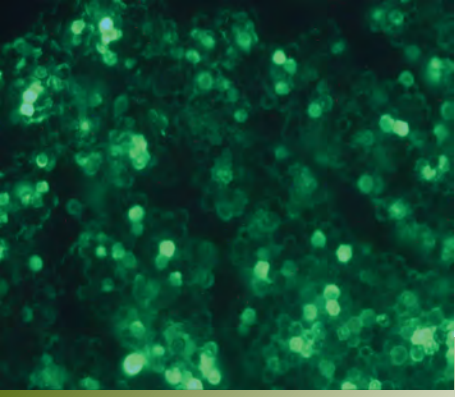

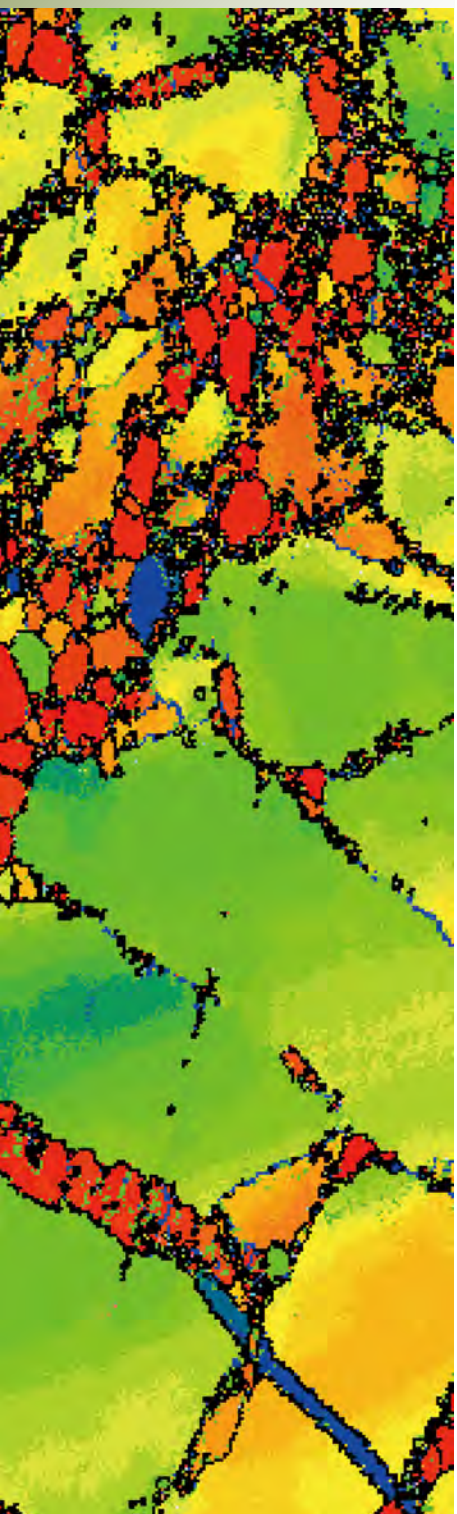

Vol.3 ,No.2, December 2016

Transactions on GIGAKU

Special issue of The 4th International GIGAKU Conference in Nagaoka (IGCN), 2015

GIGAKU Press
Nagaoka University of Technology

Transactions on GIGAKU: Scope and Policy

Nagaoka University of Technology publishes an online, open access journal titled “Transactions on GIGAKU”, which is focused on the science and technology related to GIGAKU*. The mission of this journal is to spread out the concept of GIGAKU and the fruits of GIGAKU to the global world and to be a strong network for innovations in science and technology and for development of next generations of high-level human resources. This journal, therefore, covers research and education activities related to GIGAKU in broad areas.

* See ‘What is GIGAKU?’ below.

‘What is GIGAKU?’

GIGAKU is a term composed of two Japanese word-roots; GI and GAKU. The word GI〔技〕 literally stands for all kinds of arts and technology, and GAKU 〔学〕 stands for scientific disciplines in general when used as a suffix.

The term was originally coined to describe the fundamental philosophy of education and research of Nagaoka University of Technology (NUT) when it was established in 1976. Through this term the founders of NUT intended to express their recognition that all technical challenges in the real world require a scientific approach. And NUT has a relentlessly pursued GIGAKU since then.

Thirty-five years have passed and all surrounding conditions have changed dramatically during those years. We are witnessing rapidly globalizing economics and huge scale changes in demographic, industrial and employment structures. All those changes seem to necessitate the further evolution of GIGAKU. In response to this, NUT recently announced its new “Growth Plan” and a renewed definition of the term is given;

GIGAKU is a science of technologies, which gives us an angle to analyze and reinterpret diverse technical processes and objects and thus helps us to advance technologies forward. By employing a broad range of knowledge about science and engineering, management, safety, information technology and life sciences, GIGAKU provides us with workable solution and induces future innovations.

July 2012
Koichi Niihara, President of Nagaoka Univesrsity of Technology

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"Transactions on GIGAKU" publishes original papers focusing on education, science, and technology related to GIGAKU. Proposals for special issues aligned with conferences are strongly encouraged*, and guest editors are welcomed. Papers submitted are peer-reviewed before publication. Publication charge is free for all submitted papers.

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The 4th International GIGAKU Conference in Nagaoka (IGCN)
(June 19-21, 2015, Nagaoka University of Technology, Nagaoka, Japan)

The IGCN is designed and organized to provide a cross-border, cross-sector, cross-disciplinary forum for those researchers, educators, and industrial leaders who are creating and practicing GIGAKU in various technology domains in various countries. Some papers presented in the IGCN are published in this first volume of Transactions on GIGAKU.

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Evaluation for corrosion state of the transition area between gusset plates and flanges of diagonal members on the connections of steel truss bridge

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A huge number of steel bridges were constructed in Japan during the period of high economic growth from the 1950s to the 1970s. As these bridges age, deterioration and damage resulting from heavy traffic and the effects of the natural environment are also increasing rapidly. Improved techniques related to inspection, diagnosis, repair, reinforcement and appropriate maintenance of such bridges are urgently needed. In the case of steel truss bridges, serious corrosion damage has been reported recently, especially on diagonal members and at gusset plate connections. In this study, detailed corrosion profiles of two gusset plate connections removed from a dismantled steel truss bridge are obtained using laser measurement equipment then the corrosion state of the transition area between gusset plates and flanges of diagonal members the connections is evaluated on the basis of the corrosion depth distribution over the considered areas.

1. Introduction

Many steel bridges were built in Japan during the period of high economic growth from the 1950s to the 1970s, so the number of aging bridges in the country is now increasing rapidly. With this rising number of bridges over 50 years old, there have been reports of serious corrosion damage, including the cases of the Kiso river bridge on National Highway Route 23 and the Honjo bridge on National Highway Route 7 in 2007. Around the same time, the Minneapolis I-35W truss bridge suddenly collapsed. Steel truss bridges are prone to damage affecting the truss members and the connections between them. Corrosion has a particularly severe effect on truss bridges and can lead to significant sectional loss of truss members which may lead to loss of structural integrity. In order to verify the integrity of an entire bridge system, there is a need for an inspection and maintenance regime that evaluates the impact of such corrosion efficiently and properly.

In this study, the targeted bridge is the Choshi bridge, a five-span cantilever steel truss bridge, that crossed the estuary of Tone river. This bridge was removed in accordance with the opening of new bridge in 2009 after approximately 50 years of service. Due to the influence of salt, the corrosion damage occurred severely on every members of this bridge even the repainting was carried out several times in its service life. In detailed, the upper connection P25u and P73d were cut out from an aging steel truss bridge and the pattern of corrosion at these connections was measured in detail. From the obtained results, the corrosion state at the transition areas between gusset plates and flanges of diagonal members were also evaluated.

2. Gusset plate connection

The two connections studied were removed from the Choshi bridge, as shown in Fig. 1

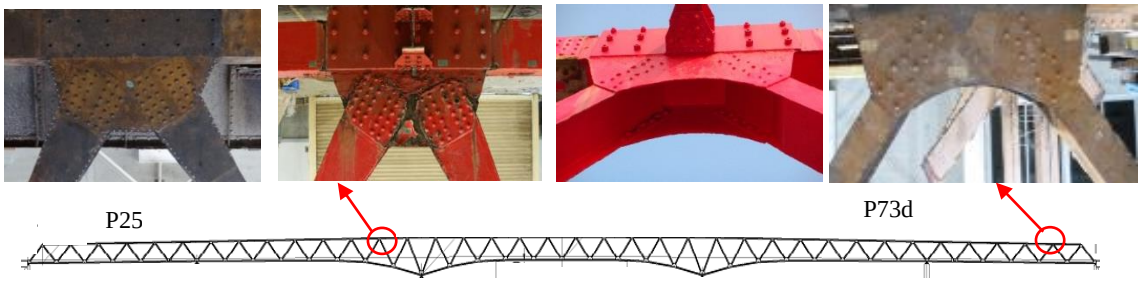


Fig. 1 Connections removed from the five-span cantilever truss bridge

3. Corrosion measurement method

3.1. Laser measurement equipment

The laser measurement equipment, shown in Photo 1, comprises ① clamp stand to support specimens for measurement, ② laser meter, ③ stepper motor for Y direction, ④A-D converter, ⑤ measurement-control equipment and ⑥ fixing device. The specifications of the laser measurement equipment and clamp stand are given in Table 1. In taking measurements, the measurement grid is selected from 1-3mm depending on the actual corrosion condition of the

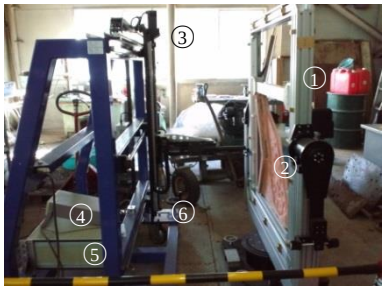
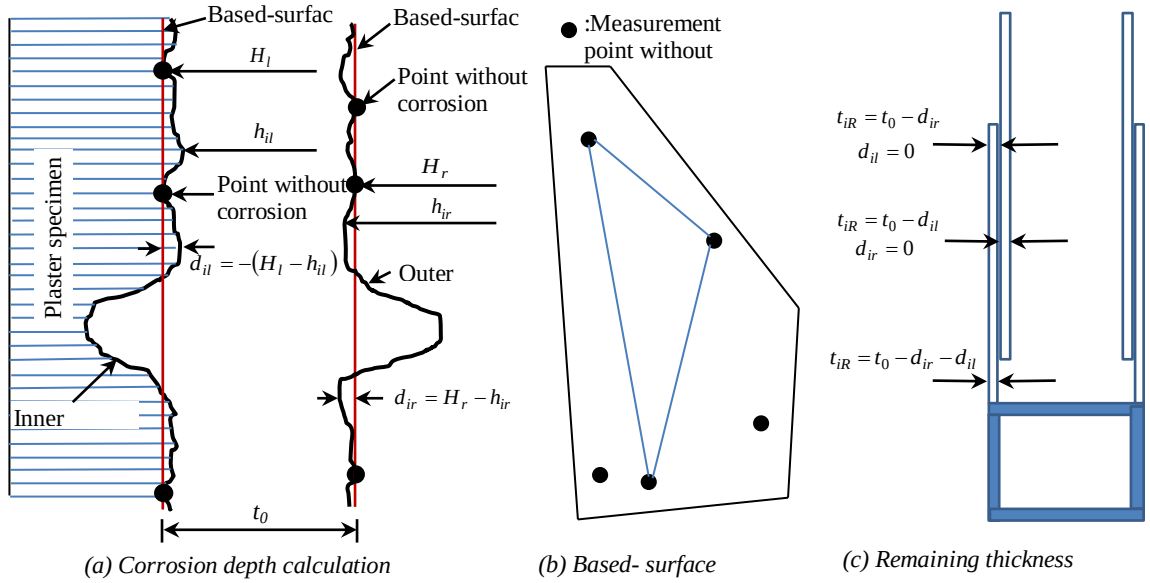


Photo 1 Laser measurement equipment

Table 2 Specifications of equipment

①Laser measurement equipment	
Measurement range (flat)	1000×1000 mm
Measurement range (Perpendicular direction depth)	100mm
Measurement speed (1mm interval measurement)	200data/min
Base of frame	Steel
② Clamp stand	
Maximum testing specimen dimensions	700×1000 mm
Horizontal rotation range	360^0
Vertical rotation range	360^0
Rotation range of microtremors	$\pm 5^0$ in 2 axis



(a) Corrosion depth calculation *(b) Based- surface* *(c) Remaining thickness*

Fig. 2 Corrosion measurement and corrosion depth calculation method

3.2 Outer surface measurement

In order to measure the corroded profile of the outer surface, the specimen was set up vertically and parallel to the laser measurement equipment. The equipment has a limited 1m x 1m measurement range, so for measurements of the outer surface directly from the large specimens, the surface was divided into segments for measurement. The normal set-up for measuring the surface corrosion profile of a specimen's outer surface was carried out as follows:

① The surface of the specimen to be measured was set up parallel to the axes of the laser measurement equipment. The distance of the laser measurement equipment from the specimen is output by the A-D converter, allowing verification that the two planes are parallel.

② The origin for measurements is set automatically.

③ The measurement range is set (start point and end point).

④ The based-surface is determined using the three-point method. Five points with no corrosion on the gusset plate were selected, three of these were used to identify the base plane, as shown in Figure 2(a) and 2(b).

⑤ Measurements are started.

At any specific point, the corrosion depth on the right, outer surface, d_{ir} (i = 1, 2,..., n), is calculated by

$d_{ir} = H_r - h_{ir}$

where h_{ir} is the distance from the laser meter to the corrosion surface at point i and H_r is the distance from the laser measurement equipment to the based-surface. The value of d_{ir} may be either negative (at a corroded point) or positive (in the area of a rivet head).

3.3 Inner surface measurement

Inner surfaces of the specimens and other tight spaces, such as the inner surface of the gusset plate, could not be measured directly using the equipment. In these cases, a method using molded plaster was adopted. Photo 2 illustrates the steps in taking a plaster mold of the specimen. The surface of a plaster specimen was then measured using the same laser measurement equipment. The based-surface in the case of inner surface measurements is set using three corrosion-free points on the plaster specimen surface. If a plaster specimen was not suitable for supporting with the clamp stand, it was held in a vise on the desk for measurement. The actual measuring procedure was the same as for outer surface measurements.

At any specific point, the corrosion depth on the left, inner surface, d_{il} (i = 1, 2,..., n), is calculated by

$d_{il} = -(H_l - h_{il})$

Photo 2 Procedure for making plaster

where h_{il} is the distance from the laser measurement equipment to corrosion point i and H_l is the distance from the laser measurement equipment to the base plane. The minus sign in the formula represents use of the indirect method to identify the corrosion using molded plaster. The value of d_{il}

is either negative (at a corroded point) or positive (in the area of a rivet head).

Then the remaining thickness, t_{iR}, at the specific point i is calculated as follows:

$$t_{iR} = t_0 - d_{ir} - d_{il}$$

where d_{il}, d_{ir} are the corrosion depths on the left, inner surface and the right, outer surface, respectively, and t_0 is the initial thickness of the steel, as shown in Figure 2(a).

4. Corrosion state of gusset plate connections

4.1. Connection P25u

On the gusset plate of the upstream side the corrosion occurred severely on the whole especially on the non-rivet-area. Its corrosion depth profile is shown in Figure 3. Due to the severe corrosion, gusset plate area is reduced by the holes' appearance on the compression diagonal member side. There are two holes on the edge of gusset plate and the remaining one is at the end of compression diagonal member. Corrosion depth profiles of inner surfaces of gusset plate and diagonal members in both upstream and downstream sides are also shown in Figure 3. As can be seen in this Figure, corrosion occurred severely on the inner surfaces in both upstream and downstream sides, especially at the edges area and at the ending of diagonal members. The average corrosion depths of gusset plate at the upstream and downstream sides are 1.48mm and 1.52mm, respectively. On the flanges of diagonal members, corrosion also occurred severely at their edges and around the rivet heads.

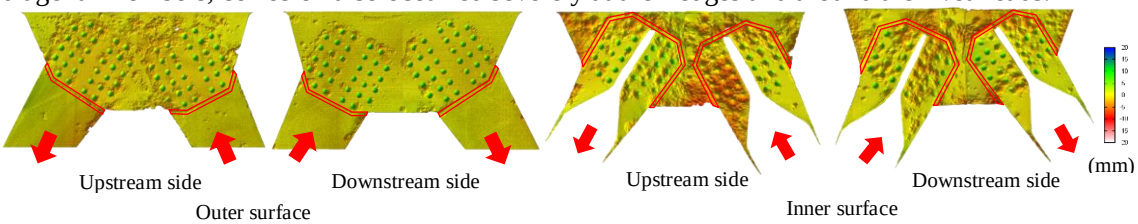


Fig.3 Corrosion depth distributions and considered transition areas of connection

4.2. Connection P73d

The corrosion depth distributions on the outer and inner surfaces of connection P73d are shown in Figure 4. This clearly indicates that corrosion occurred locally around the rivet heads on both upstream and downstream sides, at the edge of the gusset plate on the upstream side and more severely on the tensile diagonal member on the upstream than on the downstream side. The average gusset plate corrosion depth is 1.2mm and 0.6mm, respectively, on the upstream and downstream sides. As can be seen on Figure 4, on the inner surfaces there is severe corrosion at the edges of the gusset plate on both upstream and downstream sides, as well as on the flange of the tensile diagonal member on the upstream side and on the compressive diagonal member on the downstream side. The average corrosion depths are 0.9mm and 1.6mm on the upstream and downstream sides, respectively.

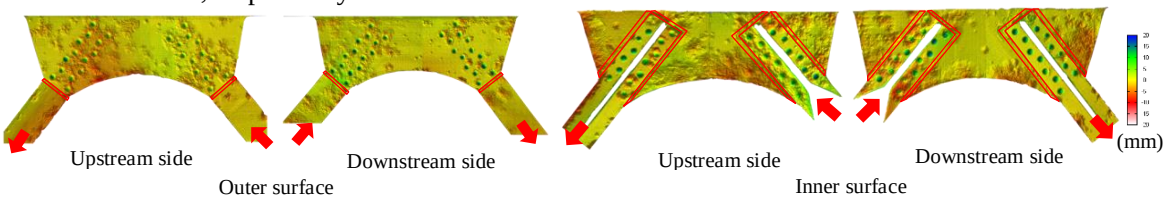


Fig.4 Corrosion depth distributions and considered transition areas of connection P73d

5. Corrosion state of transition areas

From the measurement results of the two connections, corrosion seems occurred severely at transition area between the gusset plates and the flanges of the diagonal members due to the rubbish accumulation. The evaluated areas are on the outer surfaces of diagonal members and inner surfaces of gusset plates. These areas were identified by the distance of 10mm from the edges gusset plates of outer surfaces and the flanges of the diagonal members of inner surfaces. These considered transition areas of connections P25u and P73d are indicated by the red area in Figure 3 and Figure 4, respectively.

5.1. Connection P25u

There were localized corrosion available in all considered areas.The corrosion depth frequency distribution of transition areas of diagonal members on upstream and downstream sides of connection P25u are presented in Figure 5 and Figure 6, respectively. As can be seen in these Figures, the convexity or slight deformation is available on the considered transition areas resulting the availability of the positive values. On the outer surfaces the corrosion depth values mostly range from 0 mm to 2mm except the transition area on the tensile member on the upstream side where localized corrosion available. The corrosion only occurred on the whole surface of transition area of compression diagonal on the downstream side which has the average corrosion depth of 0.83mm.

On the inner surfaces, corrosion on the transition areas is more severe than that ones on the outer surfaces. The corrosion trend and corrosion depth value are almost the same for tensile side on both upstream and downstream sides. Corrosion also occurred severely at the end areas of diagonal and at the edges of these transition areas as shown in Figure 3.

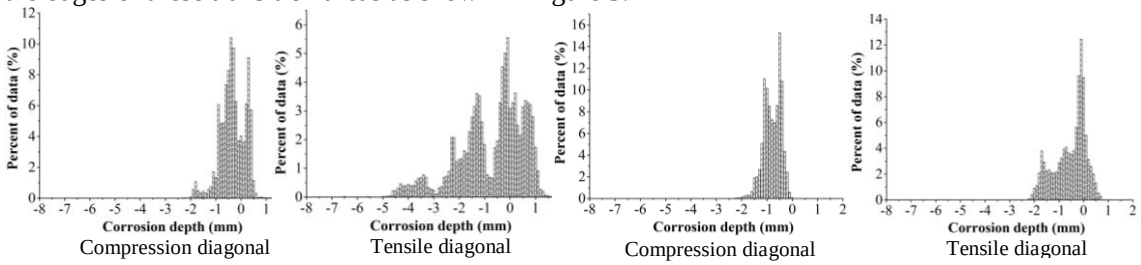


Fig.5 Corrosion depth frequency of the transition area on outer surfaces of connection P25u

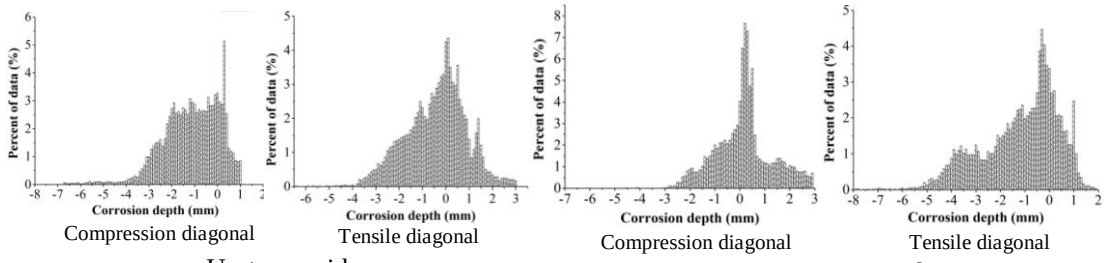


Fig.6 Corrosion depth frequency of the transition area on inner surfaces of connection P25u

5.2. Connection P73d

Figure 7 present the corrosion depth frequency of transition areas of the outer surfaces of upstream and downstream diagonal of connection P73d. The corrosion on the transition areas on the upstream side occurred severely. On the compression diagonal, the corrosion less severely than the tensile one and the corrosion depth mostly range from 1.4mm to 2mm, while on the tensile diagonal, the corrosion depths are variable with the average corrosion depth of 2.81mm. On the downstream side, the corrosion occurred on the whole transition area of tensile diagonal with the average corrosion depth is 1.63mm and the corrosion depths mostly range from 0.3mm to 2.5mm. On the compression diagonal, the corrosion depths area variable and the positive values accumulated almost half of corrosion values of the transition area.

