowledge and skills they acquired. This is because what one learns becomes complex knowledge and skills, and by discovering how to explain and convey these to third parties in an easy-to-understand way allows one to gain presentation skills. Therefore, students also learn about different presentation methods, not just PPT presentations, such as showing videos or actually demonstrating an experiment and having others experience it.

During the final stages of the PBL process, students need to try and effectively combine the knowledge and skills that they all acquired. For that reason, they engage in the task of reviewing the theme once again. Even if they have not deviated from the theme's basic concept, which was decided at the beginning, they will be able to see over time who the marketing target is, what technologies the students are capable of handling and those they are not. The students demonstrate their skills to the fullest during this stage while also reviewing the operation process so that it fits the theme concept and revising how they will present it to third parties.

By this stage, the students have accumulated enough experience in sharing concepts and undertaking tasks to share their knowledge and skills, so even if they have disagreements on directionality, they will be far better at understanding what each one is thinking. Compared to the initial stages of the PBL process, their discussion efficiency will have improved drastically.

4. Project example

This section will introduce details of the Innovation Design Exercises 1 and 2 held in FY2015-16. In this project, the instructors listed several ideas that included the four perspectives of social significance, innovation, feasibility and usability. The members made mutual proposals and assessments, and based on that, decided to all share the following contents:

- Social significance: the Japanese-style analysis of movements and modeling, which is one of the factors contributing to the excellence of service in Japan, has a high ripple effect in other countries.
- Innovation: the Japanese-style of quantitative representation of movement cannot be found in existing research.
- Feasibility: for basic movements such as bowing, it is easy to conduct a 3D movement analysis as well as a psychological analysis and examination.
- Usability: the extraction of quantitative characteristics of the movement is efficient, can be applied to teaching large numbers of people, and can also lead to increasing the value of the service accompanied with the movement.

As a theme that satisfied all of the above points, the members agreed upon: “Providing a learning service for graceful, Japanese-like movements”. For details on the contents and results, please see the university’s PBL page.

Presentations at an academic conference and verifications in field businesses are used as a means to make use of this PBL’s results. In FY2015-16, there was one international academic conference presentation made by working students as well as five domestic presentations.

The international academic conference presentation [Kudo 2015] focused on investigating the psychological analysis of gracefulness from a statistical viewpoint. When the paper was submitted, a foreign reviewer posed several questions and indicated some points regarding the representation of Japanese gracefulness from a different cultural perspective. This allowed students to realize anew the difficulty of generalizing the objective and quantitative assessment of gracefulness, and they were also able to discover further developments on theories regarding gracefulness. Additionally, students prepared around 50 Q&A questions in advance and used them to practice before holding the presentation. Their English skills may not have been perfect, but the firsthand experience made them aware that conducting a Q&A in English requires not only English skills and logical composition skills but also intercultural

communication skills. They were able to realize again that they need to continue studying in a variety of fields in the future and this proved to be a good motivator. It can therefore be concluded that taking on the challenge of this presentation led to eliciting a high level of learning motivation.

In the documents [Tsuda 2015] submitted for the domestic academic conference presentations, the main student in charge advocated an innovative bowing model. At the conference presentation, this was recognized as useful and received an outstanding lecture award. The students who were awarded this said it not only led to the motivation of more high-level learning, but also to joy and relief knowing that the project was publicly acknowledged for being good and that what they had done had been right. Hearing this opinion verifies that the presentation was effective and worthwhile.

As for the verification to be conducted in field businesses, as of FY2016, the student in charge is in the process of implementing the skills he acquired during PBL at the institution he is associated with. I have received reports that they are highly effective and would like to report on these results at a different opportunity.

Of the competencies acquired by all the members, creativity, expressive ability, design skills and analysis skills improved in particular. In the evaluation among students, they indicated that their fellow members improved on these abilities with every quarter semester. I found this result to be highly interesting and believe the activities in this PRJ improved each of the students' skills in accordance to the PBL's original aim.

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4.5 PBL case study 5 (instructor: Prof. Mitsuhiro Maeda, Innovation for Design and Engineering)

Policy Proposal for Asian Industrial Community Construction Measures

Summary: An explosive economic growth has been taking place in Asia, especially East and Southeast Asia, since the end of the 20th century. Surprisingly, it is not simply a high economic growth rate. An advanced global production network known as the Second Unbundling has developed in these areas, giving birth to a cutting-edge phenomenon found nowhere else in the world. The aim of this PBL is to dive into this historic movement of mankind and investigate a policy measure that will lead to Asia's further growth (industrial community construction measures) and to propose it to Asian government officials. The most unique characteristic of this project is that students actually travel to Asia and are able to hold discussions with government officials there.

1. Economic growth and industrial communities in East and Southeast Asia

In order to fathom the true value of the economic growth that has been taking place in East and Southeast Asia since the end of the 20th century, it is necessary to look back at the history of the world's global production networks. Until the beginning of the 1960s, "production at the site of consumption" was the general principle in the world. If the people purchasing TVs and bicycles were Japanese, the Japanese companies producing those products would build factories in Japan and manufacture them there. During the 1960s, the First Unbundling occurred (the unbundling of production and consumption). In other words, it became the age of multi-national corporations. Big businesses in developed nations began to invest in developing nations, where production costs were low. There, they manufactured products and exported them to developed nations.

