# Project BEE: Concept and Model for Service Learning in Engineering

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**Abstract**

Project BEE-Creativity Station' is the creative convergence design education which involves engineering services based on different majors. The basic structure of service learning is divided into five parts based on topics with 29 detail missions. Participants should find problem and define solving issue to serve in local site. Students can refer to the schedule book to get information about various missions each project requires. Each team found out the most crucial issue of TMB village and defined the problem by themselves. The main issues are rubbish problem, no air circulation, insect problem, drying up the rice residue, drying up clothes in the rainy season and drainage. Through this project, 10 teams made 10 items related with trash, clothes dryer, rice dryer, temperature and sewer cover for engineering service and installed successfully. All participants increased the program outcomes like as global capability, technology appliance, interpersonal skill, synthetic thinking, communication skill and self-management capability.

*Keywords:* Project BEE, Creativity Station, engineering service learning, program outcomes, basic job ability,  Teaching Manual, ABET, ABEEK;

## 1. Introduction

BEE represents 'Beyond Engineering Education'. Project BEE is designed for those who want to serve others through engineering (Seo et al., 2013). 'Creativity Station' is the creative convergence design education which involves engineering services based on different majors. To maximize its effects, we need to train the participating students beforehand in the areas of 'creativeness', 'writing for engineers', 'speaking for engineers', 'understanding local culture', and etc.

Since 2009, we have had four projects of engineering services in Surabaya, Indonesia; the first, 'contest for engineering service learning' (Choi et al., 2011): the second, 'design project for engineering services' (Seo et al., 2012): the third, 'design academy for engineering services' (Seo et al., 2013): the fourth, 'engineering service consulting'. With the experiences gained, we successfully finished the 'Creativity Station', technology-based creative convergence program, in January 2013, designed for college students from 13 universities in Southeastern Korea, EEPIS in Indonesia and UTM in Malaysia. The main spirit of the program remains the same in that the students from the different countries team up in an international convergence capstone to help the local community. That is to say, the main focus of the program is still on 'engineering', 'service', and 'education'. A little modification has been applied, though, to the way program is operated.

To systemize the learning process and its effects, we made the student guidebook and distributed it to the students. Through surveys done before and after the project, we could prove the effectiveness of the student guidebook. The success of a program requires guiding the students well. Since one leader is not enough to do the job perfectly, we need to appoint several managers to take charge of each team. When organizing a project, we could design it in such a way that merely following the program protocol leads to the desired educational goals. An alternative is that we induce the desired achievements in various ways by having only the rough outline of the program and by encouraging the students to be autonomous in their judgments and actions. Roles are divided here. To plan the program well is up to the planners. To support the students well is the job of the managers. And the participating students are the ones who actually achieve the desired goals. Another reason for the need of a teaching manual might be found when we want to carry out our project in another college or institution. Setting up the program schedule is relatively simple; you can refer to various materials. However, mere reference to other materials is not enough to assure the transfer of the accumulated knowhow, and cannot guarantee desired educational effects accordingly. With our hands-on experience, we can help others not to go through the same trials and errors. Their saved energy could be directed toward creating more similar programs with the same objective. If more and more universities operate similar programs, we may exchange students to share experiences.

Furthermore, we hope to organize an academic society in which a lot of people gather on a yearly basis to share experiences of engineering services, achievements and knowledge. We presented a concept of service learning of project BEE which is comprised in five detail projects at Section II. Basic structure of Project BEE is introduced at Section III. We introduced the student activities in Creativity Station 2013 in Indonesia at Section IV. In Section V, the achievements of program outcome for

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the whole program was analyzed according to ABET. Finally, some conclusion and remarks was depicted in order to enhance the given project.