The corrosion depth frequency of transition areas of the inner surfaces of upstream and downstream gusset plate of connection P73d is illustrated in Figure 8. As can be seen in this figures,

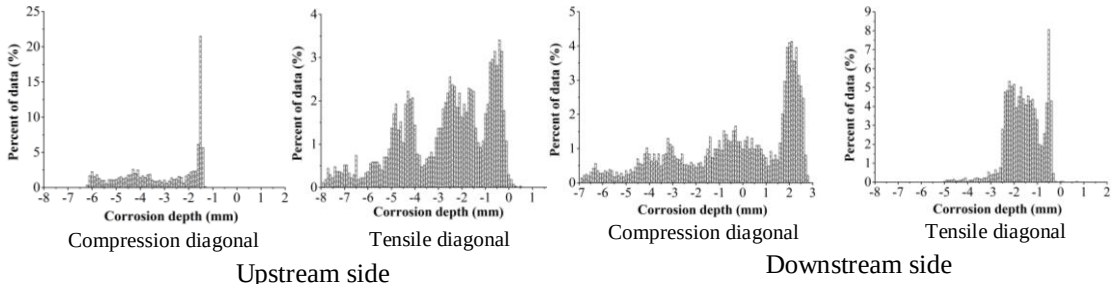


Fig.7 Corrosion depth frequency of the transition area on outer surfaces of connection P73d

half of the transition areas has positive values except the one on the compression side at the downstream side where corrosion occurred severely in this area with the maximum corrosion depth reached 9mm. However the positive values are still available on this area which accumulated one-fifth of the data.

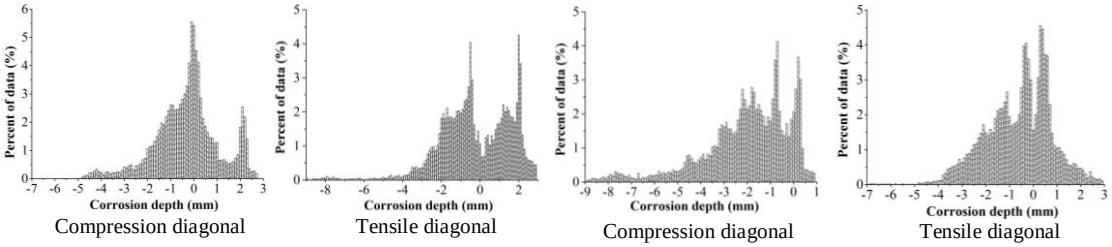


Fig.8 Corrosion depth frequency of the transition area on inner surfaces of connection P73d

5.3 Discussion

As illustrated in sections 5.1 and 5.2, there was localized corrosion and severely corrosion at the edges in almost transition areas of the two considered connections (P25u and P73d). Corrosion of boundary areas of second span-connections, P25u, occurred more severely than the one of fifth span, P73d. In each connection, corrosion of transition areas on the inner surfaces also occurred more severely than the ones on outer surfaces.

The severely corrosion on the transition areas were caused by the rubbish, salt accumulation because of the level difference between the gusset plates and the flanges of the diagonal members. These level differences are equal to the thickness of gusset plates (10 or 12mm depends on the connections) for the outer surfaces and the thickness of the flange of diagonal members for the inner surfaces (10 or 12mm depends on the connections). On the transition on the outer surfaces, the rubbish accumulation percentage may less than that ones of the inner surfaces because they exposed directly to the environment so the rubbish or salt were washed away easily by wind.

However, in almost transition areas, the positive values are available. Especially in the inner surfaces of connection P25u, the positive values accumulated half of numbers of data. Because these values mostly range from 0 to 1mm, it could be explained by the following reasons:

1) The slight deformation of the gusset plates and the flanges of diagonal member occurred during the service life of bridge. Normally in steel truss bridge design, moment and shear force in each truss members are neglected because they are small and do not effect to the behavior of the entire truss bridge system. However these moment and shear force still available and the diagonal members were fixed in their both ends resulting to the torsion and bending occurrence and then slight deformation.

2) The convexity from the based surface

3) The deformation occurred during the connection removal process or transportation.

6. Conclusion

From the detailed corrosion measurement results of, the summaries are as follows:

1. Localized corrosion is popular type at the transition areas as a result of salt or rubbish accumulation.
2. Corrosion on the transition areas of connection P25u is more severe than that ones of connection P73d.
3. The positive values are available on almost of the transitions because of the convexity from the based surface or existing deformation resulting from service life or removal step.

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A case study on FD training for Active Learning Promotion
: proposal of facilitation plan and skill

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The active learning (AL) has begun to spread through all education of Japan. The purpose of this study is to research effective teaching profession development training for AL promotion. In-service trainings of “FD training of AL promotion” for teachers was held at National College of Technologies (NCTs) in 2014-2015 years. The contents of this training were an overview of AL constitution model and Project-Based Learning (PBL) workshop in two-day schedule. The workshops were held in four places in the East Japan. The number of participants was over hundred including 94 teachers. They were asked to answer questionnaire about this FD training. The questionnaire date shows that many participants requested doing more practical examples with listening to simpler overviews of AL. Various teaching materials of AL were provided for promoting student engagement including Coach/Facilitator/Consultant (CFC) System, Facilitation Plan (FP), and Activity Program (AP). It is necessary for teachers to provide facilitation plan and to develop our skills for more effective FD training.

1. Introduction

In Japan, university education has been done the human resource development for the highly technical society. Therefore, the faculty should train students to develop life study force and proactive force. To put it more concretely, we should prompt to teachers about improvement of class about the quality, quantity and deepening of knowledge.

Concerning about problem of classroom style, the conventional classroom is one-way type, because teacher teach students only. This class gives a student passive learning. This did the learning activity. The results suggest that the students cannot improve about education and has a negative effect on their learning attitude because students do not learn if not taught by teacher, show lack of interest in class. For improvement of such situation, AL has received considerable attention. Therefore, it is necessary to take consensus building between college teachers. The question of this learning has on the difference of the teacher ability, a commonality of the class development. For further direction of this learning, it will be need to make definition of AL as the school code.

The main objective of this paper is to research effective teaching profession development training for AL promotion. This paper discusses research on effective contents of FD (faculty development) training for AL promotion, and on various teaching materials for AL promotion developed by us.

2. Method

This training was carried out in 2014-2015 years. The purpose of this training was to reform “FD training for AL promotion” for 51 National Colleges. This was planned as a part of the cooperative project of three institutions: National Institute of Technology(NIT), Nagaoka University of Technology (NUT)and Toyohashi University of Technology(TUT). The training program for NIT in East Japan area has been conducted at Sendai College. Meanwhile Akashi College took charge of this training in West Japan area.

The skill improvement of faculty has been requested by three institutions. Sendai College which was AL promotion school in the East Japan conducted "AL introduction training" in four places in Tohoku, Hokkaido, Kanto and Shinetsu areas, as one of the whole country object project by Nagaoka University of Technology.

The number of participant was 120 people including 94 teachers, where 25 was from Tohoku,14 from Hokkaido,22 from Kanto&Shinetsun area national object 33. The training schedule consists of two days' program was the following:

<Training schedule>
●The first day Day1
Point: AL overview
13:30 - 14:00　Ice-breaking & simple practices
14:00 - 15:00　AL constitution model
16:00 - 17:00　Model curriculum of NIT
●The second day Day 2
Point:The group work of project cycle management(PCM) method for project-based learning(PBL)
9:00 - 9:30　overview PBL
9:30 -12:00　exercise PCM method

3. Contents

The FD training was focused on teaching power of qualitative transformation of AL that teachers provided. The training contents of AL could be classified into three kinds of AL training contents: Instructional Design, Facilitation and Activity &ICT. These contents are total a management system, ID is Plan, F is Do, ACT&ICT is See. That is "P-D-S" as shown in figure 1 management system. AL play the control role in this management system.

This learning evaluation become outcome which was gotten by learning activity. It is to understand about process and achievement.

In this 2-day workshop, participants were controlled to a broad range of AL strategies, including AL constructional model/ID, F, ICT&ACT/PBL and PCM. (see Fig.1)

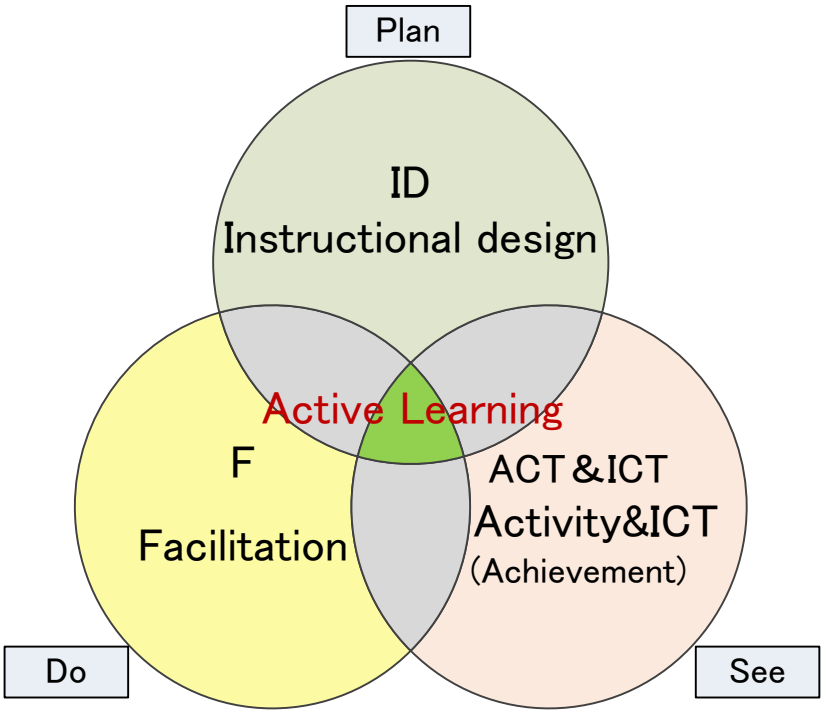


Fig. 1 AL training contents with PDM(plan-do-see) system

In addition, TEAL (technology enabled active learning) attracts attention recently. It has relationship with ACT&ICT, because TEAL is needs to use ICT and facilitation. Teachers should obtain facilitation skill for carrying out AL well, should learn how to use activity and how to make activity program(AP) for their classes. The activity program combines both an activity and a solution process.

[The first day training contents]

On the first day training contents of the first day was explained about three kinds of elements in AL for education improvement. It is ID (instructional design), Facilitation, Activity & ICT (information and communication technology).

Three kinds of elements are given as follows.

(1) Instructional Design(ID)

ID is constructed by learning commons, professor model, learning assessment, describing the teaching plan. The model of the ID is “ADDIE model”, “Gagné Nine Events if Instruction”, “First principle of Instruction by m.D.Merrill”,” The ARCS model approach by J.Keller” etc. Further, learning evaluation will apply portfolio which centered on the activities of the artifacts, such as rubrics for a self-evaluation.

(2) Facilitation (F)

Facilitation which is one of teaching method is classified into business facilitation and learning facilitation. The facilitation plan is explained by taxonomy perspective of educational goals, in particular, of “CFC (coach / facilitator / consultant) system”. This system becomes the strategies and challenges for the facilitation. Figure 2 shows the CFC system .

As the figure shows the teachers alone system or T.T (Team teaching) system. It is the class-style of AL on conventionally. It is a teaching method which shares a part each other. The CFC system is deepening T.T system more. This means the part of the teacher by three kinds of elements. The team member set the part of each teacher, carry out it at class. (see Fig.2)

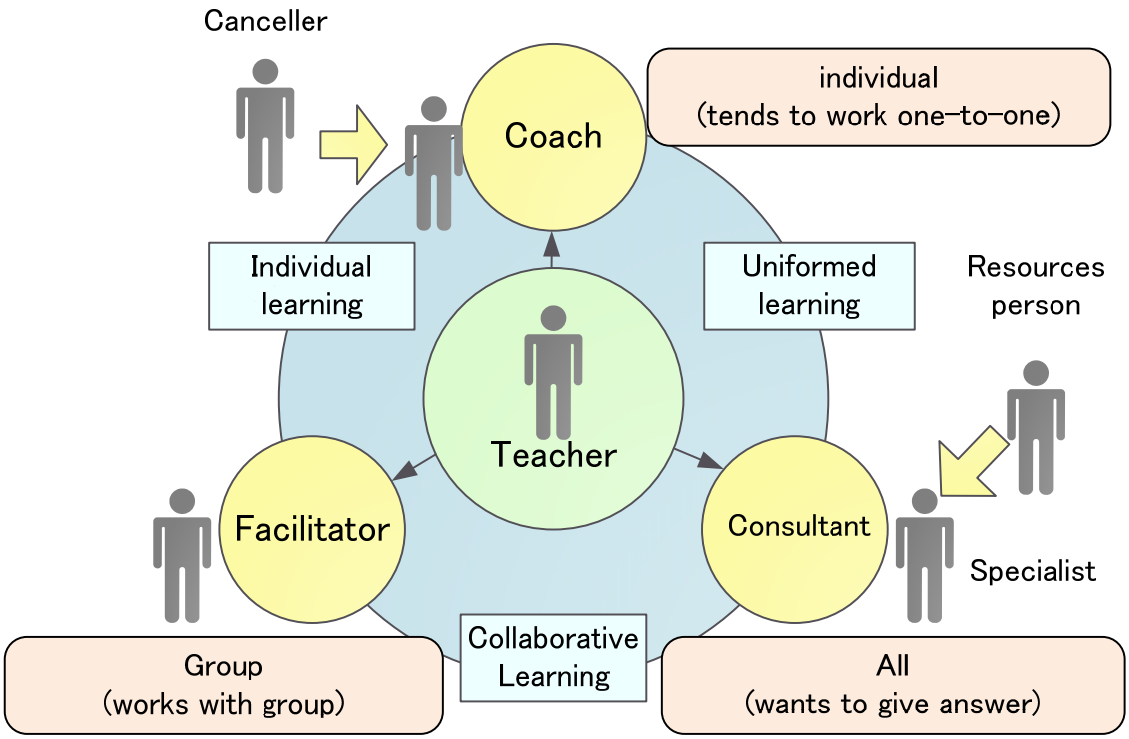


Fig.2 CFC system(M.Takeda,2012)
(Reference: “Learning Facilitation theory” GAKUJI publication, (2014).54,66)

<CFC system>

(a) Individual learning between coaching and facilitation

The coaching uses the skills such as questioning effectively. A coach expects the his own reflection. In contrast, facilitator expects interaction to be provided by knowing each other's differences opinion in the group work. It is difference between reflection and interaction.

(b) Collaboration learning between facilitation and consulting

The facilitator supports a group. The consultant assembles a classroom generally, always analyzes how the class goal is accomplished. It is difference between interaction and total consulting.

(c) Uniformed learning between consulting and coaching

A consultant analyzes outcome of class by his presentation and portfolio, design next class for students.

Teacher do not use only facilitation but also together with coaching and consulting. The three kinds of type have difference of approach. Teacher have focused on using of an individual, a group and an organization. It is the best to take together depending on the situation. In addition, a teacher should understand a concept of facilitation. The CFC system will be phased approach before reaching the effectiveness of the design method. Teacher will need to change consciousness. The class style has designed by the learning scene. This scene can be classified into three kinds of leaning types uniformed learning, individualized learning and collaborative learning in Figure 2. They are put together mutually, are formed a place of the learning. They have a mutual relationship which are applied to the location of the learning.

<Learning activities types and facilitation>

(a) Learning type of facilitation (knowledge and comprehension)

This type is a closed question, has a correct answer. Teachers teach it, students understand. This type will become traditional classroom teaching.

(b) Utilizing type of facilitation (application and analysis)

This type is a semi-closed-question. It has the expected answer. The teacher does not tell the answer, bring out the best idea in students. This type has focused on teacher experience. This is suitable for solution to the problem-based learning.

(c) Inquiry type of facilitation (evaluation and creation)

This type is an open question. It is heuristic problem. The teacher has the answer, to promote learning by teacher experience. This type has focused on interaction, is suitable for the project-based learning. (see Fig.3)

This system has three kind of type lesson such as active learning(AL), problem based learning and project based learning(PBL), Mastery learning(ML)

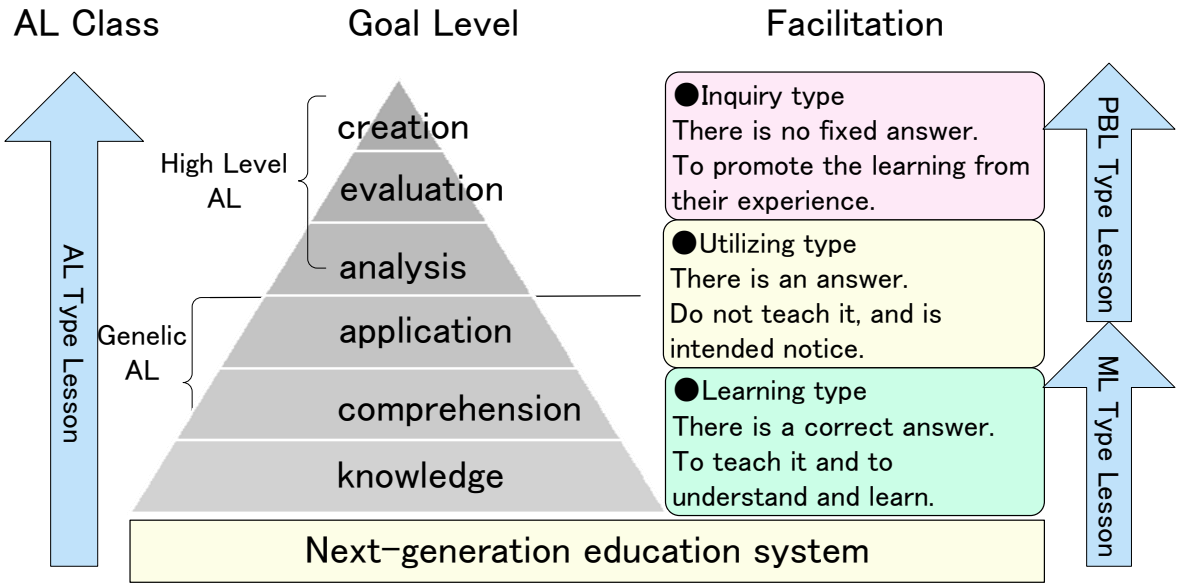


Fig. 3 Facilitation type of learning activity(M. Takeda,2012)
(Reference: “Learning Facilitation theory” GAKUJI publication, (2014).160)

In particular, this training is to achieve the learning and understanding of facilitation skills. The role of this facilitation is aggregated into three "Process design", "Process management", "Conflict management". These show in the workshop.

<Learning facilitation element model>
(a) Process design
This make teaching plan to design the learning process.
(b) Process management
This is to be inspired by the opinion. Then, the use of ICT tools in order to engage.
(c) Conflict management
This is to develop a learning environment in order to control the class room, explains the solution of the basic rules setting and discussion.

Finally, the facilitator is to aggregate opinion, to discuss the priorities of the measures proposed, encourage behavior change of the students from these activities.

(3) Activities and ICT (ACT&ICT: development of teaching materials)

Activity has been said to be with tools and knowledge creation techniques. Teachers use the activities of pair work and group work for learning activities of the AL. This study has focused on more than 300 activities in the world. The activity becomes the wisdom of ancient people. Teacher and students should use these. These activities can be defined as 'the smallest unit of activities with a specific goal in learning'. Teacher corresponds to both of this activity and resolution process, make an activity program(AP). These activities should be noted that there is a tendency of the ICT. Therefore, TEAL is noted. Figure 4 shows a complex of activities, named "Activity Cube" as shown in Fig. 4.