This, so far, is a "natural" occurrence that is taking place around the world. On the other hand, in East and Southeast Asia, things have moved a step further, manifesting itself in the phenomenon of a Second Unbundling. Here, each functional unit within a company becomes unbundled from the aggregate that is a company, and they each invest in optimal sites. Usually, when a business from a developed nation invested in a developing nation, all functional units would be invested together. However, with the Second Unbundling, each functional unit began to invest in different countries. It is a highly evolved global production network. As a result, many industrial clusters are being developed in various East and Southeast Asian countries.

Among those industrial clusters, so-called industrial communities are being born, similar to those that were developed in various areas of Japan in the 1960s to 70s. The basic principle of Maeda's PBL project is to further develop the industrial communities that are suddenly rising in various East and Southeast Asian countries and to contribute to their additional economic growth.

2. Industrial community construction measures and policy proposal

The two pillars of Maeda's PBL are the following:

The first pillar is to put together a policy proposal with contents that will have a true effect on developing industrial communities in East and Southeast Asian countries. In order to do that, students must first fully understand the mechanisms behind the economic growth of developing nations, including East and Southeast Asian countries. This requires an extensive comprehension of theories beginning with development economics. Second, students must have a deep understanding of the situation in East and Southeast Asian countries, if possible by seeing it with their own eyes. It is for this reason that on-site research is recommended and many members of Maeda's PBL frequently travel to East and Southeast Asian countries every year.

Thirdly, students must correctly understand the meaning behind why the proposal is not a business proposal but a "policy" proposal, and as such, they are not making the proposal to businesses or partners but rather to government officials. The aim of the proposal is not to make business profits by exploiting the rarity of the sudden rise of industrial communities. Instead, it is to further develop industrial communities to promote the economic growth of the country as a whole. It targets the so-called "market failure" field.

The second pillar is to brush up the policy measure that they put together to a level where they can propose it to foreign government officials without making a fool of themselves.

Coming up with a good idea and refining the contents of that idea to a level that can compete on a real foreign diplomacy level are two completely separate matters. There are a variety of manners and styles that must be observed in foreign diplomacy documents and students must learn these correctly. For most students, this will be the first time in their lives that they write a document to be submitted on a foreign diplomacy level. It will be hard work.

Overcoming these obstacles, students will actually propose a policy measure to government officials in East and Southeast Asia. For students, it is an unparalleled opportunity in their lives to shine.

The next section will highlight several representative case studies of past students' results born from their hard work.

3. Case study 1: Policy proposal for the construction of a bond collateral style finance system for small and medium-size companies (FY2013)

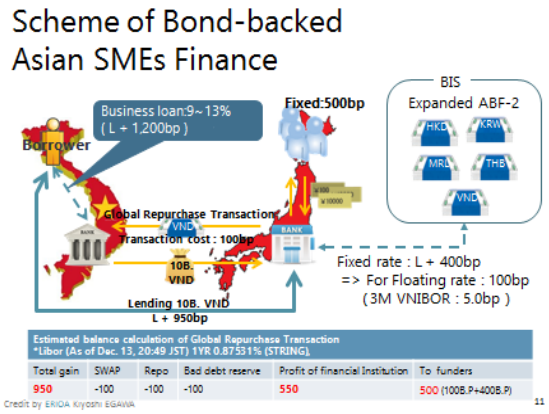
3.1 Content

The development of small and medium-size companies is one of the most crucial challenges facing every developing nation. A particularly difficult challenge in development measures for small and medium-size companies is the construction of an appropriate finance system for such companies. Finance for small and medium-sized companies is a typical example of

"market failure" and private financial institutes alone are not able to provide the socially optimal amount.

The FY2013 Maeda PBL focused on this area. The target country was Vietnam. Expectations are placed on Japanese small and medium-size companies to play a crucial role in developing the industrial communities in East and Southeast Asia. If Japanese small and medium-size companies invested in Vietnam, they would need a low interest finance denominated in the local currency. However, the current interest is over 15% in the local currency. The students therefore went to work on constructing a new system with the slogan: "Local currency-denominated, L plus 1000 (LIBOR+1,000bp)".

The completed system is as shown below. It accomplishes L+950bp by collaborating with ABF (Asian Bond Fund).



3.2 Policy proposal

On January 17, 2014, the students made a policy proposal in Tokyo to the Deputy Minister of Vietnam's Ministry of Planning and Investment, who was visiting Japan. On June 9, 2014, they made a policy proposal in Tokyo to the Governor of the Development Bank of Southern Africa, who was visiting Japan. On August 5, 2014, students participated in and gave a presentation at "The Hanoi Workshop: Entrepreneurship and Business Development – The ASEAN Economic Community Perspective," a joint seminar held in Hanoi by Vietnam's Ministry of Education and Training and the Hanoi University of Business and Technology (HUBT). On December 5, 2014, they participated in and gave a presentation at "Microfinance on the Sustainable Economy in Lao PDR", a joint seminar held in Vientiane by APEN (Asia Professional Education Network) and the Bank of the Lao PDR. On March 19, 2015, they participated in and gave a presentation before the Primary Deputy Minister of Cambodia's Ministry of Industry and Handicraft at "The APEN International Seminar on SME Finance", a seminar held in Phnom Penh by APEN.