## 2. Concept of service learning

This project is divided into five parts based on topics. 'Project 1.0: Make the best team' is aimed at making the best teams which can serve as the foundation of the whole project. A lot of things are taken into account before we separate the participants into teams. For optimal team organization, we consider many aspects including students' majors, talents, and even personality types. In 'Project 2.0: Look at problems from different viewpoint', we train students to be able to look at problems from different perspectives through various learning processes including creative invention method, design, and engineering writing. They will learn by experience how to approach a problem differently, rather than be merely taught how to come up with a pre-determined solution to each given problem. In 'Project 3.0: Solve local problems', we help solve the problems local residents are facing. The process includes 'deriving a new idea', 'product design', 'purchasing materials', 'making of products', 'writing instruction manuals for products', and 'installment of products'. 'Project 4.0: Be one with the local community' is focused on effective communication. To cooperate with the local community in an organic way, it is absolutely necessary to let the locals know who you are and why you are there in the community. Lastly, 'Project 5.0: Organize ideas and share them' helps the students evaluate their own products, organize and share ideas so that follow-up projects of the kind can continue in the future.

'Giving stamps' is one of the most important elements necessary for completing the missions specified in the manual. Every mission has a goal. If an assigned mission is completed, stamps are given as rewards. Stamps are given as reward for completion of concrete missions, such as 'idea development' and 'product making'. 'Giving stamps' is also effective for making participants keep the set schedule, such as 'daily meeting', and 'journal writing'; they will try not to be late to get stamps. And the project can proceed on schedule. For long-term team missions, each team is responsible for time allotment. The organizer only checks the given assignments on a regular basis. The intended goal is to hold the students accountable for the process as well as the results of each task. As the project proceeds, students will get conscious of the importance of teamwork more and more, since penalties are given to a team in case of any absence or failure of their members. This will help improve the entire performance of the project, not to mention enhance teamwork. Managers may advise their teams to acquire all the stamps allotted for each mission. So if their team members fully utilize the given time and meet all the criteria for getting stamps, managers give their signature. 'Stamps' divide the roles between staff members and managers. Managers are interested in improving performance of the project. Staff members, on the other hand, focus on smooth operation of the whole project. Sometimes, there comes a situation where there is a conflict between going for better performance and keeping the schedule. If that kind of situation arises, the schedule always takes precedence, because resources are limited in terms of time, human resources, and budget. In this case, staff members are authorized to give out stamps to facilitate the process.

Each part of the teaching manual is organized in the following order: outline, time, questions, objective, Materials, preparation, education, and key points.
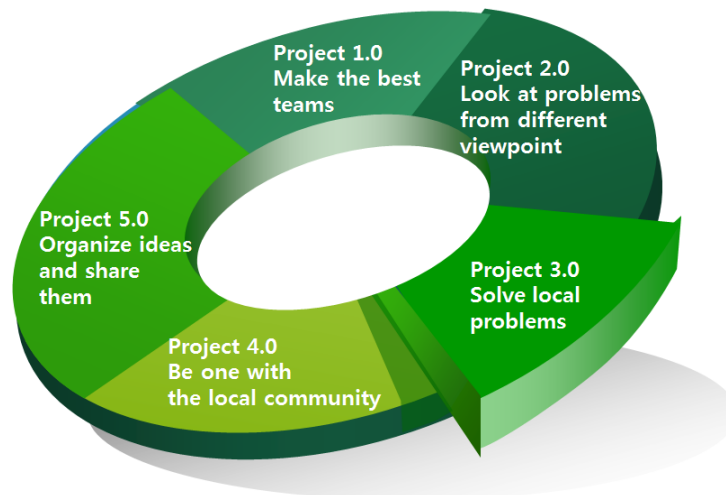


Figure 1. Basic Structure of service learning model

- 'Outline' contains introduction, objective and rough explanation of the mission.
- 'Time' indicates the total time required for the completion of each mission. It may be adjusted according to the total schedule.
- 'Questions' are the things to be asked of the students before the mission starts. Questions are used to arouse interest and curiosity of the students.
- 'Objective' shows the goals to be reached through a mission at minimum requirements. Students need to be fully aware of the given environment to meet this.

- 'Materials' identifies the materials needed for the completion of the given mission, and should be prepared before each mission starts.