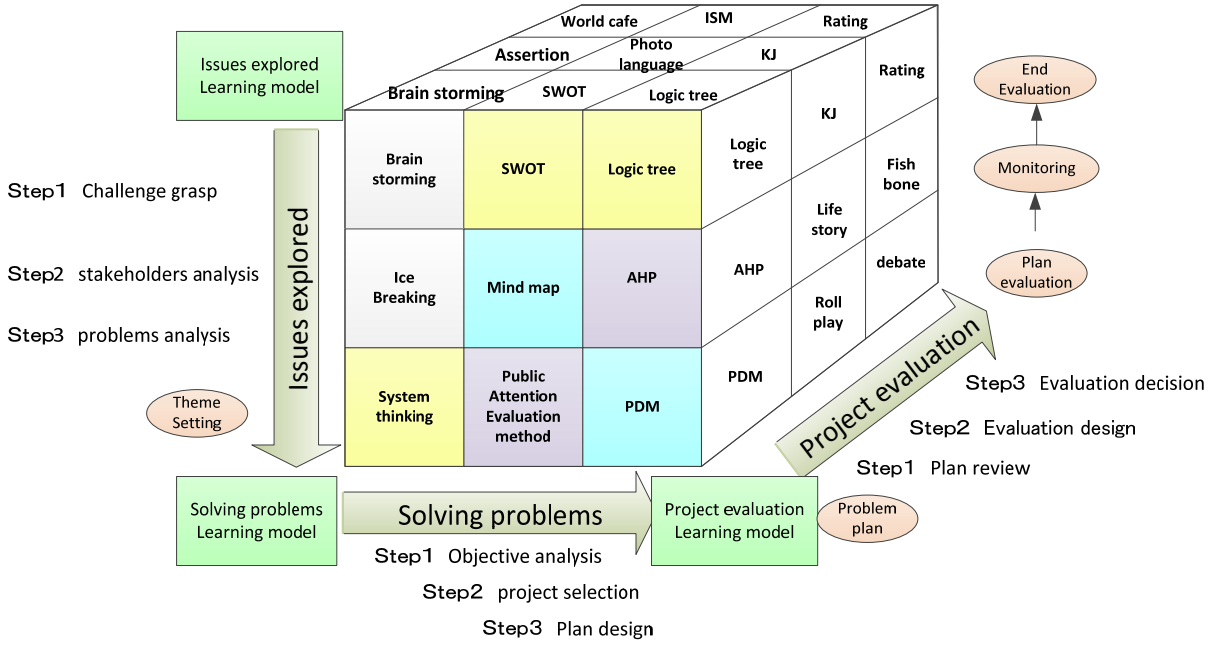


Fig. 4 Activity cube (M. Takeda,2009)
(Reference: "Learning Facilitation theory" GAKUJI publication, (2014).114)

[The second day training contents]

On the second day training contents was the group work of PCM method for PBL (project-based learning). It can be classified into two: problem-type PBL and project-type PBL. This training was carried out in PCM (project cycle management) workshop as concrete experience.

First, a theme of problem is set as "Why does not AL promotion proceed at your school?". The PCM method will be useful as an international aid technique. This confirms a problem of

present status, is useful to explore its solution of the problem, to analyze a cause of problem. PCM method including the implementation plan becomes the strategic management system. This is a combination of brainstorming, logic tree, and PDM. PCM method is used for introducing into class. It becomes an attractive class deployment. When students work on a theme of graduation study, the PCM method will be helpful. If a student submits a portfolio, then teacher is able to receive the results of the activities of the students. Teacher should develop his best methods and techniques.

4. Results

In this study a questionnaire survey was carried out after this training where the questionnaire was given in a description form and a choosing-one form. Then we researched how well a task of the training were done. Participants of 94 people completed their questionnaire forms. These reflect the opinion of the participants. The contents are as follows. (see Fig.5)

<Question contents>

Question1

1 Training was capitalizing content to your business.
2 Training was advanced in easy-to-understand order.
3 Time of the training was the appropriate length.
4 Lecturer was the appropriate teaching.
5 Training materials was appropriate.
6 You could get the knowledge and skills by training.
7 You could improve the approach to business.
8 You could get satisfaction enough about training.

Qusestion2

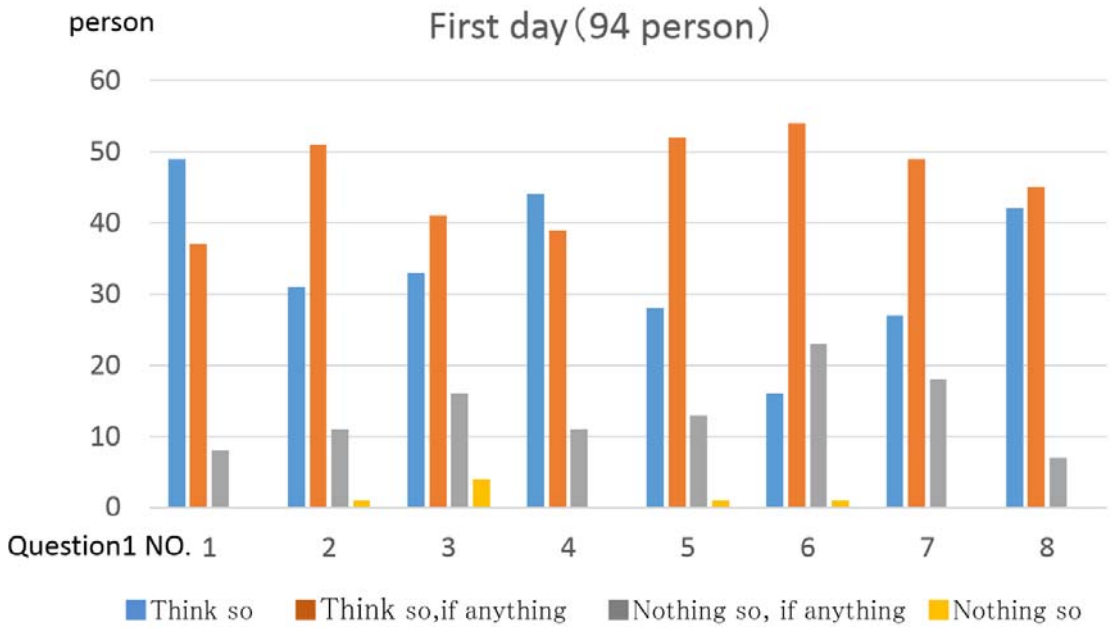
What is good point?

Qusestion3

What is improvement point?

Qusestion4

Do you have any questions about AL?



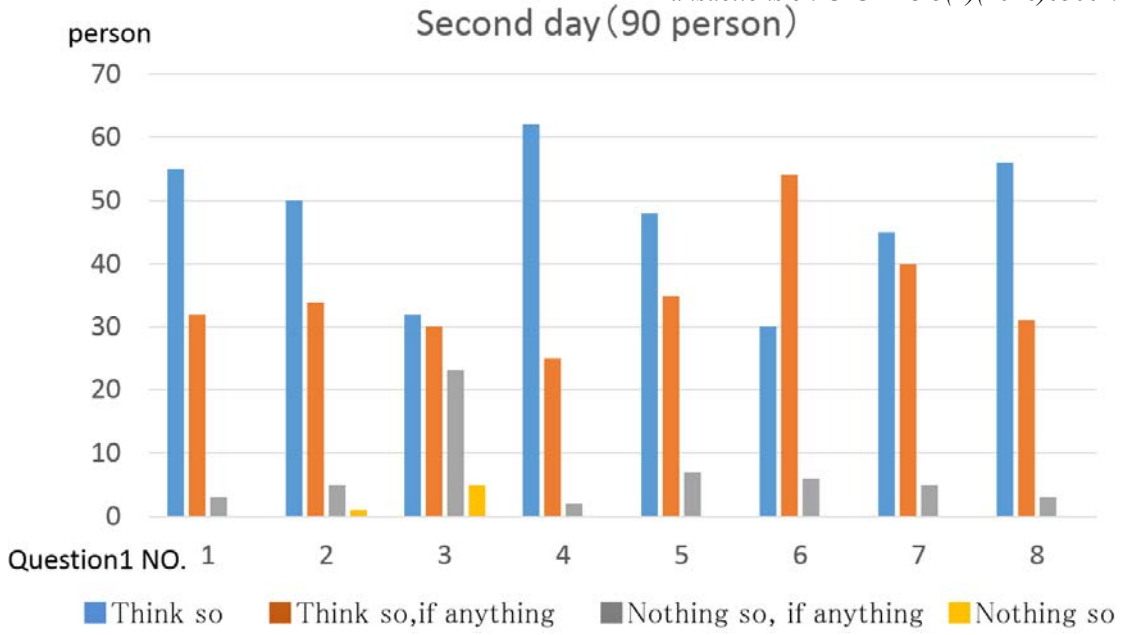


Fig. 5 Report of FD training questionnaire

After analysis of the results, the following request contents were gotten.

<Request contents by participants>

(a) Learning support for students.

(b) Teaching support for teachers.

(c) Teaching evaluation in organization

It is understood that the participants have not negative thoughts about the AL. The results obtained were contrary to our intention. It was clear that participants are understanding enough about AL. However, participants did not fully understand about the definition of AL.

The contents of the first day were explanation of the overview of AL by three kinds of elements (ID, F, ACT&ICT). The contents of the second day performed were the problem-based learning by the PCM method. It was shown from the result of questionnaire that participants were satisfied with this training and that they had good understanding of contents of the second day from figure 5. It was clear that many participants have requested a practical example than overview of the AL. Participants requested the class visit or the trial lesson. This training should add trial lesson in this training. Also many participants wished to keep in touch, request further advices from us (project staff). This training could conclude that this training is highly demanded. Participants requested to provide proper manual than practical content. (see Fig.5)

5. Discussion (proposal of facilitation plan and skill)

For the reasons mentioned above, teacher need to understanding about facilitation. Because, the purpose of the AL is not teaching, it is that the students learn on their own. It is necessary to make facilitation plan to teacher in the point of view of creating and cooperation. This study separated facilitation plan into external process and internal process from the point of view of the taxonomy by Bloom. The internal process become both thinking aspects and psychological aspects. On the other hand, the thinking aspects are expressed about knowledge, comprehension, application, analysis, evaluation, creation. The psychological aspects are expressed about receiving, responding, valuing, organization, characterization. Thinking aspects has a connection with psychological aspects. The following describes the specific measures to AL promotion. This study makes a facilitation plan in a point of view creating for collaboration of the students in the same way as a conventional teaching plan. This is comprised of a biaxial model. The vertical axis become form of learning activities by introduction, development, summary. On the other hand, the horizontal axis becomes an external process, the internal process, teaching process.

(See Fig. 6)

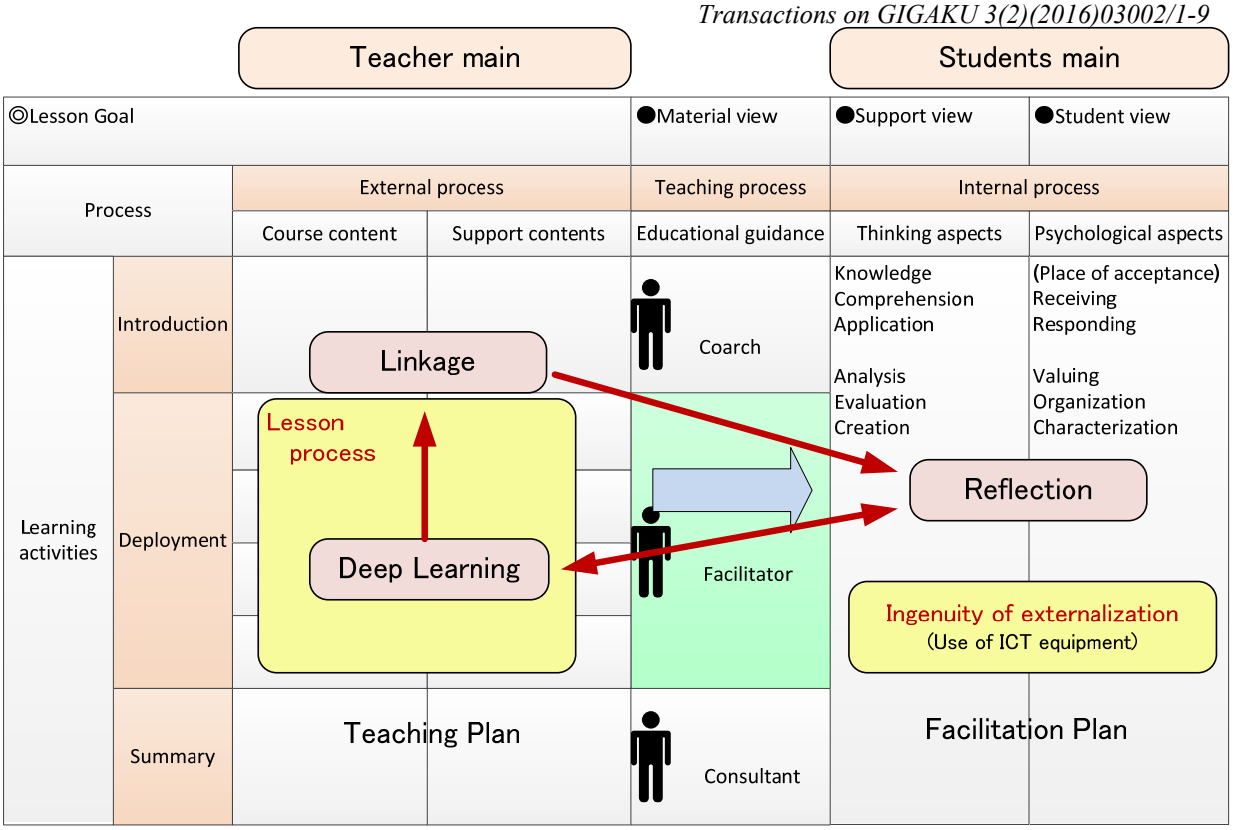


Fig.6 Facilitation plan form(M.Takeda,2011)
(Reference: “Learning Facilitation theory” GAKUJI publication, (2014).166)

This challenge has the evaluation of teacher’s facilitation skill. Teachers reflect on teaching method which encourage their own behavior change. Therefore, we have set the five evaluation items for quality guarantee of the education.

The five evaluation items of facilitation skills are as follows.

<The five evaluation items of facilitation skills>
(a) Field design
This is ability to create a place, to connect. Teachers prepare the classroom environment, set effective discussion which is designed to allow. Therefore, the teacher fixes the classroom environment. The teacher makes the place of effective talks.
(b) Personal relationship
This is ability to perceive, to pull out. Teachers bring up a rich communication skill in the discussion. Teachers will promote metacognition of students through the rich communication obtained by the group work.
(c) Structuration
This is ability to engagement, to organize. Teacher summarizes the various opinions. Students will help to have the same direction. The teacher set the learning process by notices and question.
(d) Consensus building
This is ability to summarize, to share. Teachers collects an opinion, decides the priority of the solution. The teacher aims at the self-realization through reflection of student.
(e) Information sharing
This is ability to form, to spread. Teachers will send out the solution the students decided at the workshop on the outside. This takes advantage of the properties of the TEAL, provides results to the outside. It has a deal with the globalization and accountability in school.

6. Conclusions

In this study effective teaching profession development training for AL promotion was discussed and the questionnaire data of “FD training for AL promotion” was analyzed. Some problems of the training are given as follows. AL is one of the learning method. Its purpose of

the class is a guarantee of the quality of education. This is to bring out a learning attitude of the individual student. To do this, teachers will need to know the students of personality and characteristics, and should make the attractive instructional design (ID). On the other hand, it should define the AL as school code. The definition contents will relate with education goal. As an example, it is related to competency, society basics force, general-purpose ability.

In this study of the AL three kinds of elements in this training have been discussed. These are ID (instructional design), F(facilitation), ACT&ICT (activity and ICT). Teacher should make facilitation plan, which needs for trial lesson. It will be a valuable document of the school. It was found from the result that participants request specific teaching practices. We should understand about necessary of facilitation skill. The results suggest that participants will be able to make a fascinating lesson in school that you belong.

It is concluded that facilitation plan and skill are necessary for this FD training and that the creation of case studies AL staff training programs for students should be made as future challenges.

Acknowledgments

The purpose of this faculty development (FD) is to reform on “FD training for Active Learning the promotion” for 51 National Colleges of Technology(NCT). This was planned as a part of the cooperative project of three institutions: National Institute of Technology(NIT), Nagaoka University of Technology(NUT) and Toyohashi University of Technology(TUT).

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Biomass Bamboo Powder as Filler in Natural Rubber Composites

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This work is mainly concerned with the preparation, characterization and application of bamboo powder-natural rubber composites (BP-NRC). There are two types of bamboo powder (unused bamboo powder obtained from bamboo plants and used bamboo powder obtained from waste bamboo chopsticks) used as fillers in natural rubber composites. The properties of two types of bamboo powder were determined by conventional methods and modern techniques. The physicochemical properties of natural rubber(NR) such as Mooney viscosity, plasticity number, plasticity retention index (PRI), volatile matter, dirt content, nitrogen content, and ash content were determined by testing methods (ASTM). The natural rubber and bamboo powder- natural rubber composites were characterized by modern techniques. The physico-mechanical properties such as hardness, specific gravity, tensile strength, elongation at break, tensile modulus, tear strength, abrasion resistance index and compression set of natural rubber composite (A) and bamboo powder-natural rubber composites (B-F, B_1-F_1) were determined by rubber testing methods. A soil burial test of the two specific composites, for a six months time frame showed that both composites were durable and resilient to rapid bio decay. On the context of physicochemical and physico-mechanical data as well as based on the durable composite properties, two specific composites, comprising the unused bamboo powder-natural rubber and used bamboo powder-natural rubber were able to be selected for the production of fabricated mudguard, mouse pad and tea mat. It was found to be utilized cost effective biomass bamboo powder as fillers to make eco friendly composite materials.

Keywords: Natural rubber, composites, bamboo

1. Introduction

Natural rubber (NR) is a known commodity polymer as well as a potential industrial elastomer. Because of its unique quality of physico-mechanical properties; today, it has been compounded by other ingredients designed to be used for diverse applications such as fan belt, seal ring, conveyor belt, hand cover, power cable, air craft tyres, motor car tyres, brake lining, tractor, mudguard and clutch lining, etc. [1,2]. As mentioned, natural rubber has been compounded with other renewable resource materials as well as high durable materials by physical and chemical means, especially to impart and reinforce thermal stability, hardness and flame-retardant properties [3]. One of the renewable resources, that have been available, is bamboo powder from plants and waste bamboo chopsticks. Many researchers have done systematic research works concerning with natural rubber materials relevant to rubber composites. [4-7].

Fillers are incorporated in rubber composites to improve certain properties and reduce the materials cost. Fillers are one of the most important components and are added at the second highest portion in the manufacturing of rubber products. Reinforcing fillers improve the modulus and strength of the rubber products, whereas non-reinforcing fillers have little or no effect on the rubber properties. There are varieties of fillers available and used commercially in the rubber industry. The use of fillers is necessary to achieve the level and range properties that are required for technical reasons. Natural rubber does not require the use of fillers to obtain high tensile strength. Reinforcing fillers enhance the already high tensile properties of gum natural rubber and they improve, in particular, the absorption and tear resistance. Less reinforcing fillers and high inactive fillers are used for a number of reasons. Depending on their activities, the fillers determine more or less the hardness and they reduce the rebound elasticity of natural rubber vulcanizates [8].

Natural fibers are cheaper, pose no health hazards, and provide a solution to environmental pollution by finding new uses for waste materials. Moreover, natural fibers, being available in many developing countries, would allow these countries the opportunity to use their own natural resources in their composite processing industries [9-11]. In Myanmar, bamboo is one of the abundant natural resources and the most important non-wood low cost forest product, which has been extensively utilized in a wide diversity of applications. The present work is concerned with the production of rubber composites from natural rubber and biomass bamboo powder. This work indicates that it is feasible to utilize cost effective bamboo powder and waste bamboo chopsticks as fillers to make eco-friendly composites materials.

2. Experiments

2.1. Materials

Natural rubber (Grade-3) was procured from commercial market place, Mawlamyine Region, Mon State, Myanmar. The rubber compounding ingredients such as Zinc Oxide, Stearic acid, accelerator [n-cyclohexylbenthiazylsulphenamide(CBS)], antioxidant [2, 6-di-tert-butyl-4-hydroxytoluene (BHT)] and sulphur were of commercial grade and supplied by Department of Research, Technology and Training Centre for Rubber Products (RTTCRP), Yangon, Myanmar. Other chemicals used in this work were BDH products, England. Bamboo sample used as filler belongs to the species of *Bambusa longispiculata* Gamble, locally known as Tabindaing-wa, which collected from around Mawlamyine Region, Mon State, Myanmar.

2.2. Characterization of Natural Rubber

The physicochemical properties of natural rubber such as Mooney viscosity, plasticity number, plasticity retention index (PRI), volatile matter, dirt content, nitrogen content, and ash content were determined by the testing procedures and methods as described in ASTM D1646,D1278, BS1673. The data are shown in Table 1.

Table1. Physicochemical Properties of Natural Rubber (Grade 3)

No.	Tests	*Values	Methods
1.	Mooney viscosity	52.00	ASTM D1646
2.	Plasticity Number	35.60	BS 1673 PT 3
3.	Plasticity retention Index	98.00	BS 1673 PT 3
4.	Volatile matter (%)	0.78	ASTM D1278
5.	Dirt content (%)	0.10	ASTM D1278
6.	Nitrogen content (%)	0.51	ASTM D1278
7.	Ash content (%)	0.46	ASTM D1278

***** The values of parameters are in agreement with the standard of Natural Rubber (ASTM D).

2.3. Preparation and Characterization of Bamboo Powder

Two types of bamboo powder were subjected in this work. They are unused bamboo powder from plants and used bamboo powder from waste bamboo chopsticks. The collected bamboo samples were washed with water and then cut. Bamboo chips were air-dried to obtain constant weight. The dried bamboo chips were milled to fine powder and then sieved through a mesh of 150μm and collected as bamboo powder in a desiccator. The properties of two types of bamboo powder were determined by SEM and FT-IR and shown in Table 2 and Figures 1, 2.

2.4. Preparation of Bamboo Powder- Natural Rubber Composites (BP-NRC)

The preparation of bamboo powder-natural rubber composites were step wisely carried out for efficient vulcanization. Natural rubber was first rolled about 5 min by a roller to break out the fibrous bond of rubber polymer chain. This process is called mastication. Stearic acid and zinc oxide were added simultaneously

and continuously rolled about 4 min. Then, 0.5g of CBS, 1g of BHT and (10, 20, 30, 40, 50g) of bamboo powder were added in order to make acceleration to prevent oxidize and vulcanise harder. It was then rolled continuously for about 10 min with 2.5g of sulphur to obtain a 2 mm thickness sheet. The total mixing time was approximately 20 min. During the mixing, water was passed through the roller to control the generated heat. Composite (A) is natural rubber composite without bamboo powder. BP-NR composites were prepared using the two types of bamboo powder as filler. The amount of filler loading was 10, 20, 30, 40, 50(g) respectively. The BP-NRC with unused BP comprised B to F composites whereas the BP-NR composites with used BP comprised B_1 to F_1. Table 3 gives the recipes used in the formulation of BP-NR composites.