4. Case study 2: Policy proposal for the construction of an Industrie 4.0+ model power grid system (FY2015) in Mekong countries

4.1 Content

The construction of the Industrie 4.0 model CPS (Cyber Physical System) that is currently underway is generally an initiative within one country. On the one hand, the scale of industrial manufacturing in Mekong countries (Vietnam, Laos, Cambodia and Thailand) is far smaller than developed nations such as Germany, the USA and Japan when looking at each separate country. However, on the other hand, due to AEC (ASEAN Economic Community) beginning at the end of 2015, Physical Connectivity such as power grids and Institutional Connectivity are progressing among neighboring countries.

Analyzing this sort of background, the FY2015 Maeda PBL focused on the idea of Industrie 4.0+, which was advocated by APEN in May 2015 to construct a CPS that extends across several countries (Industrie 4.0 being the construction of a CPS in one country and Industrie 4.0+ being the construction of a CPS in multiple countries).

The policy proposal that was formulated was the implementation of an electricity rate system with rates that differed according to the time of day (expensive during the day and cheap at night). This sort of system had not yet been implemented in the power supplied from Laos. Upon implementing this system, the international organization based in Laos would then move forward with optimizing electrical supply to all the countries along the Mekong River. The proposal aimed to construct a system that would use IoT to adjust the operation of factories in all the countries along the Mekong River during the day when air-conditioning demands are high.

4.2 Policy proposal

On December 3, 2015, the students held a lecture at the National University of Laos in Vientiane. They invited professors specializing in energy and electric power and proposed a policy measure.

5. Case study 3: Establishment of an international organization to support the construction of a network-based outsourcing system in Indochina countries (FY2016)

5.1 Content

Since the end of the 20th century, global outsourcing has become the norm in the ICT industry. The state of this global outsourcing has changed over time. Before, Japan simply outsourced offshore to low-cost developing nations, but now, the outsourced countries have come to possess advanced autonomy. The FY2016 Maeda PBL thought to evolve this further and create an outsourcing network that covers all Indochina countries and collaborate with other regions in the world. Doing so would provide ICT companies in Laos and Cambodia (and Myanmar in the future) with access to the global market to alleviate their current issue of not receiving enough

outsourcing orders. This would contribute to developing the ICT industries in such countries.

Specifically, the policy proposal advocated the establishment of an international organization to organize the intellectual and institutional infrastructure necessary to construct such a network-based outsourcing system. The headquarters would be established in Vientiane, and its main activities would include business matching, standardization, skills development, verifications pertaining to skill, and consulting.

5.2 Policy proposal

On January 16, 2017, the students held a lecture at the National University of Laos. They invited professors specializing in information-related fields and proposed the policy measure. They plan to further brush up on it from now and continue to make proposals to government officials in Indochina countries.

4.6 PBL case study 6 (instructor: Prof. Hideki Murakoshi, Innovation for Design and Engineering)

Development of a Multilateral Imaging System for Polarized Light Imaging and its Applied Research

Summary: In FY2015, Murakoshi's PBL project conducted the development of the system and its applied research to resin mold evaluations under the above title, producing significant research results. The first half of this report summarizes the project's results, covering from system development to its application for resin mold evaluations. The second half will cover how the "results"-orientated project was run.

1. Polarized light observation

Polarized light is light that vibrates in a single direction, and applying polarized light makes it possible to see things that cannot be seen or are difficult to see under regular light. Figure 1 shows a CD case made of resin material and by applying polarized light, you can see the distortions that were made during injection molding as polarized stripes. As shown in figure 2, when making polarized light observations, light from a lighting apparatus is filtered through polarizing plate 1 to create polarized light. The polarized light then penetrates the observation target and by viewing the target from behind polarizing plate 2, you can observe the polarized stripes.

Figure 1: CD case

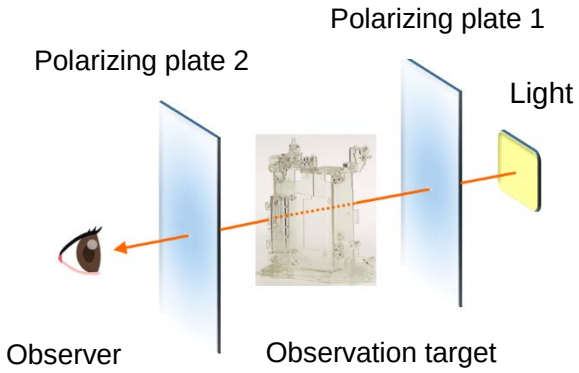


Figure 2: Polarized light observation

Changing the angles of the light and polarizing plates and also rotating the angle of the object change how polarized light is observed. Experience and know-how are required to obtain useful images with clearly visible results. Therefore, the students developed a polarized light imaging system that is able to automatically photograph polarized light images under different conditions by being equipped with multi-wavelength light sources and by rotating the observation target. The system would then be able to display the images in a movie, much like a flipbook animation.