- 'Preparation' is what managers are required to know before they start education.

- 'Education' is listed in the time order, and deals with the things to be covered for mission completion. In a certain stage, tips or references are attached to help with education

- 'Mission' describes the mission assigned to the students in the student guidebook. It also describes the rules for stamp-giving.

- 'Assignment' is given to each individual student. They need to do that after completing a mission.

- 'Key points' are the things which require special attention in the course of 'education'. Managers can assess the educational effects based on these questions.

- 'References' are the things to be referred to during the mission or related to the things having been covered though previous activities.

Participants are provided with the schedule book and the guidebook. They can refer to the schedule book to get information about various missions each project requires. The guidebook shows the students various assignments. The teaching manual provides additional explanation and will help the students understand the guidebook better. 'Learning by experience' is the key in this project. Therefore, we cannot emphasize too much the importance of full utilization of the student guidebook and the teaching manual.

## 3. Model of service learning

Whole contents of teaching manual are consist of 29 detail missions in Table 1. The duration for project work and division of time for five stages are also denoted. All missions are described in detail how to educate participants in viewpoint of manager. Especially, several missions from finding local issues to installing products should have to follow the mission flow chart in Figure 2. Some materials may not be available on the market against expectations. In this case, the students in charge of the purchase need to find the alternatives in a short time. The team which has failed the buy all materials can go back to product design only one time. That is to say, they cannot go backward and start from a different idea they thought of and continue on with designing, making purchases, and producing after this stage. Students should have to get the permission first from the owner of the building before installation. They can show the owner the product instruction written in the local language. When the installation is complete, they should check for operation and stability of the product. If anything goes awry, don't delay remedial action. Correct the trouble spots immediately as they appear to prevent future problems.

Table 1. Contents of teaching manual

| Chapter | Content | | Time (hr.) |
|---|---|---|---|
| Project 1.0 Make the best teams | • Personality test | | 1 |
| | • Placement of team members | | 1 |
| | • Team building | | 2 |
| | • Teamwork game | | 3 |
| Project 2.0 Look at problems from different viewpoint | • Creative invention method | | 1 |
| | • Design education | | 1 |
| | • Academic engineering | | 1 |
| | • Safety education | | 1 |
| | • Language education | | 4 |
| | • Balloon art | | 2 |
| Project 3.0 Solve local problems | • | Finding local issues | 2 |
| | | | 2 |
| | • | Deriving a new idea | 5 |
| | | | 2 |
| | • | Product design | 11 |
| | • | Purchasing | 2 |
| | • materials | Making a | 4 |
| | • product | | |
| | • descriptions | Writing product | |
| | • product | Installing | |
| Project 4.0 Be one with the local community | • Meet neighborhood | | 1 |
| | • Welcoming dinner | | 2 |
| | • Morning walk | | 7 |
| | • Free team mission | | 6 |
| | • General service | | 1 |
| | • Farewell dinner | | 2 |

| Project 5.0 Organize ideas and share them | • <br> • <br> exhibition <br> • <br> best member <br> • <br> • <br> • <br> presentation | Self-reflection <br> Product <br><br> Selecting the <br><br> Daily journal <br> Daily meeting <br> Final | 2 <br> 3 <br> 1 <br> 4 <br> 7 <br> 2 |
| --- | --- | --- | --- |