Table 3. Compounding Recipes for Prepared BP-NR Composites

Ingredients	Formulation (g)					
Natural rubber	100	100	100	100	100	100
Zinc Oxide	5	5	5	5	5	5
Stearic acid	2	2	2	2	2	2
CBS	0.5	0.5	0.5	0.5	0.5	0.5
BHT	1	1	1	1	1	1
Sulphur	2.5	2.5	2.5	2.5	2.5	2.5
Filler	0	10	20	30	40	50
Code No. of Unused BP-NRC Used BP-NRC	A	B B_1	C C_1	D D_1	E E_1	F F_1

2.5. Characterization of Bamboo Powder-Natural Rubber Composites

BP-NR composites were characterized by SEM (JOEL-JSM-5610, Japan) and TG-DTA (STA-503 Bahr Thermo analyzer, Rigaku Japan). Composites were examined by Scanning Electron Microscope for a visual inspection of surface morphological porosity and topological texture as shown in Figure3. Thermal stability of composites was investigated by TG-DTA as shown in Figure 4.

2.6. Mechanical Properties of Bamboo Powder-Natural Rubber Composites

The following tests were conducted on the composites using standard methods[12-16]: tensile strength, tensile modulus, elongation at brake, hardness, specific gravity, tear strength, abrasion resistance index and compression set. Characterization and comparison based on physico-mechanical properties of NR and BP-NR composites are described in section 3.

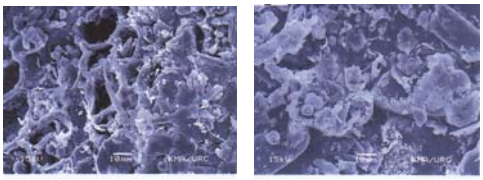
2.7. Soil Burial Test

The biodegradation of the bamboo powder-natural rubber composites was investigated as a function of filler loading. A soil burial test was carried out for six months, and the degradation of composites was evaluated through tensile testing. Morphological properties were determined by using SEM.

3. Results and Discussion

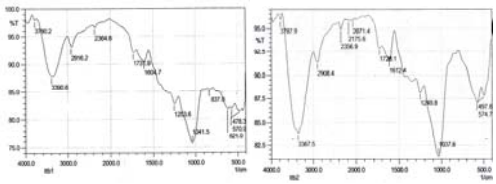
3.1. Characterization of Bamboo Powder

The SEM microphotographs of bamboo powder (Figure 1) show the surface morphology of the bamboo powder. It was found that unused bamboo powder showed meso porous structure whereas used bamboo powder showed semi-crystalline nature. According to the comparison of the FT-IR spectra of two types of bamboo powder, the functional groups contained in both types are nearly the same.



(a) Unused (b) Used

Figure 1. SEM micrographs of (a) unused and (b) used bamboo powder



(a) Unused (b) Used

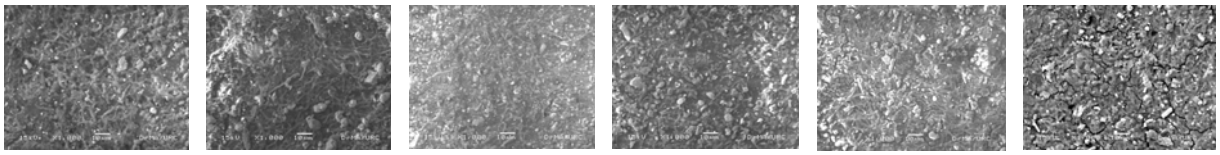
Figure 2. FTIR spectra of (a) unused and (b) used bamboo powder

Table2. Physicochemical Properties of Unused and Used Bamboo Powder

Properties	Values	
	Unused bamboo powder	Used bamboo powder
Moisture content (%)	9.86	10.25
Ash content (%)	1.63	1.56
Fiber content (%)	60.58	47.03
Bulk density (g/mL)	1.17	1.21
pH	4.95	4.97

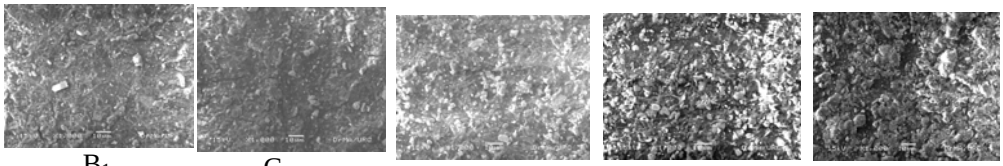
3.2. Characterization of Natural Rubber (A) and Bamboo Powder Natural Rubber (BP-NR) Composites

Figure 3(a) and (b) show the SEM micrographs of NR(A), unused BP-NR composites and used BP-NR composites. NR has almost smooth texture particles of ingredient in rubber compound and others have different morphology depending on the effect of fillers loading.



A B C D E F

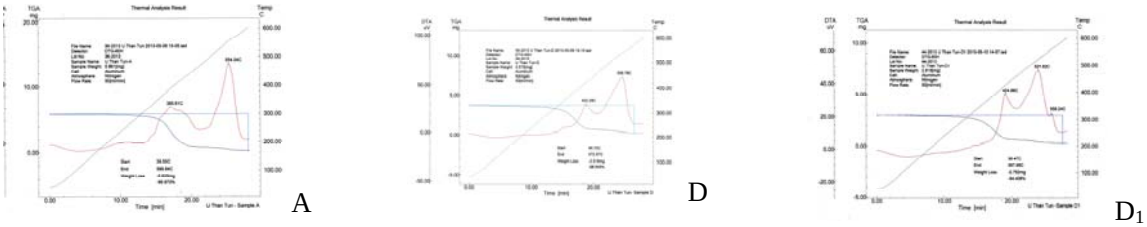
Figure 3(a). SEM micrographs of NR (A) and unused BP-NR Composites (B-F)



B_1 C_1 D_1 E_1 F_1

Figure 3(b). SEM micrographs of used BP-NR Composites (B_1-F_1)

According to the TG-DTA data, all composites show no weight loss in the range of temperature 40-120°C due to the absence of absorbed water or moisture. Secondly, between the temperature 120-340°C, thirdly, the temperature range of 340-440°C and finally the weight loss occurs between 440-540°C due to the decomposition of polymerbackbone. Only for the natural rubber, final weight loss occurs at the range of 440-600°C and for the other composites weight loss occur at slightly different temperatures. (Figure 4)



A D D_1

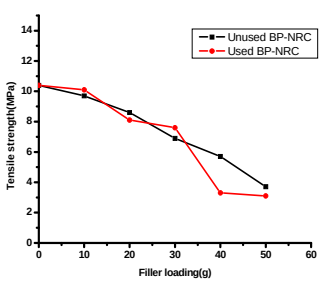
Figure 4. TG-DTA thermograms of NR(A) and BP-NR composites(D,D_1)

3.3. Mechanical Properties of NR and BP-NR Composites

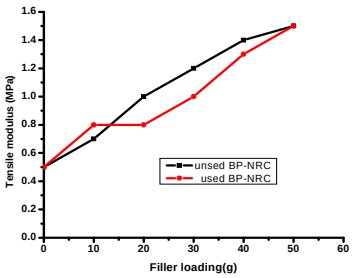
The effect of filler loading on tensile strength of natural rubber is presented in Figure 5(a). It can be seen that tensile strength decreases with increasing filler loading. The decrease in tensile strength of rubber composites with increase in filler loading has been reported [17]. The authors attributed the decrease in tensile strength to poor filling dispersion with filler addition. This behavior can be related to the probable tendency of the filler to form agglomerates. The tensile strength of unused BP-NR composites showed higher than that of used BP-NR composites. This observation is expected, and it is attributed to better filler dispersion and filler-matrix interaction.

Figures 5(b) and (c) show the effect of filler loading on tensile modulus and hardness of BP-NR composites, respectively. The results show that both properties increase with increasing filler loading, indicating increases in stiffness of the composites with the incorporation of filler into the rubber matrix. It is evident from the figure that the tensile modulus and hardness of used BP-NR composites are less than that of unused BP-NR composites, when the filler loading increases.

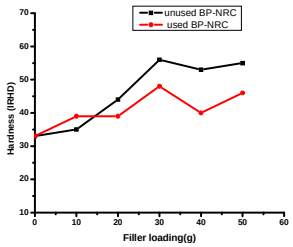
Figures 5(d) and (e) show the effect of filler loading on elongation at break (EB) and tear strength (TS) of BP-NR composites. The results showed that EB and TS of unused BP-NR is higher than that of used BP-NR composites at the filler loading studied. In general, increase the incorporation of reinforcing fillers into NR tends to decrease in EB and TS of rubber composites [4, 18]. The decreasing trend in EB and TS with increasing filler loading is attributed to increase in stiffness and brittleness, which decreased the resistance to stretch on application of strain. Figures 5(f), (g) and (h) show the effect of filler loading on the specific gravity (SG), abrasion resistance index (ARI) and compression set of BP-NR composites. The figures show a general increase in these mechanical properties with increase in filler loading. This observation is consistent with the reports [19, 20]. This may be due to more dispersion of filler (bamboo powder) in the matrix, with the resultant increase in filler-matrix interaction.



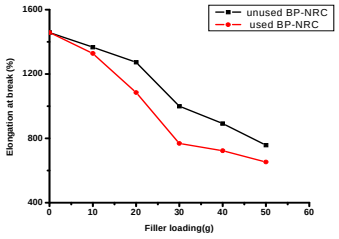
(a)



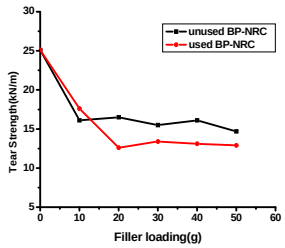
(b)



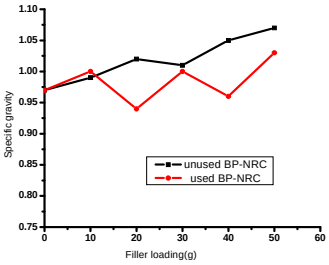
(c)



(d)



(e)



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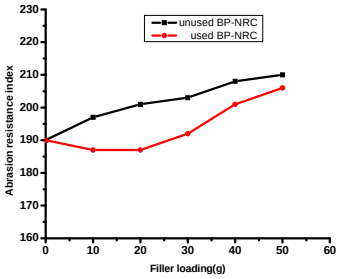

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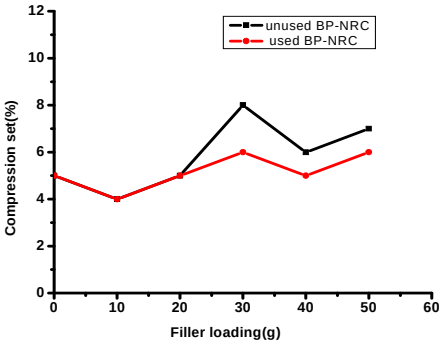
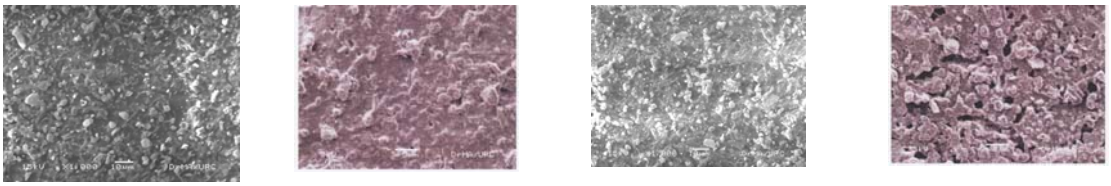


(h)

Figure 5. Effect of filler loading on (a) tensile strength (b) tensile modulus (c) hardness (d) elongation at break (e) tear strength (f) specific gravity (g) abrasion resistance index (h) compression set of unused and used BP-NR composites

3.4. Soil Burial Test

Soil burial test was carried out for six months to evaluate the degradation of BP-NR composites (D and D_1) through tensile testing and morphological properties (Figure 6). Table 4 indicates the comparison of physico-mechanical properties of composites (D and D_1) before and after soil burial test. The data showed that both composites were durable and resilient to rapid bio decay after burying under soil for six months.



D

Before | After six months

D_1

Before | After six months

Figure 6. SEM micrographs of Composite D and D_1 after six months soil burial testing

Table 4.Comparison of Physico-mechanical Properties of Composites (D and D_1) before and after Soil Burial Test

Properties	Results			
	D		D_1	
	before	after	before	after
Hardness (IRHD)	56	52	48	45
Specific gravity	1.01	1.22	1.00	1.30
Tensile strength (MPa)	6.90	6.55	7.60	7.40

Elongation at break (%)	1000	960	768	750
Tensile modulus (MPa)	1.00	0.96	1.00	0.93
Tear strength (kN/m)	15.50	14.00	13.40	12.80
Abrasion resistance index	203	200	192	185
Compression set (%)	8	7	6	5

3.5. The Production of Rubber Goods using by Two Selected BP-NR Composites

Compression set values of NR and BP-NR composites (D and D_1) were 5, 8 and 6 respectively. Hardness (IRHD) values of these composites were 33, 56 and 48 respectively. Hardness and compression set values are important parameters for selecting rubber goods, although other mechanical properties are also considered depending on the nature of finished products. According to the physico-mechanical properties as well as based on the durable composites properties, two composites, D and D_1, were selected for the production of fabricated mudguard, mouse pad and tea mat shown in Figure 7.

D D_1

Figure7. Production of rubber goods by using BP-NR composites D and D_1

3.6. Physico-mechanical properties of Fabricated Mudguard and Commercial Mudguard

The mechanical properties are important parameters to fabricate the rubber goods. Based on the data and results recorded as described in 3.3; the mechanical properties of mudguards using two selected BP-NR composites (D and D_1) were examined and compared with a commercial good as shown in Table 5. Estimated costs for fabricated mudguards are included.

Table5. Physico-mechanical Properties of Fabricated Mudguards from Composites (D and D_1) and Commercial Mudguard

Properties	Result		
	D	D_1	Commercial mudguard
Hardness (IRHD)	56	48	60
Specific gravity	1.01	1.00	1.00
Tensile strength (MPa)	6.90	7.60	8.50
Elongation at break (%)	1000	768	900
Tensile modulus (MPa)	1.00	1.00	1.25
Tear strength (kN/m)	15.50	13.40	16.50
Abrasion resistance index	203	192	200
Compression set (%)	8	6	5
Estimated cost For one pair (kyats)(viable)	2100-2300	2100 -2300	3500-4000

IV. Conclusion

Based on the comparisons of mechanical properties and durable properties, two types of bamboo powder-natural rubber (BP-NR) composites can be utilized as modifiers in the process of making rubber goods: mudguard, mouse pad and tea mat. The results of this work have shown that it is feasible to use

bamboo powder as low cost fillers and also reutilize biomass waste in an ecologically acceptable way and helps to reduce the environmental pollution, deforestation and management through recycling.

Acknowledgements

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Forearm Motion Classification based on Time-Frequency Characteristics of EMG Signals

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Electromyography (EMG) signal cantains significant time-frequency information for myoelectric control. This paper proposes a motion classification method based on time-frequency characteristics extracted from EMG signals. Short-time Fourier transform (STFT) and continuous wavelet transform (CWT) are utilized to calculate the time-frequency information. To tackle with "curse of dimensionality", this method divides the frequency bandwidth into several sub-bands, and defines feature(s) on each band.These feature patterns are then inputted into a multi-layer perceptron (MLP) neural network to achive classification of forearm motions. Motion classification experiments have been conducted with three subjects to examine the proposed method. In the experiments, classification was performed off-line. From the experimental results, high classification performance can be found with average classification rate around 90%. Additionally, classification rates of each motion, for each subject, also indicate the validation.

1. Introduction

Electromyography (EMG) signals, which are generated by muscle during contractions, can be collected noninvasively on the surface of skin. Features extracted from EMG signals contain force and timing information of muscular activities, and have been widely investigated in the context of myoelectric control [1]. Moreover, it is possible to measure EMG signals from residual muscles of amputees, many researchers have applied EMG signals to human-machine interfaces to control powered prosthetic devices and wheelchair, and so on [2]-[5].

The key part of these human interfaces is a motion classification process, which classifies motions or intentions from feature patterns extracted from raw EMG signals. Features extracted from time and/or frequency domain have been well investigated in the field of EMG motion classification. Control signals can be generated based on output of the classifiers. So far, a variety of EMG classification methods has been developed in the literature [1]-[6]. For example, Tsuji et al. utilized EMG amplitude features to recognize six forearm motions using a multilayer perceptron (MLP) neural network [7]. Yoshikawa et al. used cepstrum coefficients of integrated EMG signals to determinate seven motions with a support vector machine (SVM) [8]. A multiple-step method was developed to classify combined forearm motions, such as a combined motion of wrist extension and hand opening [9]. This method can recognize six forearm motions including four single and two combined limb functions.

Since EMG signals are inherently non-stationary, features of time-frequency (TF) domain have been extensively studied in order to employ time-varying characteristics of EMG signals for motion classification. Englehart et al. utilized TF features, which were obtained with short-time Fourier transform (STFT), wavelet transform (WT), and wavelet packet transform (WPT), to classify motions using linear discriminant analysis (LDA) and MLP [10][11]. STFT-based TF features were successfully applied to a single EMG channel to classify four forearm motions [12]. In these methods, however, motion classification is often accompanied with high-dimensionality of EMG features, since the dimension is determined according to number of EMG channels and resolution (or number of bands) in frequency domain.

It is widely accepted that when dimension of input features increases classification and

generalization performances are usually degraded. To deal with this problem, many researchers have incorporated dimension reduction or dimension projection methods prior to the classifiers, in order to find a compact feature set to avoid exhaustive training process and to reduce computation burden. The study by Englehart et al. [10] indicated that principal component analysis (PCA) can consolidate information effectively in a small-size dimension of feature. Chu et al. developed a linear-nonlinear feature projection method based on PCA and a self-organizing feature map (SOFM) to perform dimensionality reduction on WPT features [13]. Zhang et al. conducted nine-motion classification based on a variety of features: mean absolute value, zero crossings, STFT, WT and so on [14]. In this study, the authors implemented PCA and LDA to achieve dimensionality reduction.

Although dimension reduction methods have been demonstrated critical to the success of EMG motion classification based on time-frequency features, the eigenvalues or projected features are largely determined by samples in the training dataset, and, in some cases, important spectral characteristics or frequency bands may not be preserved in the final feature set. The present study aims to develop a forearm-motion classification method based on TF features. The total frequency bandwidth is divided into several pre-defined bands, and features are generated for each band in order to reduce the feature dimensionality. In this study, TF features are extracted using STFT and a continuous wavelet transform (CWT), and mean power level of each frequency band is calculated to generate feature patterns for pattern classification, where a MLP neural network is employed to recognize five forearm motions.

The rest of this paper is organized as follows. The feature extraction method and the motion classification are described in Sections 2 and 3, respectively. In Section 4, validation of the proposed method is shown with experimental results. Finally, Section 5 gives a conclusion of this paper.

2. Time-Frequency Feature Extraction using Frequency Division

N channels of raw EMG signals are recorded using electrodes attached on skin surface to classify five forearm motions: neutral, ulnar flexion (UF), radial deviation (RD), wrist flexion (WF), and wrist extension (WE), which are shown in Fig. 1. The pre-processed EMG signal is defined as E_n (n = 1, …, N) for the nth channel. Time-frequency features based on STFT and CWT are defined frame by frame along the timeline. Spectrum of the TF distribution is then divided into U bands, and one feature, mean power level, of each band is determined. So that, for each frame (time slice), the feature dimension $S = N \times U$. The feature vector $\boldsymbol{X} \in R^S$ is then input to the MLP classifier.

A. Feature Extraction using Short-time Fourier Transform (STFT)

With STFT, frequency spectrum $F_n(m, f)$ is calculated as

$$F_n(m,f) = \sum_{k=0}^{L-1} w(k) E_n(k + ml) \exp\left(\frac{-j2\pi kf}{L}\right) \tag{1}$$

for frequency f and frame m. Here, $w(\cdot)$ is the window function, L is the length of window (frame), and l is the frame overlap, respectively. Power spectrum $P_{dB_n}(m, f)$ is expressed in decibels in order to make an observation on features with small power values.

$$P_{dB_n}(m,f) = 10\log_{10}\left\{\frac{F_n(m,f)\cdot\overline{F_n(m,f)}}{L}\right\} \tag{2}$$

Fig. 1 Five forearm motions considered in this study.