2. Polarized light imaging system

Figure 3 shows the structure of the developed system and figure 4 its exterior appearance respectively. As figure 3 shows, the system is comprised of a) lamps, b) a polarizing plate, c) a rotary table, d) a polarizing filter auto charger/rotator, e) a digital SLR camera, f) an operation panel, and g) a microcontroller board (Arduino-Based Micro Computer), h) a PC. Components a through e, which are directly involved in the photographing process, are installed in a black room.

As the photographing example in figure 3 shows, by inputting settings 1 through 4 into the operation panel, the g) microcontroller board will control components a through e to photograph 800 polarized images under different conditions. The polarized images that are photographed will be sent to the h) PC to be edited in a software named PPP (Polarized Photo Processor). PPP is a software developed in this project, capable of encoding a massive quantity of image data and creating a compact movie file. Figure 5 is a playback screenshot of the video file, encoded by using PPP. The observation target is a cellophane tape cutter and the screenshot displays a lineup of four polarized images photographed under different conditions. By operating the mouse, the four screens can be rotated simultaneously and compared.

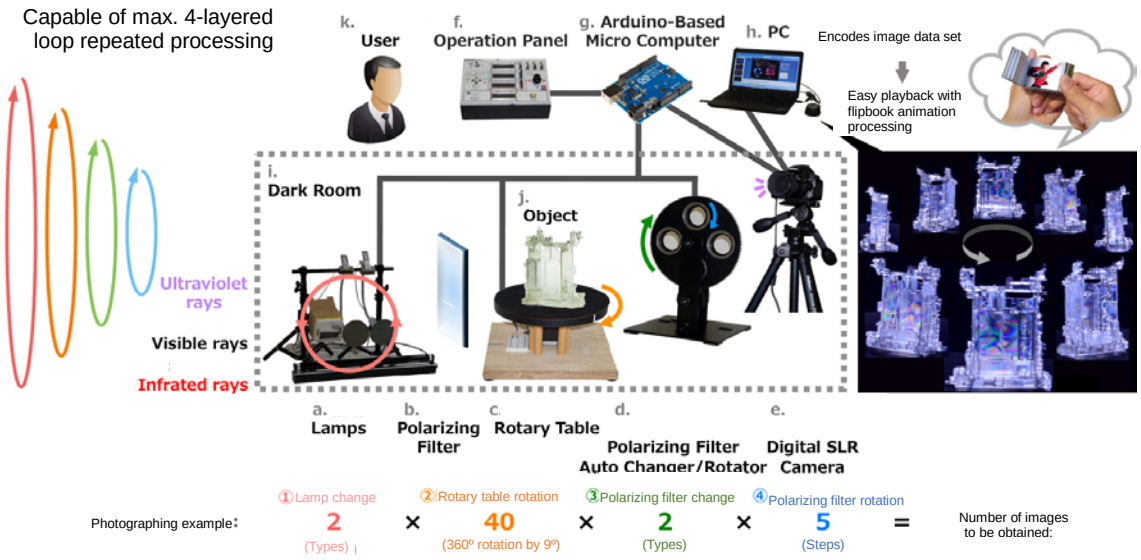


Figure 3: System structure

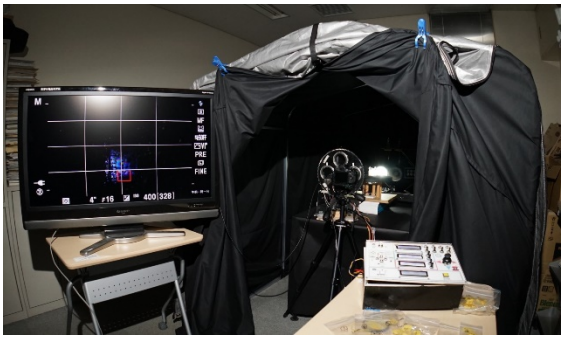


Figure 4: System exterior

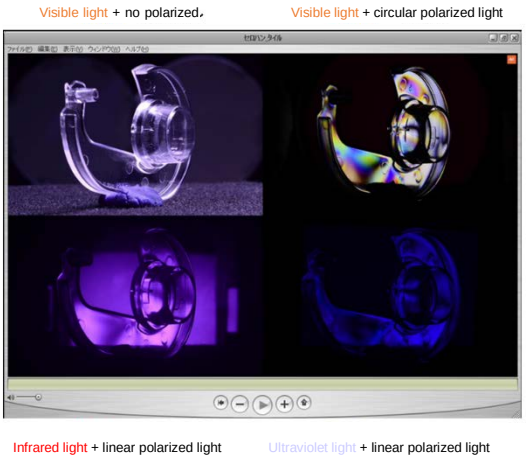


Figure 5: Video playback screen

3. Applied research on resin mold

This section introduces the case study of how this system was applied to evaluating resin mold. The CD case in figure 1 is comprised of two components on the right and left. On the left central area of each component is an injection hole from which resin was injected, and one can observe the way it spread and created a distortion, as well as the resulting polarized stripes. Additionally, students created an L9 orthogonal table (table 1) with four factors: cylinder temperature, mold temperature, injection pressure, and the time a certain level of pressure was maintained. The results of observing the samples molded by injection under those conditions are recorded in figure 6. Distortions in the molds differ depending on the conditions and can be seen to change the resulting polarized stripes. Furthermore, in polarized light observations using infrared light, students were able to observe the distortions of colored resin molds, which was not visible under visible light, as shown in figure 7. This concludes the summary of results for this project. For more details, please see reference (1).