### 3.1. Make the best teams

Every activity should start with well-formed teams. There are a lot of things to be considered in grouping students into different teams: members' different majors, talents, and even personality types. For better results, efforts for teamwork building are needed from the beginning stage. A well-formed team gets more and more competitive, and can be a barometer for the eventual level of excellence in performance. But for short-term projects which last less than two weeks, we cannot wait for teamwork to develop of itself. Therefore, to systemize the process of team formation and to accelerate teamwork building, right after the selection process for participants is over, we give them the personality test, based on which individuals are placed in a certain team. Team making and teamwork building should not be delayed. These are the first things to be done on arrival at the site of the project.
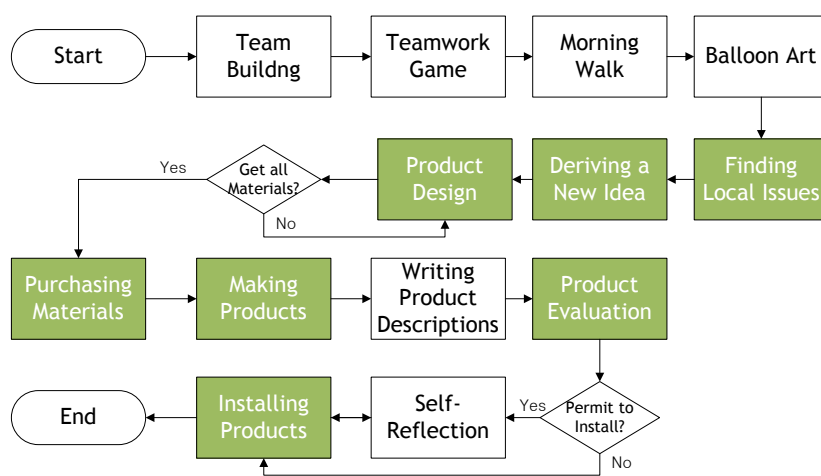


Figure 2. Mission flow chart of service learning

### 3.2. Look at problems from different viewpoint

We are so used to given problems and have been trained to look for pre-determined solutions to the problems. This routine process of problem-solving taught in traditional educational institutions hinders effective progression of this project. Students need different perspectives to approach problems while considering various aspects, identifying problems sometimes, and thinking about how the problem will fit in the whole system. It is extremely difficult to teach the students about new concepts which are different from the things that have been taught in conventional education. So we need more effective pre-educational methods. Teach them about creative invention method so that they are able to think in various ways to find a solution to a given problem. We also propose design education method which will help them look for problems by themselves, and find solutions by considering the whole system to which the problems belong. They will not be confined to merely designing products. Education in 'academic writing' will help them write the product instructions in an effective way. Educate them also about 'basic safety guidelines' and 'electricity safety' to make it safe for them to stay in the local community. 'Language education' will help them to communicate better with local people, and teaching 'balloon art' will help them get closer to local children.

### 3.3. Solve local problems

Every community we visit has some problems. We can help them find solutions. They might be experiencing the problems in their daily lives. Their way of considering a problem can be very different from ours. Even though we recognize some problems, they might not consider them problems at all. Take notice here what is more important than resolving local problems is 'making students learn through experience'. Eventually, it might happen that we might not be able to solve local problems. Or the products made through our hard work might not be permitted to be installed. Through these processes, however, students will grow and be trained.

First, identify local problems and define them. Through brainstorming, come up with an idea to deal with them. At the stage of product design, complete the drawing and make the list of the things to be purchased. Always try to be in the shoes of the user

when making a product, and prepare product instructions for local residents to refer to. Through the final evaluation, look into the feasibility of installation. After that, install the product in the right place.

*3.4. Be one with the community*

Out visit may mean a lot to local people, regardless of where we visit. 'Engineering service' is a new concept to a lot of people, and the fact that students from different countries work together for common goals might seem quite exotic (Marybeth & William, 2006). We need to let local people know who we are and why we are there. And we definitely need cooperation from the local community during our sojourn. So it is imperative we try to become one with the local people with service-oriented mentality. A single visit cannot solve all the problems. Announce the start of the project by arranging meetings with local people and holding the welcoming dinner. Walk around the area every morning and gather further information about the community while on an independent mission. With the information you got, try to help the community through general service as well, apart from engineering-related help. Finally, hold the farewell party wishing for the successful continuation of the project in the future.