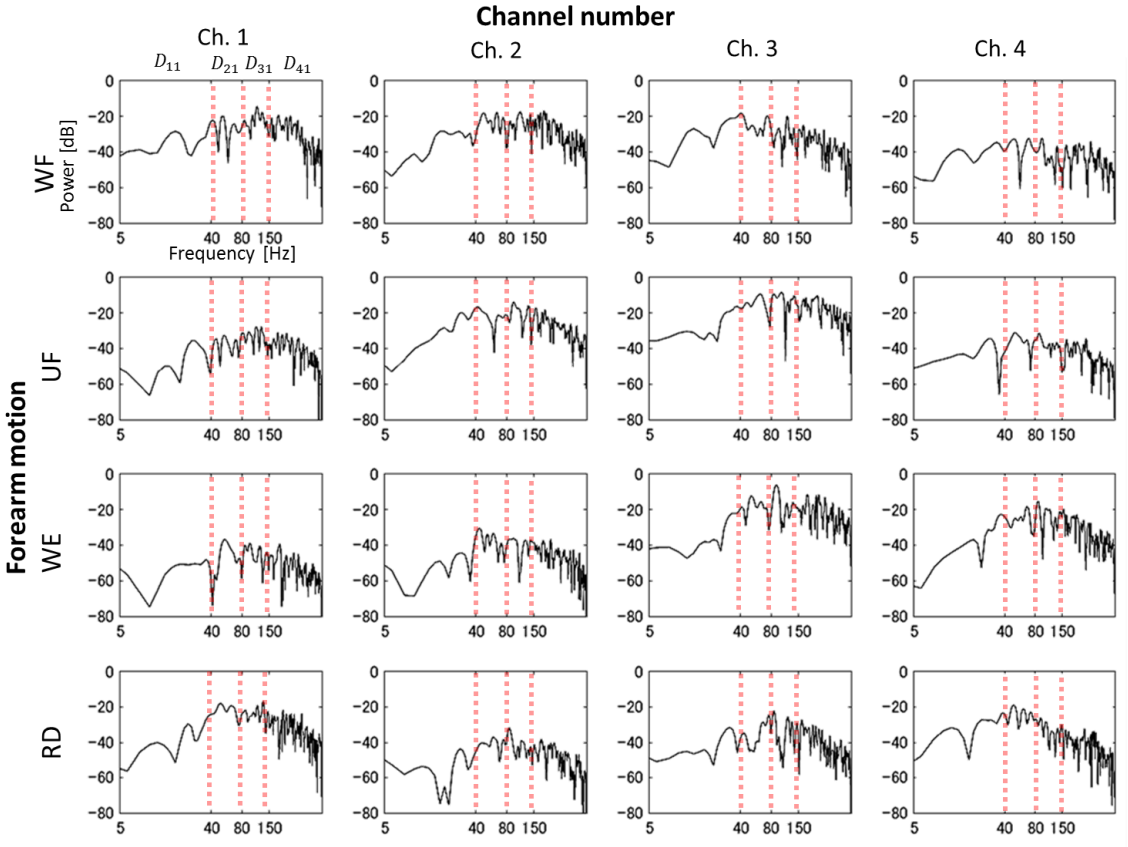

Fig. 2 Examples of power spectrums of each EMG channel for four motions.

Since range of the input data of MLP is set as [0, 1], $P_{dB_n}(m,f)$ is further transformed to fit for the classifier's input nodes, and the converted power spectrum $F'_n(m,f)$ can be expressed as,

$$F'_n(m,f) = \begin{cases} \dfrac{K + P_{dB_n}(m,f)}{100} & , P_{dB_n}(m,f) \geq -K \\ 0 & , P_{dB_n}(m,f) < -K \end{cases} \tag{3}$$

where the threshold -*K* can be set as the minimum power, when *K* < 100, and -100 otherwise.

In this study, frequency spectrum is divided into four bands ($U = 4$), i.e., 5-40Hz, 40-80Hz, 80-150Hz, and 150-500Hz, respectively. These band limits are determined based on careful observation of the frequency characteristics. Figure 2 depicts examples of power spectrums of each EMG channel for four motions. Major characteristic frequency peaks among motions can be found in the range of 40-150Hz, and frequency features in the lower band, 5-40Hz, and the higher band, 150-500Hz, are set as two elements of feature vectors. The 40-150Hz band is further divided at 80 Hz in order to keep more discriminative information for motion classification. Mean power level of each frequency band is obtained as,

$$\overline{D_{un}}(m) = \frac{1}{L_u} \sum_{k=f_u}^{f_u+L_u} F'_n(m,k) \tag{4}$$

where u represents the frequency band ($u = 1, \ldots, 4$), f_u is the start frequency of band u, and L_u is width of the frequency band. Then, for the *m*th frame, feature vector can be defined as $\alpha_n(m) = \left[\overline{D_{1n}}(m), \overline{D_{2n}}(m), \overline{D_{3n}}(m), \overline{D_{4n}}(m)\right]$ for the *n*th EMG channel. Assemble all four channels, the extracted feature has sixteen elements ($S = 16$), and the vector $\boldsymbol{X}(m) = [\alpha_1(m), \ldots, \alpha_4(m)]$ is used as input pattern for the MLP classifier at frame *m*.

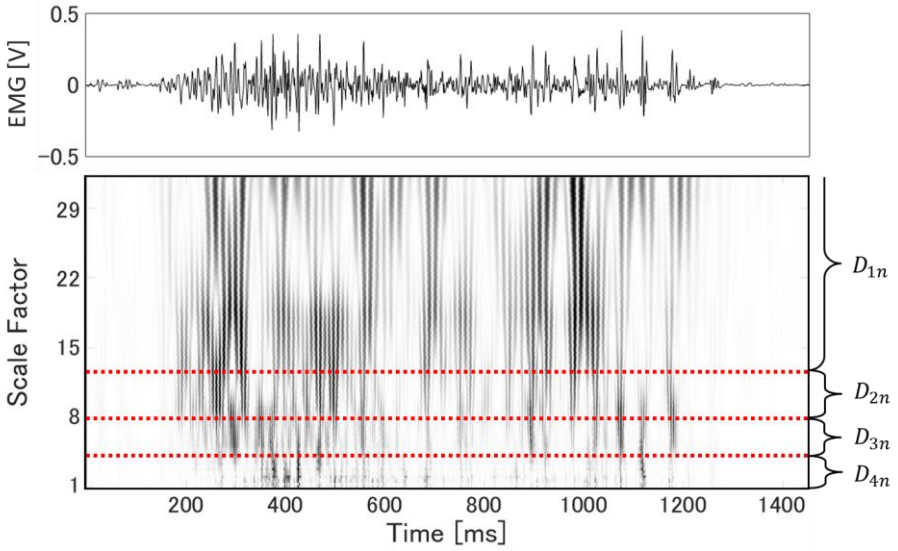

Fig. 3 An example of wavelet transform on EMG Ch. 1 of wrist flexion. (Upper) EMG signal, (Lower) Wavelet coefficients with Coif5 wavelet.

B. Feature Extraction using Continuous Wavelet Transform (CWT)

Time-frequency distribution, of EMG channel *n*, is obtained with CWT as follows,

$$W_n(b,a) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} E_n(t) \overline{\psi\left(\frac{t-b}{a}\right)} dt \tag{5}$$

where *a* is a scale parameter, which corresponds to frequency information, *b* stands for the time shift parameter, and ψ is the mother wavelet. Figure 3 shows an example of wavelet coefficients calculated from EMG signals. The wavelet coefficient is modified in a frame manner with an average of moduli in the frame *m*,

$$\overline{W_n}(m,a) = \frac{1}{L} \sum_{k=1}^{L} |W_n(k,a)| \tag{6}$$

However, frequency information calculated with CWT has different resolution over the bandwidth, which is related to the mother wavelet. Similarly, four frequency bands are defined as 5-60Hz, 60-90Hz, 90-180Hz, and 180-500Hz, respectively. The frequency division is set close to that of the STFT method described in the previous subsection. Then, mean power vector of four bands, $\alpha_n(m)$, is calculated for the frame *m* of EMG channel *n*. Finally, $\boldsymbol{X}(m)$ is generated from $\alpha_n(m)$ for motion classification.

3. Pattern Classification and Motion Decision

In this section, the feature vector $\boldsymbol{X}(m)$ is inputted into a MLP classifier to recognize forearm motions. The MLP is trained with a traditional error back-propagation method. Each output node of MLP corresponds to a motion, and the motion pattern is defined as $P(m) = [p_1(m), \ldots, p_D(m)]$ for $\boldsymbol{X}(m)$, where *D* is the number of motions. For training of the MLP, sample data sets are required for all motions. Through the training procedure, weight coefficients of the MLP are tuned to output one for one node, which is corresponding the motion label for the input sample data, and to output zero for all other nodes. A mean squared error (MSE) function is defined between the classifier's outputs and the training target values.

Since EMG signals are quite unstable, even with a well-trained MLP classifier, misclassification may happen. To prevent this problem, entropy of the MLP's outputs is calculated and compared with a pre-defined threshold for motion decision [2]. The entropy of output for the *m*th frame, $H(m)$, is defined as

$$O_d(m) = \frac{p_d(m)}{\sum_{l=1}^{D} p_l(m)} \quad (d = 1, \ldots, D) \tag{7}$$

$$H(m) = -\sum_{d=1}^{D} O_d(m) \log O_d(m) \tag{8}$$

where $O_d(m)$ is the normalized output by the sum of D output values. The entropy $H(m)$ indicates ambiguity of information. If $H(m)$ is less than a threshold H_0, specific motion that corresponds to the largest output of the MLP is determined as the classification result. Otherwise, the classification is suspended.

4. Experimental Results

A. Experimental Setup

Motion classification experiments have been conducted to examine the proposed method with three subjects (A, B and C), who are all male, physically unimpaired, and right handed. EMG signals were measured with an EMG system (Bagnoli-4, Delsys Inc). Four channels of electrodes were attached on subjects' right forearms, as shown in Fig. 4. Sampling frequency was set as 1 kHz. For pre-processing of the EMG signals, a maximal voluntary contraction (MVC) method was applied to raw EMG to correct differences in EMG activation levels between channels.

In these experiments, length of the window L was set as 256 ms, and l was 64 ms. In the method using STFT, hanning window was utilized as $w(\cdot)$ in Eq. (1), and K in Eq. (3) was set as 100. Additionally, in the method of CWT, three mother wavelets: Coiflets of order 5 (coif 5), BiorSplines of oder 3.9 (bior 3.9), and Daubechies of order 9 (db 9) were used. The scale a was set as 1, 2, …, 128 in Eq. (5). A three-layer neural network was used in the experiments, which consists of 16 nodes in the input layer, 12 nodes in the middle layers, and five output nodes, respectively. For each subject, 360 sample sets were prepared to train the MLP. The training process continued until the MSE was less than 10^{-4}. However, if the error after 20,000 training iterations was still larger than 10^{-4}, the training procedure was terminated. Classification, on 937 test data sets for five motions each subject, has been achieved off-line. In the motion decision part, H_0 was set as 0.2.

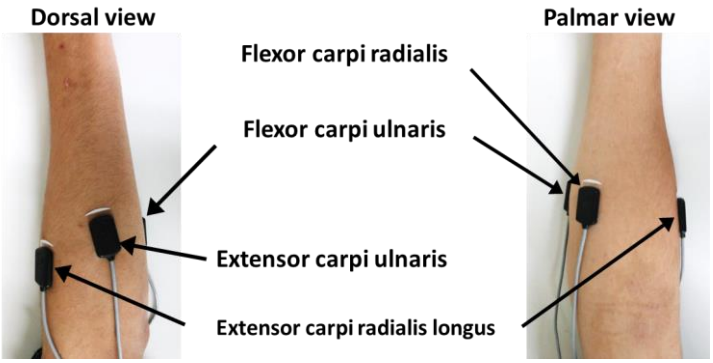

Fig. 4 Four EMG channels used in the experiments.

B. Motion Classification Results

Classification rates of five motions were calculated for each subject. Table 1 shows classification rates of three subjects using the STFT-based TF feature vectors. Except for motions WE and RD of subject C, all classification rates are over 90%. Then, classification results based on three CWT methods are depicted in Tables 2, 3 and 4. Similar results can be found with those of STFT. In addition, classification rates of some motions decreases with CWT methods than that of STFT. General speaking, five motions can be classified for three subjects. It is needed to be mentioned that some test samples, which were not classified correctly, were suspended due to entropy values. Recalculate the classification rates considering suspension would give a practical evaluation of the proposed method. From these results, validation of the proposed method can be confirmed.

Table 1 Classification rates of the method using STFT

	A	B	C
Neutral	96.07	92.99	93.84
Wrist flexion	95.08	99.03	100.0
Ulnar flexion	96.08	98.68	92.86
Wrist extension	93.48	95.00	79.01
Radial deviation	100.0	100.0	84.75

Table 2 Classification rates of the method using CWT (coif 5)

	A	B	C
Neutral	97.70	99.00	96.15
Wrist flexion	96.72	95.15	96.15
Ulnar flexion	92.16	88.16	90.00
Wrist extension	95.65	86.25	79.01
Radial deviation	100.0	97.21	89.83

Table 3 Classification rates of the method using CWT (bior 3.9)

	A	B	C
Neutral	93.77	92.59	90.29
Wrist flexion	96.72	99.03	100.0
Ulnar flexion	78.43	94.74	100.0
Wrist extension	100.0	95.00	74.07
Radial deviation	100.0	98.32	86.44

Table 4 Classification rates of the method using CWT (db 9)

	A	B	C
Neutral	97.70	99.60	99.54
Wrist flexion	96.72	94.17	85.90
Ulnar flexion	98.04	93.42	81.43
Wrist extension	100.0	86.25	76.54
Radial deviation	100.0	93.30	84.75

Then, the mean values and the standard deviations of classification rates for four methods are summarized in Fig. 5. The statistics of classification rates are evaluated over five motions. From Fig. 5, it can be found that the method based on CWT can achieve equally performance as STFT.

Difference of classification performance among three CWT methods indicates that improvement may be expected if the mother wavelet function and/or the frequency division are optimized and selected according to a motion classification problem. A further investigation is worthy to study how the parameters of the proposed method and the mother wavelet functions can affect the classification results. We will make an additional report in our future works.

5. Conclusions

In this study, we attempt to propose a pattern classification method based on time-frequency characteristics of EMG signals. With short-time Fourier transform (STFT) and continuous wavelet transform (CWT), time-frequency-based feature vectors can be extracted. Unlike the traditional methods, which adopt a feature reduction or projection method, such as PCA, frequency bandwidth is divided into sub-bands. Then, for each band, feature(s) can be developed so that the finally feature

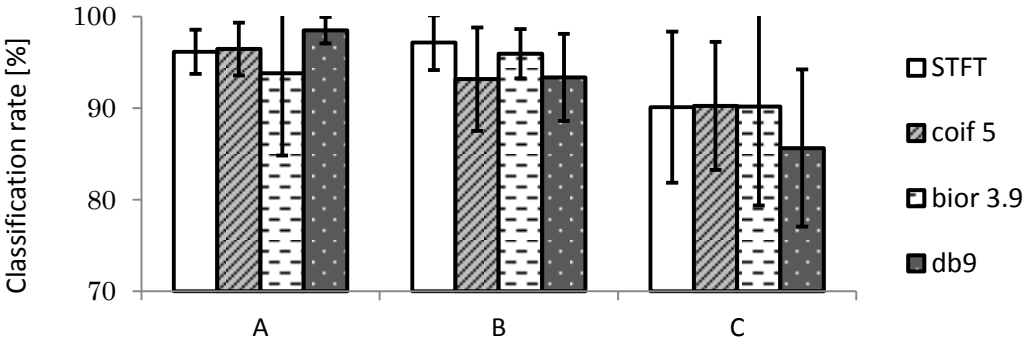

Fig. 5 Mean classification rates over five motions for each subject

dimension can be kept in a compact size while preserving the frequency characteristics of EMG signals. In this study, a simple MLP neural network has been utilized for pattern classification. From the experimental results, we can find that the proposed method has conducted relatively high classification performance, for both TF features extracted with STFT and CWT. However, for some combination of motion-wavelet function-subject, classification rates are less than 80%. Also, difference, although not significant, among the classification results for four experimental conditions can also be found.

As the first step of our study, classification performance and validation of the proposed method has been evaluated and confirmed in this paper. For our future works, it is necessary to conduct experiments with more subjects, in order to verify individual difference with the proposed method. In addition, comparison experiments with the conventional methods using dimension reduction or projection would be conducted in our future studies.

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Development and Nationwide Spread of a Low Cost ICT System in Agriculture by KOSEN Network

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In this paper, we reported on activities of our project in smart agriculture. The one of big issues of ICT system in agriculture is that there is no standard of that. So it is difficult to integrate the existing components of various manufactures. This is also one of the reasons that the system prices do not fall. The high cost causes a barrier of adopting ICT system especially for small or middle scale farmers. It is necessary to clear the barrier in order to realize nationwide spread of smart agriculture. We are developing low cost ICT devices in agriculture and try the nationwide demonstration experiment by using KOSEN network. KOSEN is a college of technology and there are 51 KOSENs organized by the institute of national colleges of technology, Japan. Since all of KOSENs belong to one organization, it is easy to cooperate with each other for same objectives. We organized a research project in smart agriculture with 12 KOSENs. Because those 12 KOSEN places are distributed in various parts of Japan, we can implement nationwide experiments in smart agriculture. Since each KOSEN has cooperation with the regional farmers, this experiment will contribute to promote the usage of ICT system in each region. This project was started in October 2014 and prototypes of sensor network system were developed. Currently we are preparing for experiments at each KOSEN.

1. Introduction

There are severe aging and shortfall of successor in Japanese agriculture. Fig.1 shows the changes of Japan's farming population. Each line indicates farming population of each year. The major age group is shifting to elderly group year by year. In 2010, the major age group came to over age 75. Total of the farming population is also decreasing year by year. To maintain the productivity of Japanese agriculture, management size of field per farmer must be increased. But a large scale farming is difficult by using the way of traditional Japanese farming. Smart agriculture is attracted as a solution of this big issue. Although smart agriculture have been already adopted in some Japanese farmers, it still be minor method compared with the traditional way. There are some hindrances that prevent from spreading smart agriculture in Japan. One of them is high price of ICT systems in agriculture. And there are no standard of smart agriculture system. If there were a standard of the ICT system, we could integrate various manufacture's components according to the standard. The standardization also helps to decrease the price of the ICT system by activating the market.

It is necessary to clear these barriers in order to realize nationwide spread of smart agriculture. We are developing low cost ICT devices in agriculture. The system is designed according to the standardization roadmap by IT strategic headquarters of the cabinet [2]. And we try the nationwide demonstration experiment by using KOSEN network.

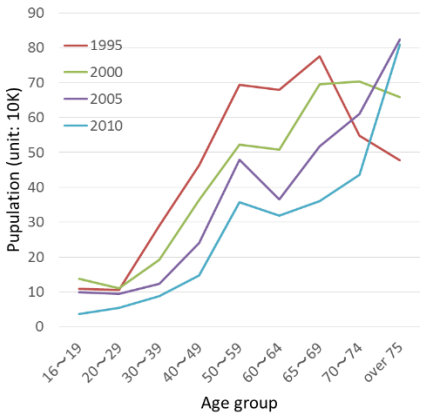

Fig. 1 Changes of Japan's farming population (Source: Ministry of Agriculture, Forestry, and Fisheries, Census of Agriculture and Forestry in Japan [1])

2. Experiment

We study this project on KOSEN network. KOSEN is a college of technology and there are 51 KOSENs organized by the institute of national colleges of technology, Japan. We organized a research project in smart agriculture with 12 KOSENs. Because those 12 KOSEN places are distributed in various parts of Japan, we can implement nationwide experiments in smart agriculture. Fig.2 shows locations of KOSENs. The number on the map indicates location of each KOSEN. Red circles indicate the cooperated KOSENs. Yellow circled KOSENs lead research on low cost ICT system in this team. These five KOSENs (Sendai, Tsuruoka, Toba marine, Anan, Kagawa) and one company (Jisedaitech limited partnership) are developing components of the ICT system shown in Fig.3. These components are going to be assembled as sensor networks and web applications shown in Fig.4. The sensor networks are set in crop fields. Environmental information and crop situations are measured by the weather sensor, stereo camera sensor and stress sensor. The measured values are send to the database by the communication devices. Work of farmers is recorded as worker information, it will be stored in the database. These stored data in the database will be managed by the cultivation management system. After the ICT system will be completed, the sensor networks and web applications will be spread to regions of cooperated KOSENs shown in Fig.2 and the measured values in nationwide will be able to be gathered in the database. Since each KOSEN has cooperation with the regional farmers, this experiment will contribute to promote the usage of ICT system in each region.

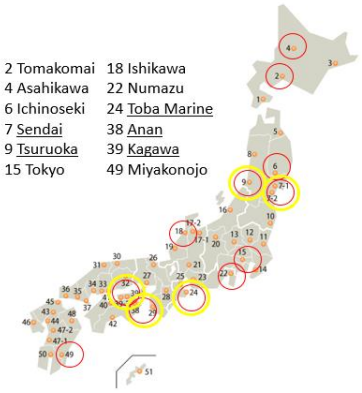

Fig. 2 Location map of KOSENs

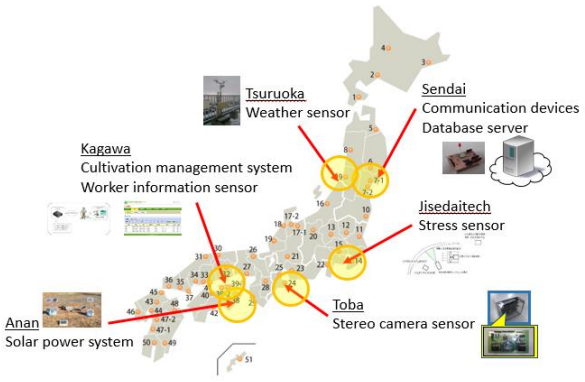

Fig. 3 Development of components of the ICT system by the five KOSENs and one company

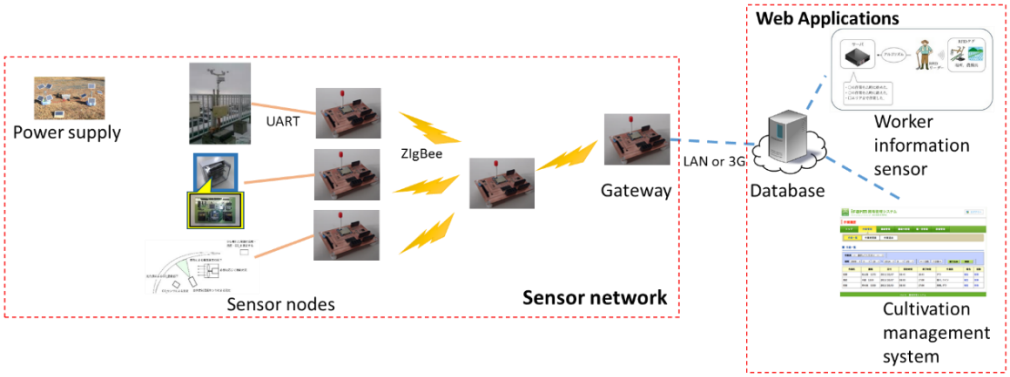

Fig. 4 Sensor networks and web applications

3. Results and Discussion

3.1. Low cost ICT system

It is important to realize a low cost ICT system in order to spread smart agriculture. We are trying to develop the low cost ICT system as much as possible. In order to realize low cost, we used popular and cheap embedded boards. Hardware circuits were designed to constitute by the minimum necessary electronic components. Software was programed to make full use of sleep function to achieve low power consumption. We have developed the three components shown in Table 1. Each cost is expressed as current value. Since there are two types of gateways, you can select one of them. Because other components shown in Fig.3 are under design, we cannot indicate these costs.