Table 1: L9 orthogonal table

Experiment No	Cylinder temperature (℃)	Mold temperature (℃)	Injection pressure (bar)	Time maintaining steady pressure (sec)
1	210	40	300	2
2	210	60	500	5
3	210	80	700	10
4	240	40	500	10
5	240	60	700	2
6	240	80	300	5
7	270	40	700	5
8	270	60	300	10
9	270	80	500	2

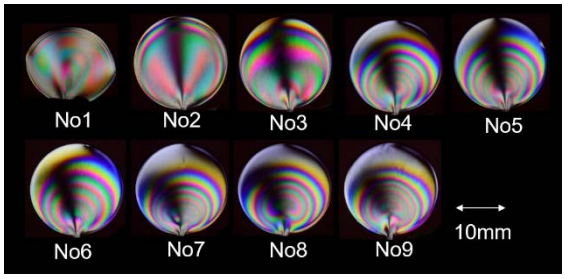


Figure 6: Polarized light observation of samples molded by injection under different conditions

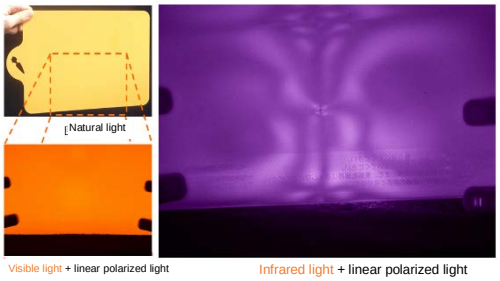


Figure 7: Polarized light observation using infrared light

4. "Results"-oriented project management

This project led to holding eight external presentations, such as at academic conferences, as well as participating in eight exhibits. In addition to that, a press release was issued, interviews were given, and the project was published in a newspaper article that took up seven columns with photos. It was also entered into the 28th Leave a Nest Research Fund Town Workshop Award where it won two awards. Furthermore, it has filed for a patent (2) and volunteer members still come together and are continuing activities to make it into a business. It goes without saying that these results were made possible due to the outstanding members who participated in the project. However, it was also rooted in the "results"-oriented project management, which was introduced at the beginning of the project and laid the foundation for all its activities. The reasons I chose a "results"-oriented project management are because 1) for newly graduated students, having a research accomplishment in their final education level gives them an advantage when looking for jobs, and 2) for working students, the acquisition of competencies coincides with their needs, but results presentations are the best way to back it up with evidence.

This project was conducted by a total of five members: two working students, one newly graduated student, and two overseas exchange students. Soon after its commencement, they held vigorous discussions and set up the following objectives.

1) To create a highly practical technological development capable of contributing to the improvement of manufacturing processes.
2) To conduct applied research with the developed system, pursue a high level of potential and marketability, and release information on the results.
3) To acquire skills through the project to be able to become immediate assets in society and achieve further growth as individual people.

Important here is consensus building between the members. In order to create many accomplishments over the year, they took time to talk about each of their backgrounds, the reason they came to study at the school, and what they wish to do. Working students shared their knowledge and experiences of corporate work and about achieving accomplishments. In this way, they deepened their mutual understanding of one another and agreed on the above

objectives. After deciding on the objectives, the project members used them as a foundation to thoroughly discuss matters and decide on the project theme and annual schedule. The schedule presented during the 1Q mid-term presentation is shown in figure 8. It already includes future milestones such as academic conference presentations, which conveys their aspiration to actively build up and release their research accomplishments.