*3.5. Organize ideas and share them*

Every activity should start with well-formed teams. There are a lot of things to be considered in grouping students. The success of the project is not dependent on functions and proper installation of the product. Short-term successes and failures all serve the purpose of making students experience things. What's more important is experiential learning for the students: evaluating their own products, giving assessment to their members, and sharing ideas (Hatcher & Bringle, 1997). The success of the project can be discussed after a long while when the accumulated experiences from continuous yearly programs can develop into improved versions each year. Self-reflection allows the participants to look back on the past activities during the project and share experiences with peers. By holding the exhibition where the assessment of the product will be given, participating students, other students, and neighbors can have a chance to evaluate the products themselves. By consensus, team members select the best member. Every activity happening during the project should be documented in the daily journal. Daily operation of the project is checked and arranged in the general daily meeting every morning. Lastly, the final report session will facilitate conveyance of participants' experiences to many people.

## 4. Creativity Station 2013 in Indonesia

Tegal Mulyorejo Baru (TMB) village is located on the neighborhood of EEPIS at Surabaya, Indonesia and in close vicinity to the coast. TMB is a big village but almost people are migrant workers. Problems exist everywhere we go. Problems felt by local people and our perceived problems may be different. Participants tried to define a problem to which a solution is feasible for the duration of the project. Even finishing up the solving problem for the village by participants only is beyond our capacity, problem formulation is valued in the process of problem based learning. Things to be considered when identifying a problem were formulated as follows.

- Don't define a problem to which we have a pre-perceived solution. Undesirable problem definitions are; "Since it is hot, they need an electric fan.": or "Since it is not ventilated, they need a ventilator."

- Recommended ways include; If you see a room for children which is musty because of lack of ventilation and is not good for health, we might later discuss ideas to deal with it with team members, and one of the suggested solutions might be installing a ventilation system.

- That is to say, the ventilation system should be only one of the solutions to get rid of must in the room. Please remember that there are many possible solutions.

50 undergraduate students in third and fourth grade from Korea, Indonesia and Malaysia participated in this program and they were divided to 10 teams. One team is made up of 5 students who are 2 Indonesian, 2 Korean and 1 Malaysian. We considered individual personality of each student for building teams such as the MBTI (The Myers-Briggs Type Indicator) type and specialty. And they carried out missions of this project on seven-day six-night at TMB village and around EEPIS campus in Surabaya at Figure 3.

Each team found out the most crucial issue of TMB village and defined the problem by themselves. The main issues are rubbish problem, no air circulation, insect problem, drying up the rice residue, drying up clothes in the rainy season and drainage. Participants should have defined the most urgent problem to be dealt with of all the problems local people are experiencing. The next step is to find solutions. There are a lot of ways to look for solutions, but the most effective way might be 'brainstorming' in case of short time. Team members spontaneously talk about their ideas in the brainstorming session. For efficiency, it is a good idea to distribute sticky papers to each student to write down their ideas on. Collect the papers and put them on the wall and start from an idea which the smallest number of students shave thought of. They could consider all different perspectives ranging from general solutions to seemingly totally unrelated ones. Any idea was welcome in the process of brainstorming. The key is to select out the final idea which the most feasible is considering multiple variables (environment, manpower, budget, time, and etc.). Once they have selected the most appropriate idea amongst all the possible 'solutions', they should write it down according to the principles of 'academic writing' before they try to explain the concept.

Finally 10 teams made 10 items for engineering service and installed successfully from their own ideas. When we were there, it was a rainy season. It's difficult to dry clothes. Also there were many problems of waste disposal in there. A team, before starting

the installation, should discuss the site and concrete ways of installation with the manager. Users' convenience should be considered as the top priority in the installation process. Installed items are like below and shown in Figure 4.