Table 1 The developed components and these costs

Component	Main parts	Cost
Weather sensor	Sensors: SEN-08942 (wind speed, wind direction and rain fall), SHT21(temperature and humidity), MPL115A2(pressure), AM-5904(insolation) Controller: Arduino Pro	¥15,000
Solar power system	Solar panels: 5W * n Battery: 12V5Ah DC-DC converter: MA78AR05-0.5	¥8,000 (200mA load Type) ¥3,500 (50mA load Type)
Communication devices	ZigBee communication module Controller: TWE-lite	¥1,500
	Gateway Controller: Raspberry Pi model B+ RTC: DS32301 3G communication module: 3GPI Wi-Fi dongle: GW-USNANO2A	¥35,000 (3G Type) ¥6,000 (Wi-Fi Type)

3.2. Progress in the development of each component

3.2.1. Weather sensor

In recent years, application of ICT to the field of agriculture allows the acquisition and analysis of the weather data of the farmland, and improvement of the productivity is expected because cultivation environmental management becomes easy. However, installation in the farmland is difficult, because the existing meteorological equipment is expensive and large. Therefore, in this study, we developed a low cost and small meteorological equipment and built the local weather data acquisition system for the farmland. Measuring objects are wind speed, wind direction, rain fall, atmospheric pressure, air temperature, humidity and insolation. Fig.5 and Fig.6 show the developed system and results of the measure experiment.

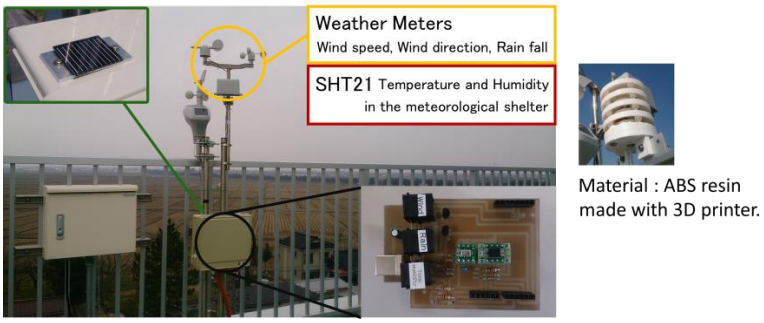

Fig.5 The developed weather sensor system

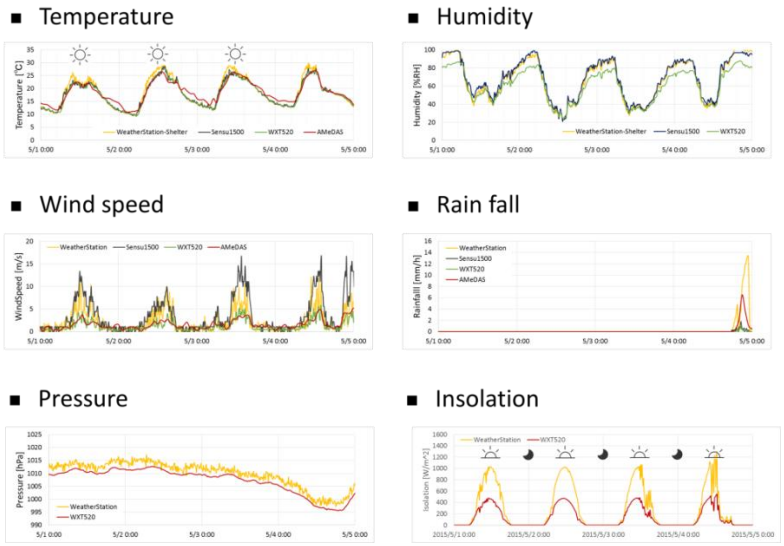

Fig.6 Results of the measure experiment

3.2.2. Solar power system

In the farm, we have to secure the power source to construct the environmental sensor and wireless network. We need to study of reducing the cost of the cost independent power supply to spread the low cost field environmental monitoring system broadly. We have developed the two kinds of low cost independent power supplies to use low price solar batteries and storage batteries for the monitoring sensors which consume 5V 50mA and 200mA. The total parts cost of 200mA load type is ¥8,000,and that of 50mA load type is ¥3, 500. We experimented with the power supply system for 5V 50mA sensor type by charging and discharging from March to June in southern Tokushima. Fig.7 shows the system configuration diagram. Fig.8 shows the photographs of the power supply system and the experiment scenery in the farm. We show the result of charging and discharging test in the farm from April 29 to June 3 in Fig.9. As the result, the device worked properly. However, the device stopped after rainy weather continues for many days in the beginning of April. As future works, we need to clarify an index adjusting direction and angle of solar battery to fit each location. And we analyze local past weather data to be useful in all over Japan. These will help to expand the locations for installation. We will conduct the experiment in all over the country.

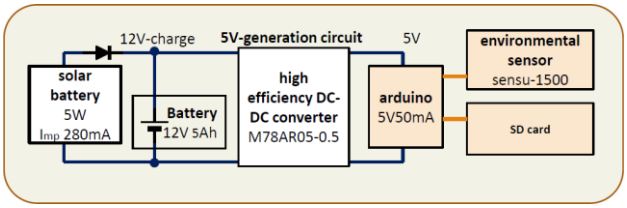

Fig.7 System configuration diagram.

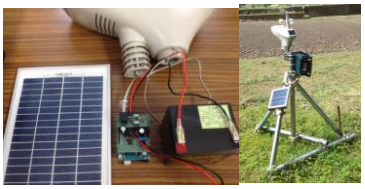

Fig.8 System appearance

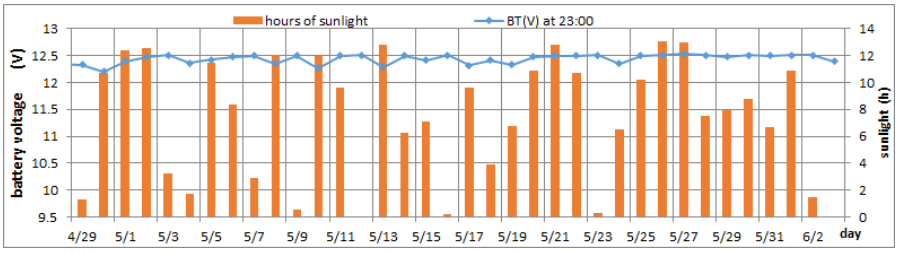

Fig.9 Hours of sunlight and storage battery voltage at 23:00 in farm (4/29~6/3)

3.2.3. Communication devices

The communication devices are used to establish wireless connection among sensor nodes and to communicate to the database server. We developed small size ZigBee communication modules that can be connect to our developing sensor nodes and gateways. This module has three modes: parent, child and repeater. The parent gathers sensor data from children. So, a module connecting to a gateway is set as parent mode and that connecting to a sensor node is set as child mode. The repeater is used to extend the communication distance. The sensor data are gathered in the gateway and send the data to the database by using 3G or Wi-Fi. Since the gateway has SQLite database, the data can be stored temporarily when the communication condition to the database server is bad. We developed these communication devices as show in Fig.10 and 11. We confirmed the data flow from sensor nodes to the database server correctly.

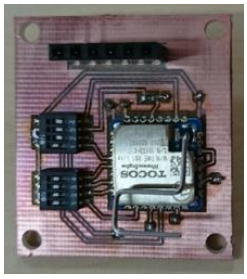

Fig.10 ZigBee communication module

Fig.11 Gateway

3.2.4. Database server

We adopted MongoDB as our database. Since Mongo DB is a schema-free database, we don't need to design strict tables like used in SQL database. Farm information is consisted of many kinds of data and it is difficult to decide what kinds of data should be stored in the tables. Since we can use schema-free design, it is easy to customize data structure for each farm and adapt to future reconstruction. We designed some collections for data management. Collection is like a table of SQL but the structure is flexible. The collections were designed according to a standardization roadmap by IT strategic headquarters of the cabinet [2]. This means that our system can connect easily to other systems based on the same standardization roadmap. Fig.12 shows the relations among the collections. Naming rule and relations among entities of gatewayList and sensorNodeList were designed similar to those of metadata of sensor information and farm work list of the roadmap. edicode is same as vegefru code that is standard code for name of vegetables and fruits. Sensor data from sensor networks is stored in sensorData and information recorded by web applications is stored in cropSituation.

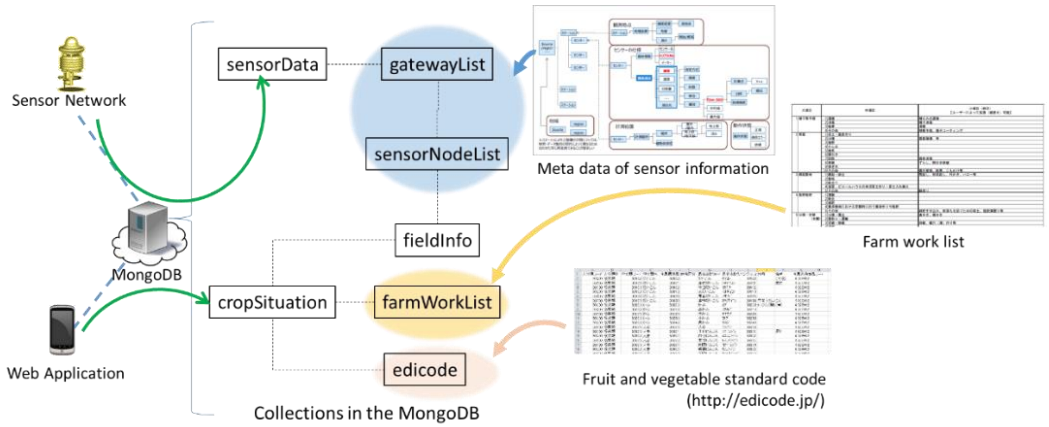

Fig.12 Relation among collections in The Mongo DB

3.2.5. Stereo sensor camera

In this study, when developing the stereo cameras shown in Fig.13, we considered (1) the possibility of long-term battery operation (operation at low power consumption), (2) the ability to exchange data via wireless communication, (3) a compact size that does not restrict installation locations, (4) a dustproof and waterproof construction suitable for outdoors installation, and (5) the ability to set up and operate the cameras easily without any special manipulations. On the basis of these considerations, we selected a camera module, wireless module, and DC-DC converter. Additionally, in consideration of an outdoor installation, we implemented a simple device design that is lightweight, compact in size, and requires minimal maintenance. Furthermore, we designed the circuit to be operable with commercially available dry-cell batteries. Table 2 lists the modules selected in this study.

Fig.13 Schematic diagram of stereo camera sensor network system

Table 2 Details of each module

Module	Features
CPU board: P430F169 (10 MHz)	Low power consumption, High-speed processing, 60 KB flash / 2 KB RAM
Wireless module: XBee (2.4 GHz)	Low power consumption, Low cost, Ad hoc Zigbee protocol
Camera module: C1098-SS	VGA image output function (jpg), Low power consumption
IO ports	14 ports (input/output)
Power source	1.5 V dry-cell battery

Images captured by a stereo camera are first stored in a data collection server. Then those data are sent via a cloud service to user terminals and synchronized. At the server, the three-dimensional structure of the subject plant is analyzed by using the captured image, and LAI calculations are performed on the basis of an estimation model. In the preprocessing for the three-dimensional structure analysis, processing to restore the three-dimensional structure of the object must be performed. Here, we attempted to use the phase-only correlation method [3, 4] to restore the structure of the subject plant.

3.2.6. Stress sensor

How plants grows can be presumed by measuring water potential. A psychrometer is used for measurement of water potential or water stress. It is a kind of air moisture sensor. Although we can get correct data of water stress by the psychrometer, it is not very easy to measure and they are very expensive. Fig.14 shows Section of stoma. A stoma absorbs CO2 to photosynthesize and discharges the water vapor which is as a result of the photosynthesis. So we are planning to use temperature and CO2 density to estimate water stress by the sensor fusion method. Fig.15 shows Stress measurement by CO2 and tempeareture.

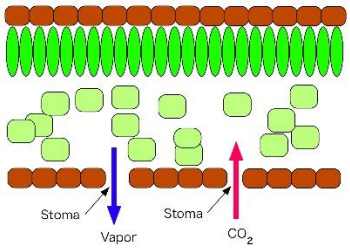

Fig.14 Section of stoma

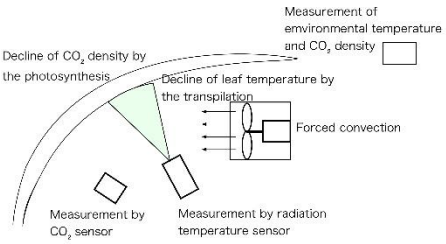

Fig.15 Stress measurement by CO2 and temperature

3.2.7. Worker information sensor

Recently, many IT vendors are offering the system which records an agricultural-work diary on Cloud. However, in these systems, a farmer has to input work record using PC or a tablet. The input by PC had the heavy burden for the farmer. In this research, we propose the system which creates agricultural-work record automatically from the RFID tag data attached to farm machines and implements or farmland. Fig.16 shows the outline of our proposed system. We have completed development of a prototype system. So, we are planning the verification test in Kagawa Prefecture at the end of August, 2015.

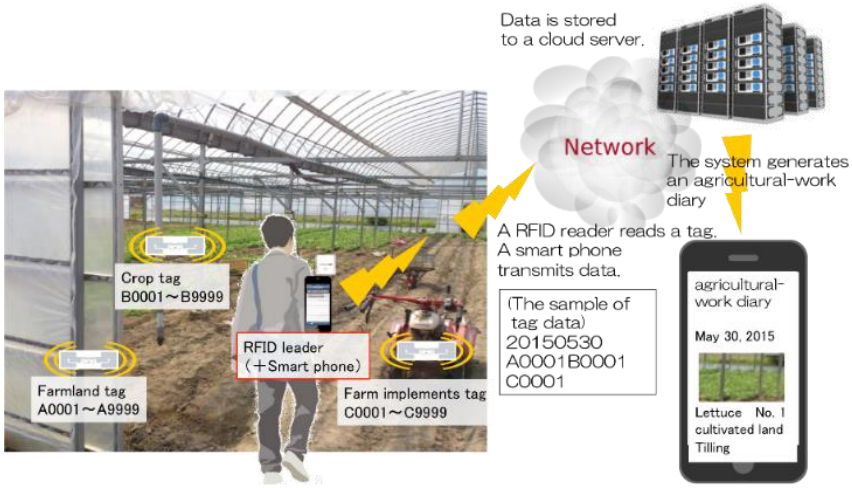

Fig.16 Outline of Worker Information Sensor System

3.2.8. Cultivation management system

Fig.17 shows the top page of the iFarm website, which was designed for assisting cultivation recording and cost management. Farm work schedules, including who handles each task and where the tasks take place, are recorded in iFarm. Workers can easily check their tasks from a PC or smart phone. Workers also submit work reports after tasks are completed, again using a PC or smart phone, making calculating labor costs easy. Any farming costs, including costs for fertilizers, seeds and seedlings, are also recorded to make cost calculation for crops easy. This way, iFarm assists and promotes stable management of farming households. In addition, we propose a new function that outputs a predicted harvest date for an input planting date, and vice versa, for different types of crops. The function is also capable of automatically generating farm work schedules. Fig.18 shows the output schedule and how the schedule is generated. At first, as shown in the figure, a planting date is determined for the harvest date. Then, as in Section 3.2.7 above, based on the schedule intervals of tasks registered in advance, the date for each task will be determined.

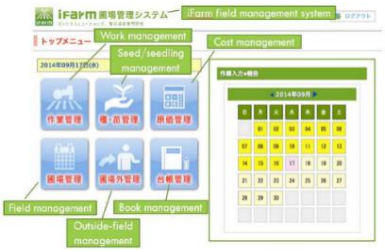

Fig.17 The top page of iFarm

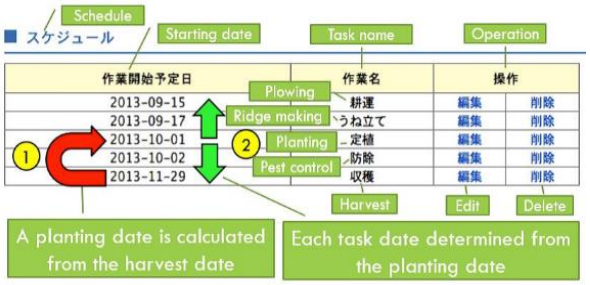

Fig.18 Generating work schedules from input harvest dates

4. Conclusion

The low cost sensor network system has been developed by KOSEN network. Schema-free database has been designed according to standardization roadmap by IT strategic headquarters of the cabinet. We confirmed correct data flow from sensor nodes to the database. As future works, the components under design have to be developed as soon as possible. We are also preparing the nationwide experiments in some regions of cooperative KOSENs. We will start the demonstration experiments of the ICT system in these regions in near the future.

Acknowledgments

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Development of Engineering Design Educational Program Cooperation with Local Community

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In order to train engineering design ability for the students in advanced corse in Tsuruoka college, unique program has been developed and executed. This program includes unique three policies; 1) Cooperation with local community type education, 2) Subject crossing type group activity, 3) Training camp activities. After repeating the preliminary meeting between teachers and officail staffs in local goverment, main theme was decided. This program was executed in local area, Sagae city park and Tobishima island, to tackle problems peculiar to the areas. Detailed contents were proposed from students by inspection at target area. In Sagae city, for example, the students tried repairing the park bench, and manufacturing the park signboard. In Tobishima island they proposed and manufactured solar cooker and the rocket heater, etc. By experiencing the program, the students themselves realized the progress especially in motivation to the activity, contribution to local community, and cooperation and communication in group.

1. Introduction

An engineering design is the educational program that pursues the materials and methods fulfilling social needs by integrating various knowledge and technologies[1]. This program tackles the problems which do not necessarily have a correct answer, and finds out a realizable solution. The engineering design ability includes various factors such as problem setting, creativity, integration of various knowledges, communication skills, and teamwork ability, and so on. Therefore, the engineering design education can be said to be the basis of engineer education. From 2012 in Tsuruoka college, the new subject named "practical design engineering exercise" has been established and carried out for the students of 1st year of advanced course since recognition of the importance of training of engineering design ability. This paper describes introduction and operation of the new program developed by us as a training of engineering design. The feature of this subject is including three policies; 1) Cooperation with local community type education, 2) Subject crossing type group activity, 3) Training camp activities at target local area[2].

2. Proposed Program

In order to carry out the design education program developed effectively, three policies described above were introduced. Details of those are described as follows:

1) Cooperation with local community type education; Students clarify the problems which the local area holds, and tackle solutions from various view of points in cooperation with local community. In the program we tackled the subject in connection with the design of city park in Sagae city and making eco-house in Tobishima island in Sakata city. The activity area and main theme were determined by repeating the arrangement beforehand between the teachers and corresponding local government staffs.

2) Subject crossing type activity; The group of students was composed by mixture of subject-of-study, i. e., departments of mechanical engineering, electrical and electronic engineering, control and information systems engineering, and chemical and biological engineering(Fig. 1). The reason of such group constitution is that the students are able to tackle the problems from various aspects.

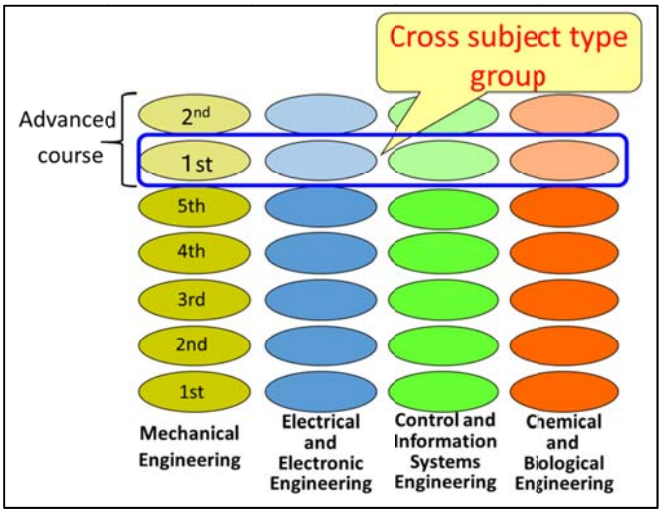

Fig. 1 Constitution of cross subject type group in this program.

3) Training camp activities; Training camp was carried out for the students to understand the values of collaboration and the responsibility of the individual in groups. As other purpose, the students can concentrate on activity all day. During training camp, lecture meetings by invited visiting lecturers were also held, in order to offer useful various knowledges to the students.

The operation time of this program consists of 90hours(school hours) and is equivalent to two credits. The time arrangement for this program is shown in Table 1.