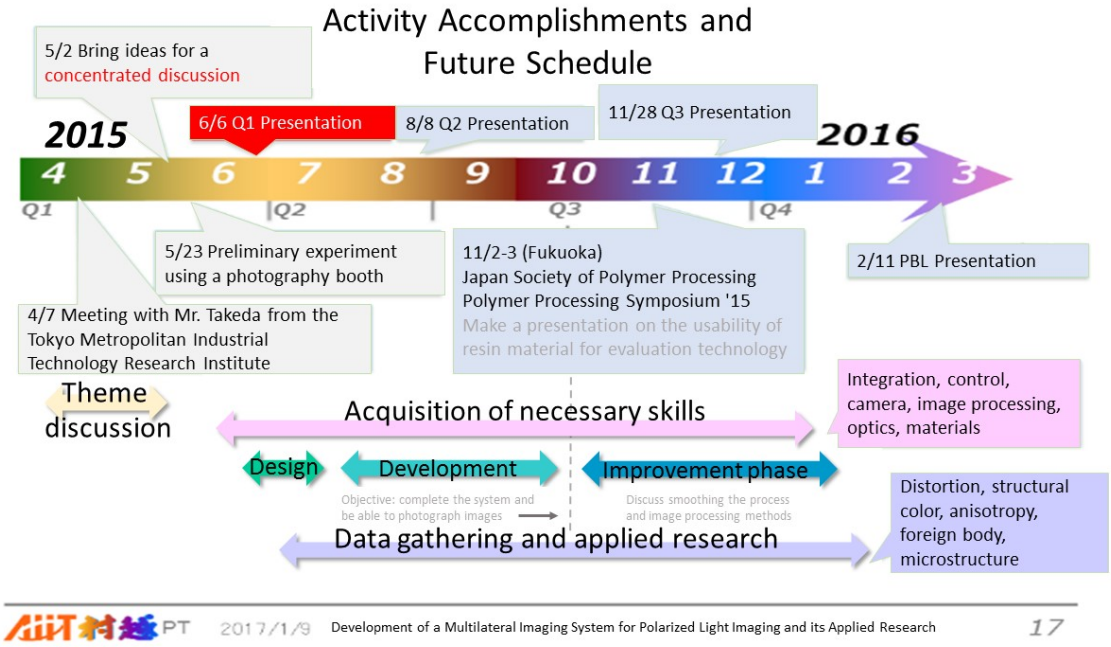


Figure 8: Annual schedule table

Through the "results"-oriented project management, the students were able to hold excellent presentations/exhibits based on multiple research accomplishments during the mid-term presentations between the first and third quarters, as well as the results presentation on February 11. Visitors spoke very highly of their work. For details of the "results"-oriented project management, please see reference (4).

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4.7 PBL case study 7 (instructor: Prof. Shigeomi Koshimizu, Innovation for Design and Engineering)

Development of a Seating Authentication System

Summary: This technology development-based research began with the desire to develop a new personal authentication technology. The unique concept of authenticating individuals by their buttocks was proposed, which initiated repeated developments, experiments and verifications, allowing the students participating in the project's process to learn about the methodology of technology developments. Later, they obtained a patent and currently, a joint research has begun together with several companies for the system's practical application.

1. Seating Authentication

This is a form of authentication whereby a person sits on a chair and his/her feature quantities are extracted from the distribution of pressure on the seating surface. It then uses pattern identification technology to authenticate individuals. As such, it is sometimes called "bottom authentication". Its biggest characteristic is for being a stress-free authentication method because users must only sit and are not required to do or be burdened with anything else. Its authentication success rate has also reached approximately 99%.