- 4 items were related with the trash; Spinning Trash Bin, Separation bins, Recyclable cutter and Trash compactor
- 3 items were clothes dryer; Height adjustment dryer, Vinyl house type dryer and Umbrella type dryer
- 1 item was the rice dryer
- 1 item was the temperature fan
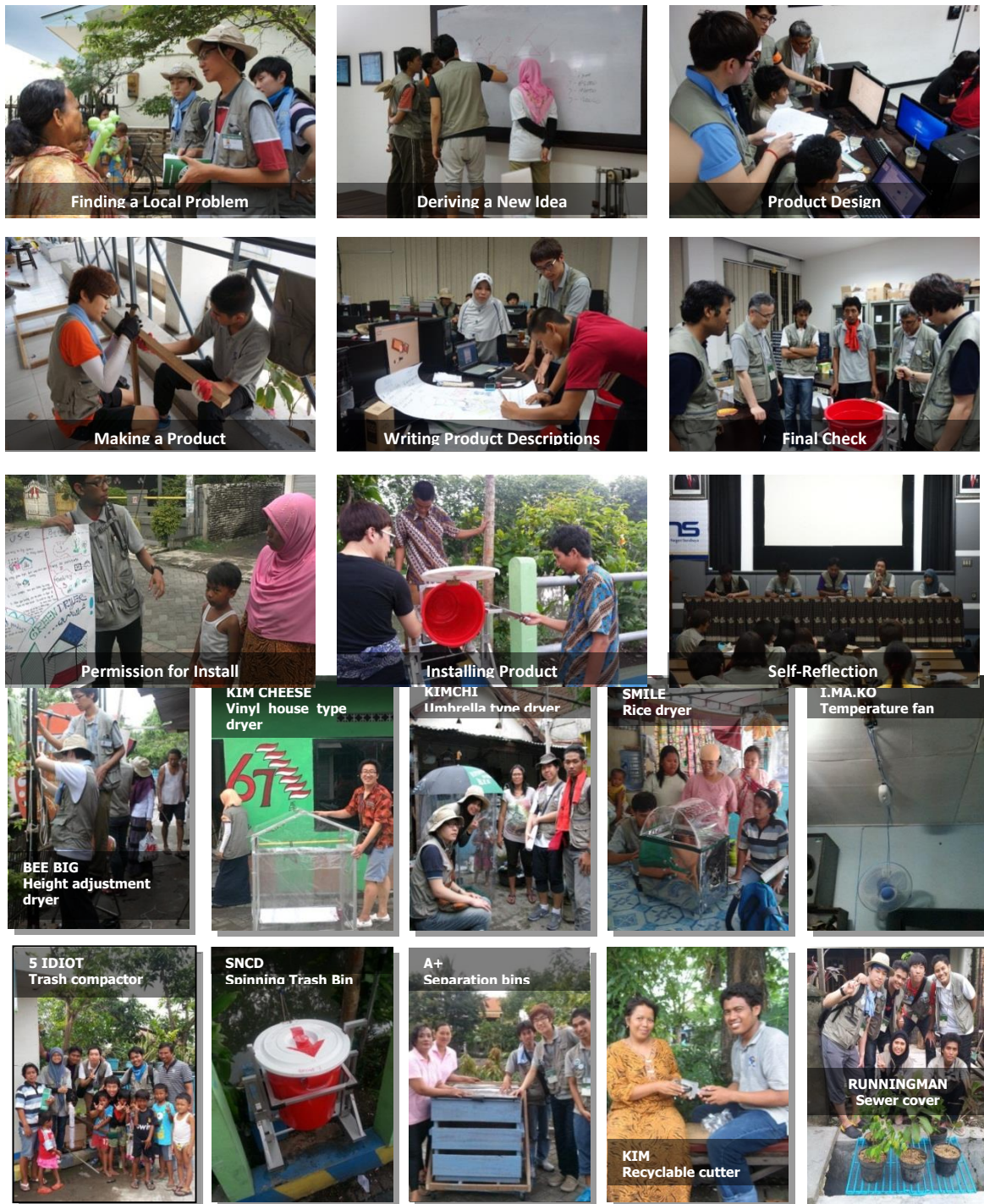- 1 item was the sewer cover



| Finding a Local Problem | Deriving a New Idea | Product Design |
| Making a Product | Writing Product Descriptions | Final Check |
| Permission for Install | Installing Product | Self-Reflection |