Table 1 Time distribution for the program

Contents	Description	Operation time
1) preliminary investigation	investigation about target area and suitable engineering technologies	8hrs
2) camp activity in local area	field study, lecture, meeting, etc.	32～48hrs (4～6days)
3) group work in campus	continuing manufacturing	26hrs (2h/weeks×13weeks)
4) presentation	proposal about their design or products	8hours
5) others	additional activity time	0～6 hrs
total		90hrs

The scholastic evaluation for students concerning of this program was judged by the following aspects and using score distribution:

1. Evaluation from auditor in presentation 40%
2. Evaluation from the teacher in charge in presentation…….. 25%
3. The resulting report after practice 25%
4. Activity in this practice 10%

total 100%

3. Practice of Program

3.1 Sagae City Park Project(2012)

From 2012 we have attempted introducing the program toward the Sagae city park project, which is activity for proposing ideas for the park becoming more comfortable one for citizens. As a first phase of the activity, inspection of the city park by students was performed at the Sagae city park. They searched for what are the deficient points in the park facilities. Also, the students began to clean up to garbage littered in the park and to conduct the maintenance-and-repair volunteer(Fig. 2). The purpose of this volunteer activity is to find out clearly the deficient points in the park throughout such activities. There is also the purpose of brewing the atmosphere with which the students of a different affiliation subject of study are each other becoming frank. As results of the inspection, many of the comments about deficient points were proposed, e.g., the map signboard for visitor is not found, the wooden benches have been decayed(Fig. 3), etc.

(a) (b)

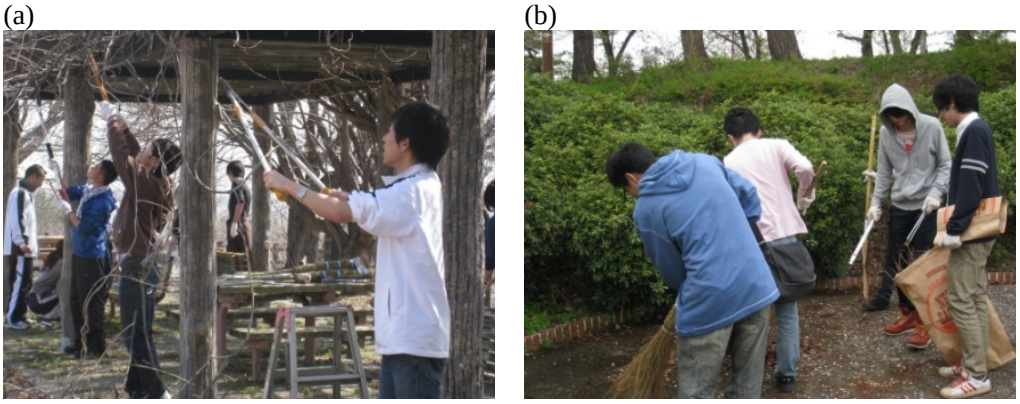

Fig. 2 Volunteer activities in the city park
(a) Pruning of thinner timber; (b) Cleaning up to garbage littered

The camp activities were carried out at a training camp site placed side in the city gymnasium. The students held the meeting after returning to the site of a training camp, and designed the plan of activities after today. During the training camp, the visiting lecturers were invited and the lecture meetings were held concerning the engineering design. Each of themes of lectures are listed in Table 2. All of lectures contain very helpful information for constructing the ideas of engineering design, and can lead design solution from various views of points. The contents of activity are listed in Table 3.

Fig. 3 Wooden benches decayed

Table 2

Theme of lectures	Lecturer	Affiliation
For substantial engineering design education	Kazuhiro Mitsumori	Consulting engineer, Sun Forrest Office
Investigating the under of a ground	Yasuo Honda	Chairman of Japan Consulting Engineers Association
Pollution and an environmental problem	Toshio Oiwa	Consulting engineer, Oiwa Environmental Consulting Engineer Office
About safety of foods	Matsuda Kiichi	Division-of-Research Manager Nitto best Corporation

Table 3 Contents of activity from respective groups(Sagae city)

group	contents
group 1	Repairing the park bench
group 2	Manufacturing the park signboard
group 3	City stamp rally which used QR Code
group 4	Illuminations in the city using a piezoelectric element
group 5	Cafe establishment of the memorial hall contiguous to a park

For example, details of groups 1 and 2 are as follows:

group 1 The old wood blocks of park bench were changed for new ones(Fig.4a). Students purchased the new wood blocks from the store and carried out cutting, filing, coating painting, and making screw holes. In particular, the step of making a screw hole was delayed. Because the position of a screw hole should be correctly located, punching the holes toward perpendicular must be very correctly. Punching was performed by the electric twist drill at the park. However, the accuracy in the perpendicular direction was not enough and the screws were not slightly applied to a flame of benches. Then as redo, new woods were purchased and punching were processed by using the driller in the college. By experiencing such basic manufacturing processes, the students would study the important elements in design education, e. g., importance of accuracy of dimensions, and excellency of processing machines.

group 2 Manufacturing the park signboard was processed by combining thinner timber generated in the park and wood blocks purchased(Fig. 4b).

After the camp activity was completed, the remaining manufacture steps were continued after returned back to the Tsuruoka college.

The debrief session for the citizens about results obtained from this activity was held in Sagae city hall(Fig. 4c). The city personnel, the citizen, and the media representative audited to the debrief session. After proposal by students, questions and answers were held on each groups. The park signboard designed and manufactured was presented to the city and was installed inside the city park.

Fig. 4 Products and debrief session about the activities
(a)Wooden benches repaired(by group 1); (b)Signboard installed(by group 2); (c)Presentation in Sagae city hall.

3.2 Eco-House in Tobishima Island(2014)

Tobishima is only one of remote manned island in Yamagata Prefecture. The area of an island measures 2.7km^2. Population is about 200 persons. An elderly ratio is about 67%. Although the industries are fishing and sightseeing, the industries should be more activated for sustaining the living in the island. By holding the preliminary meeting with staff of the city it was recognized that social of the island have required interesting events which can attract tourists from mainland. The teachers of this subject decided as main theme in Tobishima “the making eco-house” which is the energy self-support type engineering designs using the natural power sources peculiar to the island. In the future, this activity would support the island sustaining the people’s life even if the life-line is broken by a large scale natural disaster. The site of training camp was kindly offered from city staff

to use the gymnasium of elementary and junior high schools in island. At the beginning of the camp the students recognized clearly what kind of engineering design is useful for the residents of the island. Features of environment in Tobishima are warm climate and there are many fine days. Solar energy seems to be utilized. Since there are also much driftwoods on the sea side and thinner timbers in woods, a woody fuel is abundant. Therefore, the handmade solar cooker, the rocket heater by burning drift woods, fresh water generation system from sea water, and so on were proposed from the students.

Table 4 Contents of activity from respective groups(Tobishima Island)

group	contents
group 1	solar cooker
group 2	the rocket heater using drift woods
group 3	vacuum pump for vacuum preservation of the food
group 4	system of making fresh water and natural salt by distilling sea water by burning drift woods
group 5	system of making fresh water generation by evaporating sea water using direct sunlight

Since public transport in the island was poor, the school car was carried for convenience. Meal was prepared by themselves borrowing the galley in the school. The students resided in the gymnasium except outdoor activity. During the camp period, the lecture meetings same as *Sagae city park project* were held at the camp site(Fig. 5 a-c).

Fig. 5 Examples of camp activity scenes
(a)Movement of a school car by the ship; (b)Cooking for meal; (c)Site in gymnasium of elementary and junior high schools; (d)Lecture meeting in the camp site

For example, details of groups 1 and 2 are as follows:
group1 Beginning of making solar cooker, students recognized that the commercial one is expensive and large weight. Therefore it was turned out that low cost and lightweight cooker would be convenient. The students tried to make the solar cooker by using familiar materials such as aluminum foils and the umbrella(Fig. 6). As a result of experiments, they found out that temperatures at the points at light concentrates rose to 65℃ when the outside air temperature of 29℃. However, it was not able to reach a temperature rise to the more high temperature. In order to attain the further temperature rise, improvements such as increasing in area of an umbrella and smoothing of irregularity of the surface of aluminum foils should be conducted. In addition, the fixing instruments that make the cooker not blown away by a wind were required.

Fig. 6 Demonstration of solar cooker manufactured

group 2 A rocket heater is heating apparatus which burns the combustion gas emitted from burning woods. Combustion gas burns in a hot furnace and generate heat air(Fig. 7). The stack chimney draft was attached so that the combustion gas may not flow backwards. The body of the heater was manufactured by using the discarded metal container. By burning the driftwoods, the bottom temperatures of the oil in the pan on the furnace reached around at 250℃, and the exhaust gas temperature was about at 56℃. It was turn out that a high temperature required for cooking or heating can be realized by using this system. In order to improve the durability, metal at main body should be high heat resisting property.

(a) (b)

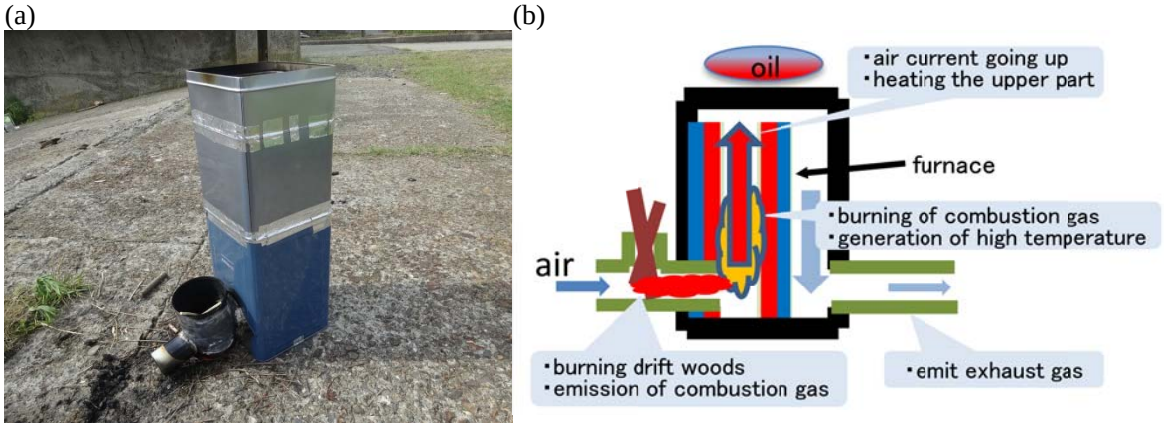

Fig. 7 Rocket heater (a) Outside view of heater, (b) Mechanism of heating

The debrief session for the citizens about results obtained from this activity was held at "Environmental fair in Tsuruoka 2014" as large environmental event in the city held on September 21, 2014 in the city gymnasium. Students presented in form of poster and exhibiting the manufacture products(Fig. 8).

Fig. 8 Debrief session in "Environmental fair in Tsuruoka 2014"

After the practice of the program in Tobishima island, the questionnaires for the students about this program were conducted in order to investigate the change of a student's consciousness. The self-evaluation, how are the degree of achievement for students in his own consciousness and capability at before and after the program were conducted. The questionnaires were carried out to all the 24 students who participated in this program, and received the reply from all the members. Question items are 1. motivation to the activity, 2. contribution to local community, 3. problem solving capability, 4. responsibility, 5. cooperation and communication in group, and 6. confidence. Each of items were evaluated by marking numbers from 1(weak) to 5(strong), and all scores were averaged(Fig. 9). As shown in the figure, it seems that the students themselves realized the progress in the all items, especially in motivation to the activity, contribution to local community, and cooperation and communication in group. Although completeness of manufacture products was low and there is also much problem, the students realized the fulfillment and responsibility throughout this practice.

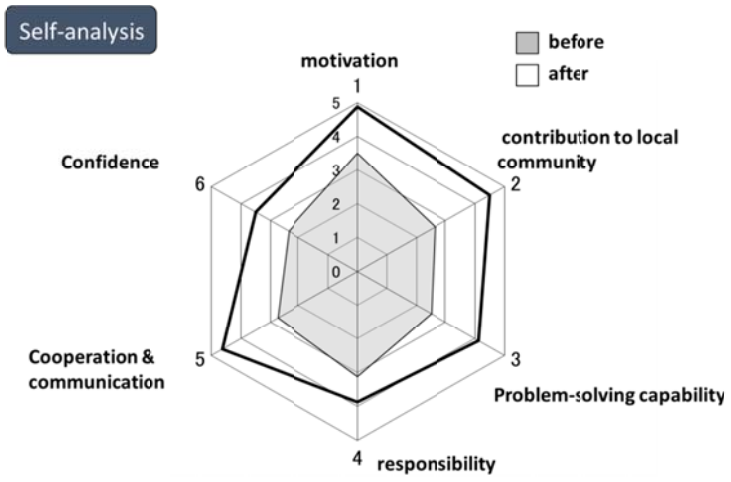

Fig. 9 Results of self-analysis by students before and after the program

4. Conclusion

Contribution for local type PBL education program for student in advanced course in NCT, Tsuruoka college has been developed and carried out from 2012. This program includes three of unique policies; 1) Cooperation with local community type education, 2) Subject crossing type group activities, 3) Training camp activities. Throughout activities in Sagae city or Tobishima island, the students realized the fulfillment and responsibility to tackle the engineering problems in local area, which make the students engineer possessing elements of engineering design ability.

Acknowledgments

The authors would like to thank official staffs of Sagae city and Tobishima island in Sakata city for their supports in activities and helpful discussions.

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Product and Service Safety Schemes of New Zealand

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New Zealand has two key laws which deal with product safety, the Consumer Guarantees Act and the Fair Trading Act. In 2007 the Government issued a government product safety policy statement to complement the Consumer Guarantees Act. The Consumer Guarantees Act is a general consumer protection law which gives minimum standards of quality for goods and services. The Fair Trading Act is designed (among other things) to promote product safety and to prevent injuries. In relation to product safety, the Fair Trading Act allows the government to: recommend the introduction of product safety standards; declare goods to be unsafe (a product ban); and order a compulsory recall. Customs Service can also enforce safety provisions, under the Customs Act. There are many ministries and government agencies involved in safety of all the four phases of products (production, distribution, usage and disposal). Service component is also included. Government action will generally be taken by the agency that has the lead interest in the class of product, supported by other relevant agencies. Industry sector associations and the NZ Retailers Association play an active role in promoting self-regulation. Maintaining food safety standards and managing recall risk are two increasingly pressing issues for New Zealand companies.

1. Product safety laws

New Zealand has two key laws which deal with product safety, the Consumer Guarantees Act and the Fair Trading Act.[1,2] Consumer Guarantees Act (CGA) gives consumers certain guarantees when they purchase goods and services. The Act puts responsibilities on retailers and manufacturers/importers and sets out rights and remedies consumers can claim if these guarantees are not met. The guarantees apply to goods (new and second-hand) and services which are purchased for household use. Excluded from the Act are goods and services that are supplied for business use and goods supplied by auction. Relevant to product safety are the guarantees contained within the Act that goods sold are of 'acceptable quality'. Goods that are unsafe are said to be of 'substantial failure' and the consumer has the right to reject the goods.

A government product safety policy statement is designed to complement the Consumer Guarantees Act by making it clear to manufacturers and importers what is considered 'acceptable quality' and 'fit for purpose' under the Act. In 2007 the Government issued a government product safety policy statement that clarified acceptable levels of formaldehyde in clothing.

The Government has revised consumer laws to help consumers transact with confidence and to support honest business practices. The law changes were included in the Consumer Law Reform Bill.[3] In December 2013 the Consumer Law Reform Bill went through the final legislative processes and received Royal Assent.

Avoiding product liability is a stronger incentive in jurisdictions where suppliers and manufacturers are liable for personal injury or liability for other damages. Reputational damage in the market place from high profile cases where goods are found to be unsafe probably has a higher commercial impact than an award of damages by a Disputes Tribunal or other court.

Unlike the statutory guarantee that goods of an acceptable quality should be safe, the statutory guarantees in relation to services do not expressly refer to services being safe. The safety requirement is probably implicit in the guarantees that services are carried out with reasonable care and skill and that the services are fit for particular purpose. If consumers suffer physical damage or loss as a result of services being provided which are not safe, then the services are unlikely to have been provided with reasonable care and skill, or to have been fit for purpose.

Breaches of the Consumer Guarantees Act are only actionable at the suit of consumers in the civil courts. Consumers are unlikely to be motivated to take on cases in relation to the lower-priced goods which are frequently the subject of product safety concerns. Breaches of the Consumer Guarantees Act are not offences enforceable by the Commerce Commission (or any other public agency).

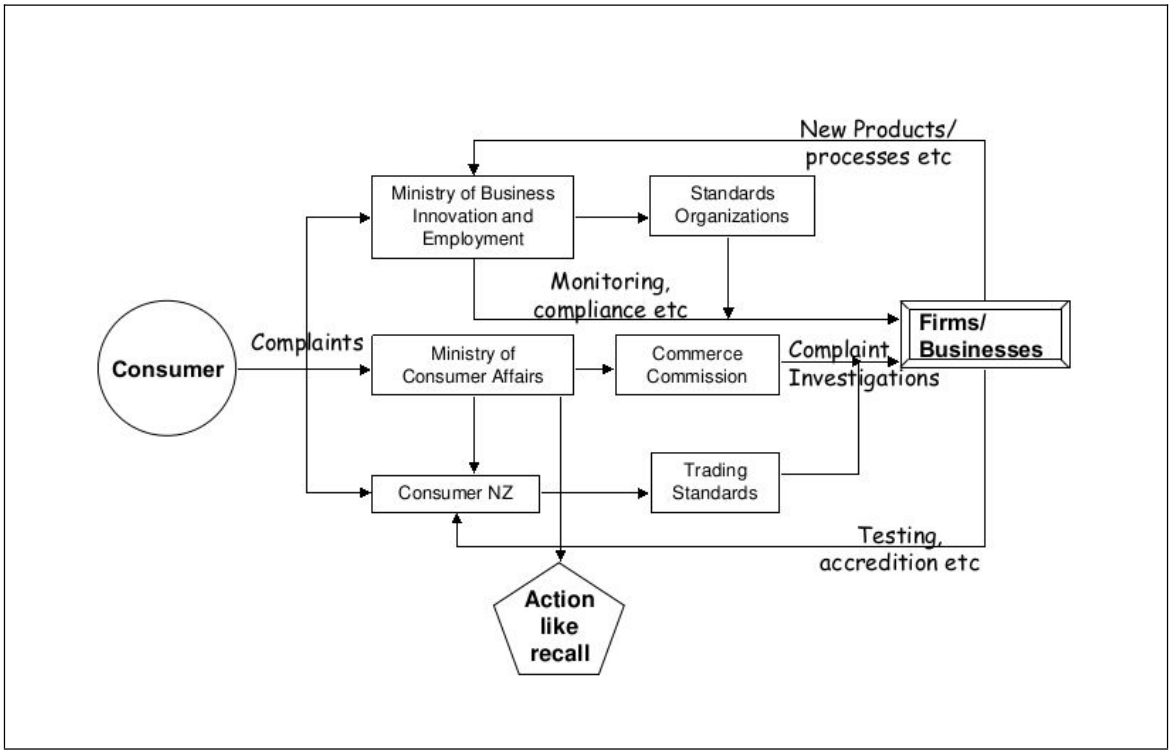
Fair Trading Act 1986 includes provisions dealing with product safety (Part III) and the safety of services (Part IV). The features of these provisions of the Fair Trading Act include: Regulations may be made establishing product or service safety standards for the purpose of preventing or reducing the risk of injury to any person (sections 29 and 35).

In relation to product safety, Part 3 of the Fair Trading Act 1986 provides the Minister of Consumer Affairs with the power to ban products, set standards through regulation and order compulsory recalls. The Consumer Guarantees Act 1993 also provides a guarantee that consumer goods are safe. The FTA is administered by the Ministry of Business Innovation and Employment (MBIE) and enforced by New Zealand Customs Services and by the Commerce Commission post importation. These provisions cover all consumer products with the exception of food, gas and electrical products, motor vehicles and cosmetics that are regulated by other agencies under product specific legislation.[4]

Anyone buying goods or services in New Zealand is protected by consumer laws. Fair Trading Act makes it illegal for businesses to mislead consumers, give false information, or use unfair trading practices. It applies to anyone in trade - from big players like hotel chains, airlines and department stores, to small or temporary businesses like a souvenir stall or ice cream stand. Under this Act, goods must be fit for their normal purpose, safe, durable, have no minor defects and be acceptable for safe use.

Different government departments and agencies and public organizations implementing Product safety schemes and handling complaints are presented in figure 1 below.

Figure 1: Different Players Involved in Product Safety Schemes



2. Product safety standards

The Product safety standards may relate to: the performance, composition, contents, manufacture, processing, design, construction, finish or packaging of goods; the testing of the goods during or after manufacture or processing; and the form and content of markings, warnings, or instructions to accompany the goods.[5]

Service safety standards may relate to: the maintenance, repair, treatment, processing, installation, assembly, cleaning or alteration of goods; the construction, maintenance, repair, cleaning or alteration of any building or other fixture on land; and the development of land.

There are six current regulated product safety standards in New Zealand. There are no regulations for service safety standards. The product safety system in New Zealand is generally consistent with the Australian system under their Trade Practices Act.

Trading Standards investigates complaints about consumer products that are not subject to mandatory product safety standards (this is done by the Commerce Commission), or otherwise covered by other regulations (e.g. food, medicines). Trading Standards also monitors voluntary compliance with national standards where there's information that there may be the potential for injury but the need for formal government intervention has not yet been established. When an investigation concludes that critical safety requirements are not being met, the Ministry assesses whether the powers of the Fair Trading Act are required, depending on the potential injury risk involved, and the ability and or willingness of the suppliers to voluntarily self-regulate.