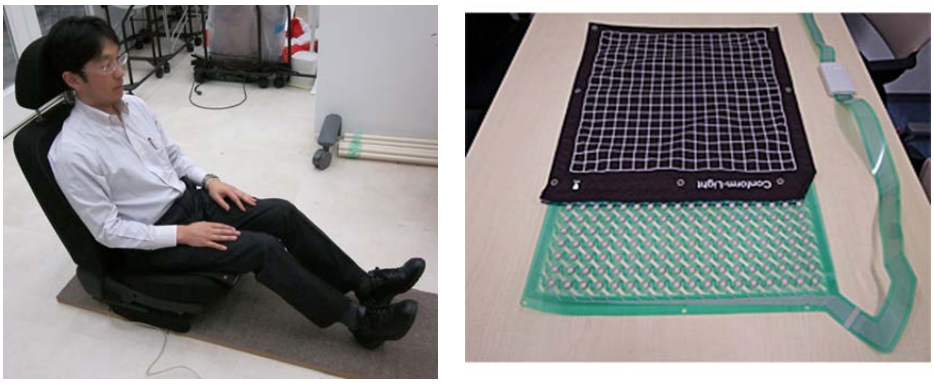

Figure 1: An experiment underway and the pressure sensor sheets being used

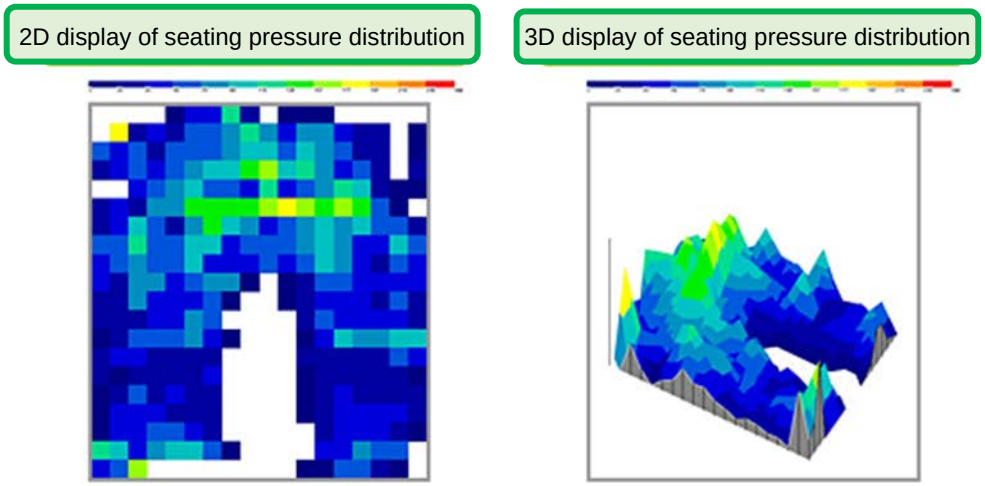

Figure 2: Pressure distribution on the seating surface

2. Thinking from the Ideal Final Result (IFR)

There are three main types of personal authentication methods. The first is authentication using one's possessions, the most common example being IC card authentications. The second is called knowledge authentication, the most common example being password authentications. However, issues arise when IC cards are lost and passwords forgotten, making authentications impossible. The third is biometric authentication, the most common example being fingerprint or facial image authentication. However, biometric authentications seem to come with their own issues. For example, fingerprint scans require users to go through the motion of placing their fingers on the scanner and facial image authentications places a psychological burden on the user of taking a photograph of his/her face.

Therefore, the idea born from IFR was this seating authentication, which only requires users to "be there" to be authenticated. A large merit is that users need to only sit to be authenticated, without needing to perform any other special motion.

If we were to name the approach that engineers are good at – where they try to improve the existing state of a system – as "forecast", its opposite would be the approach designers are good at taking, namely the Ideal Final Result notion, where they "backcast" from an ideal vision. PBL teams consist of diverse human resources, including both engineers and designers, and they derive innovative ideas by repeating this kind of forecast and backcast, which can be said to exemplify AIIT's style.

Table 1: Existing methods of personal authentication

Knowledge authentication	Password, security code, table of random numbers…
Possession authentication	Magnetic card, IC card, key…
Biometric authentication	Fingerprint, face, vein, iris, voiceprint…

3. Personal authentication with the MT system from quality engineering

The seating authentication uses the MT system from quality engineering as its pattern identification technology to authenticate individuals. 39 feature quantities are derived from data obtain from 18 x 20 = 360 pressure-sensitive sensors laid on the seating surface. These are further converted into one Mahalanobis distance to identify patterns. It is big data analysis in its truest sense.

Feature quantities include “maximum pressure values” and “contact area of the buttocks” that are calculated from the seating pressure distribution – literally data that portrays the person’s characteristics. This project used 39 feature quantities, which is a high number, in order to heighten authentication precision. These 39 feature quantities are then converted to “Mahalanobis distance”, which is a multidimensional space, to be used as a determination index when authenticating individuals. In other words, this Mahalanobis distance is small for known users and large for unknown users. Then by adding a threshold value, it can identity whether the user is known or unknown. For example, if Person A is a known user and Persons B through Z are 25 unknown users, the results of the calculated Mahalanobis distance (MD value) is as indicated in figure 3. Person A’s MD value is small, while the unknown users’ values are large, and by setting 100 as the threshold value, it can identify the known user.

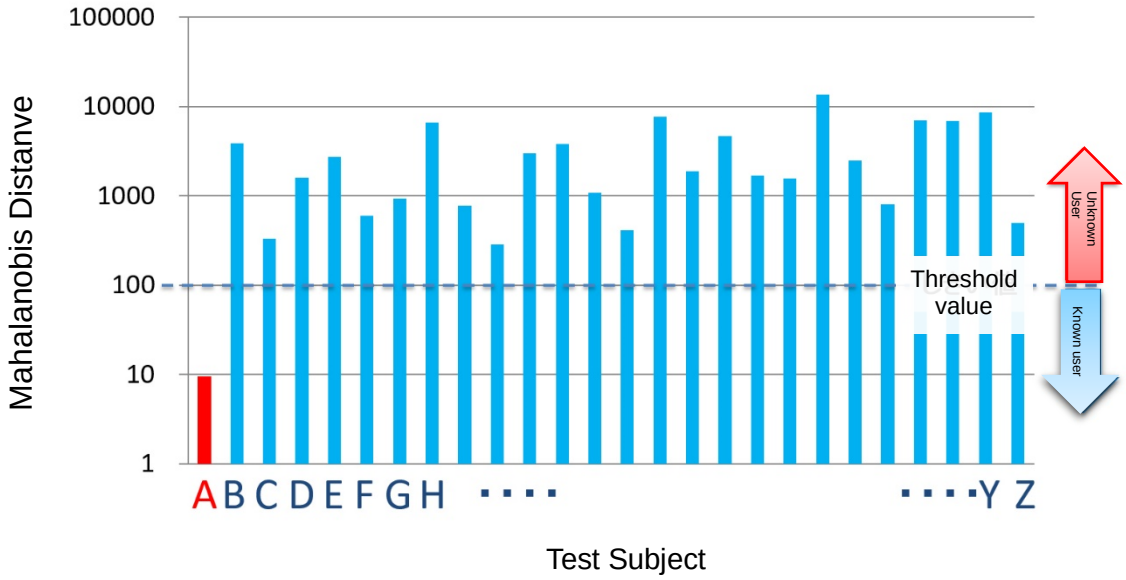

Figure 3: Identification of known users and unknown users using Mahalanobis distance

There are two types of error rates when dealing with personal authentication. The first is the false rejection error rate (the rate of mistakenly identifying a known user as an unknown user), and the second is the false acceptance error rate (the rate of mistakenly identifying an unknown user as a known user). The results of an experiment investigating these two error types are indicated in table 2. The false rejection rate was 2.2%, but when the person reseated

him/herself, authentication was successful. The false acceptance error rate was 1.1% and when looked at from the opposite end, it indicates that the authentication success rate was 98.9%. In order to further improve these figures, it is necessary to devise new and effective feature quantities.