Figure 3. Field sketch of each mission



BEE BIG Height adjustment dryer — KIM CHEESE Vinyl house type dryer — KIMCHI Umbrella type dryer — SMILE Rice dryer — I.MA.KO Temperature fan

5 IDIOT Trash compactor — SNCD Spinning Trash Bin — A+ Separation bins — KIM Recyclable cutter — RUNNINGMAN Sewer cover

Figure 4. Installed items of Creativity Station 2013

10 managers whose they consisted of 1 Korean, 2 Malaysian and 7 Indonesian were in charge of each team project. Professors with engineering majors followed and monitored their team every time and everywhere. And checked all mission of each stages

and advised when needed. We gave also to students an opportunity to look back on the past activities and focus on themselves. Self-reflection note should cover various aspects including ability to utilize one's own skills and resources, cooperative spirits, communicative skills, self-management, analytic thinking, global capabilities, and etc. Several sentences from the student reflection are as following.

- I've got new experience and new friend, learned how to solve local issue and how to apply our capability. This program made my communication skills to improve, our engineer soul come to live and another people to care.

- This program has taught me many new things such as thinking as an engineer and thinking out of the box. I also share some knowledge with other participants. I have grown one step than before and hope this growing will keep continuing

- Throughout this program, we had many activities that packed our schedule. Every single activity was fun and had something for us to learn. I was so amazed at how wonderful the office of Creativity Station was. My impression was that this project is really established here and they organized it perfectly. We also had our first Korean language class and we were each given a Korean book to use throughout the lesson. I was again impressed that we each have a book to guide us and I did not expect this at all. I was really happy. When we checked in to Carica Homestay, the accommodation was really clean and comfortable, I really appreciated that.

- I think that the balloon art competition was a way for us to have fun and also as a tool for us to mix with the local people. It was a great activity. It was fun meeting the local people and the children were excited when they saw that we would be giving them the balloons. It also made it easier for us to speak to their mothers and ask them about local issues in the village. We enjoyed mixing with the children and taking photos with the local people. Once we had enough data for local issues we went back to campus to decide which issue we should select. We had long discussions on this.

- Product design taught me a lot about technical aspects of building a product. I learnt how to apply theory into practice. I benefitted a lot because I am from a different major. We also discussed about our budget and thought about the feasibility of our product.

- I think this program is very necessary, because of this program I can increase our knowledge, experience and make a better conversation quickly.

## 5. Program outcomes in Creativity Station 2013

The United States and many other countries have been introduced the accreditation for engineering education to guarantee international equivalence of their own students. The standard of equivalence includes program outcomes both major knowledge and liberal arts. Educational objectives are firstly determined by each university and college, and the accreditation system is established to achieve the learning objective. They also decide the program outcome by themselves. Individualized instruction programs focused on the personality for each student. Compared with ABET (Accreditation Board for Engineering and Technology), ABEEK (Accreditation Board for Engineering Education of Korea) has an additional program outcome, that is an ability to understanding of different cultures and cooperating internationally.

The achievements of program outcome for the whole program were analyzed by Seo (Seo et al., 2012). Recently, Korea Research Institute for Vocational Education & Training presented "BJA (Basic Job Ability) of students". Depending on BJA, the previous program outcomes are assorted into six groups. An ability to utilize resource, information and technology is matched to engineering knowledge, experiments analysis, design analysis, problem solving, and engineering tools use. Self-management capability also is matched to life-long learning and professional responsibility. An ability to think synthetically is matched to engineering impact and contemporary issues. Use the Matching table with basic job ability of students and ABEEK program outcomes in Table 2, survey results of primary program outcomes of engineering service design project can be classified.