Ministry of Business Innovation and Employment, draws on consumer complaints, market place sampling/testing and data and intelligence sourced from other organizations within New

Zealand and overseas. The Minister is able to take action that ranges from interim bans of a product through to permanent regulations. The basis for the majority of these provisions are published standards. The preference is for New Zealand or joint Australia/New Zealand standards, the majority of which directly relate to the equivalent ISO standards.

3. Unsafe goods notice and product bans

The Minister of Consumer Affairs has the power to stop the sale of goods by declaring them to be 'unsafe goods'. A ban stays in force for 18 months, unless withdrawn earlier. At this point it can be imposed indefinitely or for a further specified time. There are unsafe goods notices for: lead in children's toys; hot water bottles; candles with lead in the wicks and candlewicks containing lead; and pistol crossbows. The Commerce Commission investigates complaints about products that have a product safety standard or have an unsafe goods notice attached to them.

The Minister of Consumer Affairs can order a compulsory product recall where goods being sold do not comply with a product safety standard; or are of a kind which will or may cause injury and the supplier has not recalled the goods or taken good enough action to recall the goods. New Zealand does not require notification of voluntary recalls, but Trading Standards does offer assistance to companies undertaking a recall.

4. Food safety - Food Act 2014

Food safety has many ingredients. Robust biological science has been developed on food hazards. Supply chain integrity is another. Companies must have supply chain traceability that is real, comprehensive and action-able. If food or food ingredients are contaminated, it is just as important to know the source and current location of the items and substances in question as it is to know the biological facts of the contamination.

The news in August 2013 of potential Clostridium botulinum contamination was bad for New Zealand, which prided itself on exporting food of the highest quality. The 38 tonnes of the Whey Protein Concentrate (WPC) in dairy export supply chain fell under suspicion of contamination. The inquiry concluded that the regulatory framework was fundamentally sound, but recommended improvements. Underlying many of these was the idea that the dairy industry must anticipate future risks as well as counter existing known threats. The Inquiry also observed that, if Fonterra had possessed a strong food safety culture, this incident would probably not have happened.[6]

Scores of consumers were made sick during October 2014 after eating supermarket-bought fresh vegetables contaminated with the bacteria, Yersinia.[7] The Ministry for Primary Industries is refusing to confirm carrots and lettuces as the source of a stomach bug that's hit more than 100 people and put 38 in hospital. But in both above cases, existing traceability systems were found wanting.

Demand for product recall has increased significantly over recent years as consumer awareness increases, legislative requirements become more stringent, supply chains more complex and contractual conditions more onerous. The impact of a product recall event has the potential to cause severe damage to a company's brand reputation and survival. Maintaining food safety standards and managing recall risk are two increasingly pressing issues for New Zealand companies. But while product recalls are becoming larger and more frequent, most food and beverage companies are unaware of the magnitude of their recall risk.

Food Standards Australia New Zealand (FSANZ) has established a rigorous and transparent process for assessing the safety of GM foods. The responsibility for demonstrating the safety of any new food product on the market lies with the developer of that product. This is also the case for new chemicals and drugs.

5. Regulatory authorities

Consumer NZ moves from testing products to testing businesses with new accreditation scheme. Consumer NZ, the non-profit organization started in 1959, delve into the quality of products and services and investigate consumer issues, and has launched a scheme called Consumer Trusted to enhance that. Consumer Trusted is based on a Code of Conduct for the accredited business, which includes the right to exchange or return for a full refund a non-perishable product within 30 days of purchase; no bond charge for returning faulty goods; refunds for products worth over $100 that go on sale within a week of purchase; and advisers to help customers of the accredited business. [8]

Medsafe is the New Zealand Medicines and Medical Devices Safety Authority. WorkSafe NZ is New Zealand's workplace health and safety regulator. Biosecurity New Zealand is a division of Ministry of Agriculture and Forestry charged with leadership of the New Zealand biosecurity system. It encompasses facilitating international trade, protecting the health of New Zealanders and ensuring the welfare of environment, flora and fauna and marine life.

Environmental Risk Management Authority (ERMA) is to safeguard people and the environment by regulating the introduction and use of hazardous substances and new organisms under the Hazardous Substances and New Organisms (HSNO) Act. ERMA regulates the importation, development and use of plants, animals and other new organisms including genetically modified organisms.

New Zealand Transport Agency (NZTA) contributes to an integrated, safe, responsive and sustainable land transport system, in support of the updated New Zealand Transport Strategy.

Many industry sector associations and the NZ Retailers Association play an active role in promoting self-regulation. They are involved in the development of industry codes of practice, provision to business of advice on suppliers' responsibilities under the Consumer Guarantees Act, and the development of national standards through participation on standards technical committees.

6. Insurance Schemes [9]

The Accident Compensation Corporation (ACC) is responsible for administering the country's universal no-fault accidental injury scheme. The scheme provides financial compensation and support to citizens, residents, and temporary visitors who have suffered personal injuries. ACC was based on an insurance model that provided cover for all, regardless of fault or cause of injury.

All New Zealanders and visitors to New Zealand who get injured can apply for help from ACC. It does not discriminate what caused the accident and where the injury happened at work, during sport or recreation, at home or on the road. ACC can also help a New Zealander returning from overseas with an injury, as long as the victim is a permanent resident, and have not been away for more than six months. Because of the wide range of help available from ACC after an injury, victims cannot sue for personal injury in New Zealand, except for exemplary damages.

This scheme will also cover accidents due to use of unsafe products and services. In a way it helps manufacturers and suppliers of unsafe products and services from heavy legal and insurance liabilities. Suppliers and manufacturers are for practical purposes exempt from liability for physical

injury to consumers and any third parties under the Accident Compensation scheme. Unsafe products and services, in addition to causing harm and distress to individuals, it can have an impact on costs to the government health budget and to the Accident Compensation Corporation.

ACC manages about 1.6 million injury claims each year and collect as much information about those injuries as possible. These data are used to measure the safety issues with product and services.

Whilst ACC provides cover for most accidents at work, employees can still sue for work-related illnesses that the ACC does not cover, including: ✦ Mental injury or stress not accompanied by any physical injury; Nervous shock or fright not accompanied by any physical injury (this may result in serious illness, such as heart attack or stroke); and Disease brought on over time (eg exposure to the elements or extremes of temperature).

So, insurance firms such as Zurich NZ is trying to sell Employers Liability Insurance. Zurich's policy covers damages and legal costs for employees who have suffered injury or disease arising from, and in the course of, their employment.

Zurich's product safety and recall insurance provides a combination of recall planning and preparation advice, broad coverage plus post-loss consultancy to help minimize damage to the brand and the balance sheet. In response to this problem, AIG created NOVI, a free and confidential service that enables businesses to better understand their product recall risk exposure by estimating the probable maximum loss from a recall event.

7. Conclusion

The most fundamental issue which faces any product safety system is that regulations can only have a reactive role because the range of goods and services available to consumers is too great for a regulator to sensibly monitor or test for safety compliance. It can only react to particular problems which arise. New and emerging product safety risks and concerns challenge the reactive model. Increasingly risks and issues are being raised around chemicals and new technologies where risks are virtually impossible to determine. Many small businesses lack the capacity to test products, and/or do not consider testing for product safety before they supply goods, which means potentially unsafe goods get on to the market un-checked.

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A Practice of Engineering Design Education through the Development of Educational Materials using LEGO-Mindstorms

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Recently, cross-sectional education is required for cultivating of engineers who can be active in multiple fields in addition to the professional expertise and skill attached importance in conventional engineer education. This paper presents an example of practice of an Engineering Design Exercise (EDE) that is one of cross-sectional education subjects in National Institute of Technology, Nagaoka College (NITNC). The design theme of the EDE in last academic year (2014) was set to "development of educational material, using the LEGO-mindstorms for measurements and control with programing", which is one of learning contents for technology and home economics classes of junior high school. It was received over 90% positive feedback from a result of questionnaire concerning the EDE by the students and the junior high school teachers. The students probably could aware the importance of teamwork, facilitation skill, and cross-sectional ability. Although there are some mismatch between actual and supposition using the materials, the quality and students effort were very highly appreciated by the junior high school teachers. From these results, we conclude that the EDE in NITNC could achieve a certain result as a cross-sectional education.

1. Introduction

Recently, cross-sectional education is required for cultivation of engineers who can be active in multiple fields, in addition to the professional expertise and skill. However, there are several suggestions about that Japanese engineering educational system is not enough especially for Engineering Design Education. Although Engineering Design Education is multiply defined, it is classified to an Active Learning (AL) that enhances followed three skills,

(1) Designing skill…Solving skill of society problem with technologies, information and so on.

(2) Accomplishing skill…A skill for accomplishing a task under some restrictions.

(3)Activity skill in a team…Performing skill of tasks as a team or a team member.

Project Based Learning (PBL) is one of effective method to enhance these engineering design skills and the way for problem solving. It had been reported that many attempt of the PBL with regional cooperation, but most of them are focused on a relation with companies and societies. [1][2][3] This report presents an example of practice of an Engineering Design Exercise (EDE) that is one of project based and cross-sectional education subjects in National Institute of Technology, Nagaoka College (NITNC). The EDE has started in 2013 for advanced course students in NITNC and it has performed as not only the engineer cultivating, also regional cooperation such as awareness campaign for science in Nigata prefecture. Last academic year, we succeeded to cooperate with local junior high school teachers about for carrying out the EDE subject in NITNC.

2. Outline of Engineering Design Exercise in NITNC

The EDE has been offered a part of experimental subject called "Advanced Experiment". This subject is arranged in first half of fiscal year of advanced course in NITNC since 2013. Table 1 shows the time schedule of the EDE in 2014. The EDE was conducted for 15 weeks and the contents are

mainly included the following three objectives:

(1) Learning facilitation skill (Week 1 and 2)

Participated students start to learn facilitation skill such as importance of ice break, consensus building methods that needed for the group work and PBL. All students attending the EDE were divided into eight groups after leaning lecture of the facilitation skill. Each group consists of four or five students who have graduated from different departments of NITNC. Then, in case of the previous year, two group work using a multiple axis robot arm and LEGO-Mindstorms were conducted as the ice-break. Fig.1(a)(b) shows the photograph of the ice break with LEGO-Mindstoms and a practice of consensus building using "Matrix method".

(2)Learning PDCA cycle (Week 2)

After the ice break, the students learn a method for completing tasks by PDCA cycle which based on a scheduling sheets and daily reports. The scheduling sheets and the daily reports are prepared by each group. And subject teacher, in charge of the group, checks the progress situation and evaluates achievement in practicing of the PDCA. Fig.2 shows an example of scheduling sheet after finishing the PDCA. The scheduling sheets are revised multiple times based on the progress.

(3)Exercise of PDCA (Week 3-15)

From Week 3, the students start the practicing of the PDCA based on designed theme. The design theme in 2014 was set to "development of educational material, using the LEGO-Mindstorms for measurements and control with programing", which is one of learning contents for technology and home economics classes of junior high school. Planning presentation and final presentation were organized while the PDCA term. The students make a presentation about the research result of market and competitive products, and formed concepts of educational materials using the LEGO-Mindstorms in planning presentation. Furthermore, they make again a presentation of developed materials with demonstration in the final presentation. An actual junior high school teachers were invited the final presentation as an evaluator of developed materials. The invited teachers participated a technical seminar of LEGO-Mindstorms before the final presentation.

Table 1 Time schedule and contents of the EDE in 2014

Week	Contents
1	Guidance, grouping and ice break 1, engineering facilitation
2	Consensus-building, ice break 2
3	Process of planning, explanation of design theme, present state analysis, forming a concept
4	Presentation about the present state
5	Planning, making a time schedule sheet
6	Preparing the planning presentation
7	Planning presentation
8	Practicing based on PDCA cycle
9	Practicing based on PDCA cycle
10	Design review
11	Practicing based on PDCA cycle
12	Practicing based on PDCA cycle
13	Final test, mounting the work products, evaluation
14	Preparing a final presentation
15	Final presentation

(a) Ice break

(b) Practicing of consensus building

Fig.1 Photograph of the lecture part of the EDE

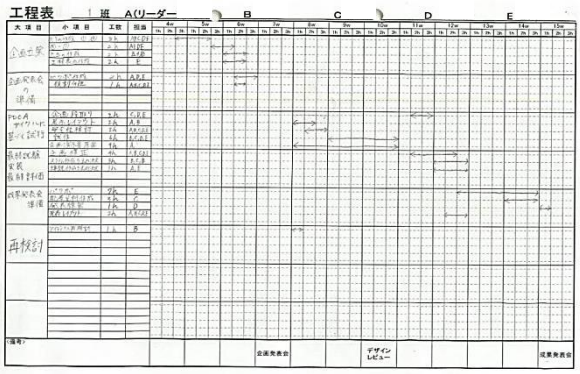


Fig.2 Example of the scheduling sheet

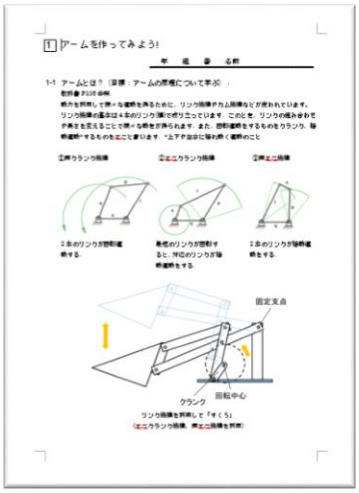
3. Developed educational materials

The students started to develop the material from Week 8. Table 2 shows the title and keywords of developed educational materials by eight groups. These materials are reviewed by each students group in the design review which held in Week 10, and they discussed about the material concept, developing approach, developing schedule. Then, students tried to make an educational material that including the textbook for teachers and junior high school students, teaching plan, evaluation method, sample programs, and assembled machine with LEGO-Mindstorms. Fig.3 shows an example of developed materials by group 8. The final presentation is organized at final time of the EDE and the students made a poster presentation and conducted the demonstration of developed material to the evaluators. Finally, best material was selected by a vote on the final presentation with seal by junior high school teachers, subject teachers of NITNC and all participated students and staff of NITNC.

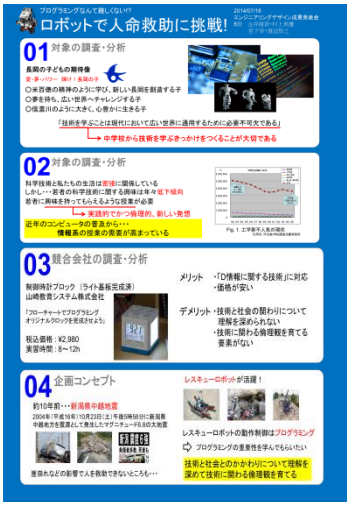
Table 2 Title name of developed materials and the keywords

Group	1	2	3	4	5	6	7	8
Material title	Easy, Simple Mindstorms	Learn with pleasure Measurement and Control	Simple lecture	Be a LEGO Master!!	LEGO-Drive	LEGO is Easy !	Let's drive rise reaping machine with line tracing!	Programing is not difficult. Let's challenge the life-saving by robot!
Key-words	Simplicty, Groupwork, Easy understanding	Measurement and Control	Maze, Group study	Reduction of incidence, Group work, Enjoy	Enjoy, Study, Creativity	Rice planting, Easy, Teamwork	Culture of Nagaoka, Discussions, Support	Rescure robot, Groupwork, Programing

(a) Assembled machine



(b) Textbook



(c) Concept poster

Fig.3 Example of developed materials

4. Results of questionnaire

After final presentation, questionnaires were carried out for participated junior high school teachers and the students that regarding to the content and the approaching method of the EDE. Fig.4 shows the result of the questionnaire for the students that asked about difficulty level of the design theme. Most students answered the difficulty level was difficult or very difficult. This reason is considered that there is no clearly answer of the design theme about developing educational material. Fig.5 shows the result of the students' outcomes through the EDE. The students probably could aware the importance of teamwork, facilitation skill, and cross-sectional ability after the EDE.

Fig.6 shows the result of the questionnaire for junior high school teachers and it was received over 90% positive feedbacks. Although there are some mismatches between actual and supposition using the materials, the quality and student's effort were very highly appreciated by the junior high school teachers. From these results, the EDE in NITNC could achieve a certain result as a cross-sectional education and an approach as regional cooperation.

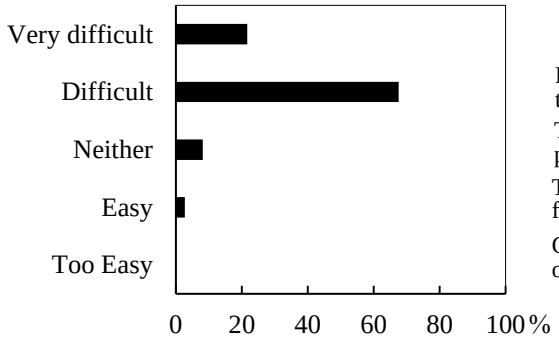


Fig. 4 Result of the questionnaire of participated students which asked about the difficulty level of the design theme

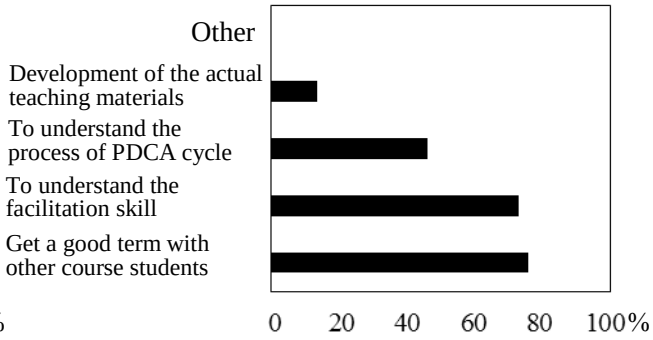


Fig. 5 Result of the questionnaire of participated students which asked about the outcomes through the EDE (Multiple answered allowed)

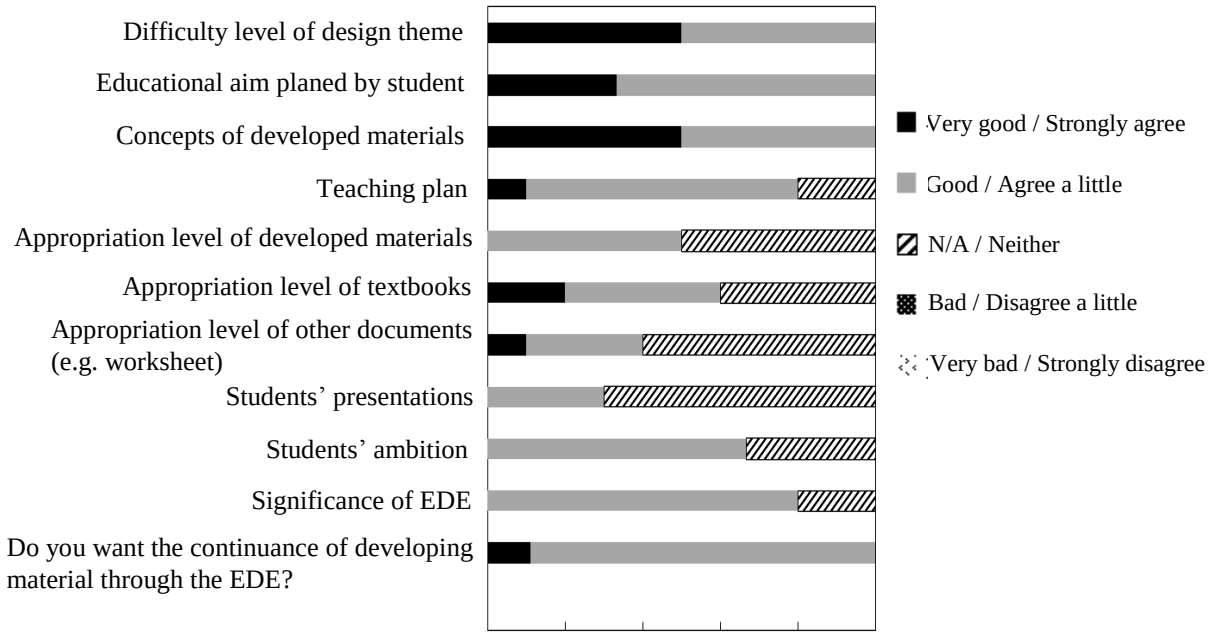


Fig. 6 Result of the questionnaire of participated junior high school teachers which asked about the contents of the EDE

5. Discussion

NITNC has started the EDE since 2013. Hence, the design theme using the LEGO-Mindstorms is second attempt for the EDE at the college. A design theme of first EDE in NITNC was "development of an experiment material for Younger's Science Festival". After finishing the first EDE, typical voices were received from participated students and teachers as followed:

(1) There was enough leeway about the theme. (Positive)
(2) Learning the facilitation skill was new experience and very nice. (Positive)
(2) Quality improvement of the developed material is necessary. (Negative)
(4) The level of the design theme was easy. (Negative)

It was seemed that the participators of the first EDE have felt satisfactions about the learning contents, and dissatisfactions about the design theme. In addition, it was very difficult to receive the feedbacks about the work products from third party such as users of developed materials. On the other hand, in case of the reported design theme, it was seemed that the difficulty level of design theme was improved and the evaluation of outcomes of the EDE become easy because of questionnaire from participated junior high school teachers.

6. Conclusion

This report presented the case study of the cross-sectional education in NITNC. In order to good efficiency education for enhancing the engineering design skill, the EDE has conducted as the AL and PBL type subject since 2013 in NITNC. It was succeeded to make the cooperation with local junior high school teacher through the EDE in last academic year because of the design theme which focused on the subject of junior high school. The design theme, "development of educational material, using the LEGO-Mindstorms for measurements and control with programing", was a little difficult for the students because unaccustomed experience. However, participated students could feel and understand the importance of the facilitation skill for completing group work and many tasks based on the PDCA cycle by the team. It is concluded from these results that the EDE is going to be continued as a cross-sectional education in NITNC with revising the contents.

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