On a side note, the seating authentication algorithm introduced here was a completely new concept and because there were no patent filings similar to this seating authentication, we were able to obtain its patent [(2)].

Table 2: The two error rates in personal authentications

Test subject	A	B	C	D	E	F	Average
False rejection error rate	0.0%	6.7%	0.0%	0.0%	6.7%	0.0%	2.2%
False acceptance error rate	0.0%	1.3%	0.0%	5.3%	0.0%	0.0%	1.1%

4. Developing the seating authentication system into a business

As the concept of authenticating users with their buttocks was so unique, the results of this project were featured in a variety of media, such as newspapers, TV programs, magazines and books [(3)].

Professor Viktor Mayer-Schonberger from the Oxford Internet Institute, University of Oxford writes in his book "Big Data" that the modern age is one in which "everything is digitalized and made into a business". As an example, he introduces the seating authentication system developed in this project[(4)]. He emphasizes that in this age of connecting things to the internet with IoT, things that weren't digitalized before have become digitalized as numbers and this leads to new businesses.

Regarding the business application of this seating authentication, the first possibility is applying it to the driver's seat in a car to authenticate drivers. If the person sitting in the driving seat is a known user, the engine will start, and if not, the engine will not start. This can be developed into a service to prevent car theft (figure 4). Additionally, there are an increasing number of companies that have free address seating in their offices. By applying the seating authentication system to office chairs, it will make it easy to identify who is sitting where. It can also be applied to the employees' attendance management.

This project, in the capacity of PBL, came to an end after a year, but there are members who are currently working on a joint research with several companies to apply the technologies of this buttocks authentication to practical levels and produce an innovation.

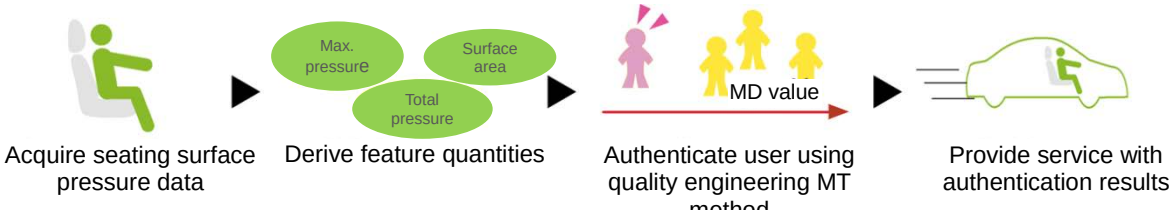

Figure 4: Flow from seating authentication to providing the service

References

(7) S. Koshimizu: "Authentication Based on Seating Pressure Distribution Using MT System", *Journal of Teknologi*(Science & Engineering), Vol.68, No.4 (2014), pp. 87-90.

(8) Patent: "Personal authentication device and personal authentication system" (Patent no. 5610439), Date filed: September 12, 2014.

(9) Kenneth Cukier, Viktor Mayer-Schoenberger: "The Rise of Big Data", *Foreign Affairs*, Vol. 93, No. 3, pp. 28-40. 2013.

(10) Viktor Mayer-Schoenberger: *Big Data: A Revolution That Will Transform How We Live, Work, and Think*, Kodansha, 2013.

Afterword

We were finally able to release a brochure on the AIIT PBL method. Between April 2005 to December 2017, we have received over 1,000 students. It is deeply moving to reflect on these 12 years where we were able to contribute to human resources development through the PBL education conducted at the school.

In recent years, the recurrent education of working individuals has become acknowledged as an important matter on a national level. A cabinet decision was just made by the KPI to double the number of working individuals who receive recurrent education from the current approximately 500 thousand to one million within a few years. When considering the recurrent education of working individuals on a graduate level, it was previously thought that employees involved in a company's development research should aim to acquire a doctoral degree. However, we live in an age where it is difficult for us to work all throughout our lives on the frontlines as an expert with only what we learned until our 20s. It has become necessary for people of all ages to acquire new knowledge and skills in order to live fulfilling lives. There are, of course, people who manage to do this by studying on their own. Additionally, education offered within a company are often very useful. However, seeing the accomplishments of the professional degree program at our school, with PBL implemented at its core, I would very much like to see the AIIT PBL method spread further as one of the pillars of recurrent education for working individuals.

We will continue to improve and develop this education method to meet your hopes and expectations. If you would like to share any opinions or criticisms after reading this brochure, please feel free to contact us.

December 5, 2017 (AIIT foundation anniversary)
President of the Advanced Institute of Industrial Technology
Dr. Seiichi Kawata