Table 2. Matching table with basic job ability of students and ABEEK program outcomes

| Notation | Basic Job Ability of Students | No | ABEEK Program Outcomes |
|---|---|---|---|
| TA | Technology appliance | 1 | Engineering knowledge |
| | | 2 | Experiments analysis |
| | | 3 | Design analysis |
| | | 4 | Problem solving |
| | | 5 | Engineering tools use |
| IS | Interpersonal skill | 6 | Multidisciplinary function |
| CS | Communication skill | 7 | Communication skill |
| SC | Self-management capability | 8 | Life-long learning |
| | | 11 | Professional responsibility |
| ST | Synthetic thinking | 9 | Engineering impact |
| | | 10 | Contemporary issues |
| GC | Global capability | 12 | International cooperative |

Table 3. Program outcome in each mission

| Mission | Program Outcomes |
|---|---|

|                                | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|--------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|
| Team Building                  |   |   |   |   |   |   | ○ |   |   |    |    | ○  |
| Teamwork Game                  |   |   |   |   |   |   | ○ |   |   |    |    | ○  |
| Morning Walk                   |   |   |   |   |   |   | ○ | ○ |   |    |    | ○  |
| Balloon Art                    |   |   |   |   |   |   | ○ | ○ |   |    |    | ○  |
| Finding Local Issues           |   |   |   |   |   |   | ○ | ○ | ○ | ○  | ○  | ○  |
| Deriving a New Idea            |   |   | ○ | ○ |   |   | ○ | ○ | ○ | ○  | ○  | ○  |
| Product Design                 | ○ | ○ | ○ | ○ | ○ | ○ | ○ |   |   |    |    | ○  |
| Purchasing Materials           |   |   | ○ | ○ |   |   | ○ |   |   |    |    | ○  |
| Making a Prototype             | ○ | ○ | ○ | ○ | ○ | ○ | ○ |   |   |    |    | ○  |
| Writing Product Descriptions   | ○ |   |   |   |   |   | ○ |   |   |    |    | ○  |
| Writing Reflection Notes       |   |   |   |   |   |   | ○ | ○ | ○ | ○  | ○  | ○  |
| Prototype Evaluation           | ○ |   | ○ | ○ |   |   | ○ |   | ○ | ○  | ○  | ○  |
| Installing Products            | ○ |   | ○ | ○ | ○ | ○ | ○ |   |   |    |    | ○  |

Associations with Program Outcomes in each mission are depicted in Table 3 (Seo et al., 2013). The achievements of program outcome are evaluated by the survey from the participants. Some improvement opinions have been directly reflected in the planning for next program. The survey was carried out on 49 participants before they get involved and after finished the whole project at February 2013. Through surveys done before and after the project, same questions per program outcomes can be used to analysis the achievement of several missions. According to calculate the average from four questions in each program outcome, we ask 48 questions on primary program outcomes in each step. We made inquiries about grade, gender, duty and major in order to standardize sample group. From Table II, survey results of primary program outcomes of engineering service design project can be classified as the achievement data of basic job ability. In Figure 5, all achievement degrees are increased, but especially global capability (GC) and communication skill (CS) are increased more.
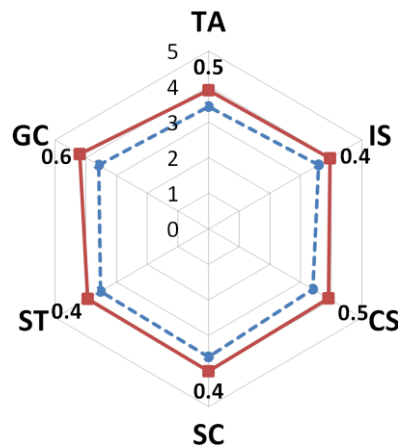


Figure 5. Improvement of basic job abilities
(Dashed line: Before project, Solid line: After project)

## 6. Conclusions

Innovation Center for Engineering Education at Pusan National University developed the engineering service design program which is 'Project BEE-Creativity Station' for multi-disciplinary teams of Korean, Indonesian and Malaysian students. In this paper, we introduced the concept of service learning is presented with five topics which are consist of 29 detail missions. Participants can refer to the schedule book to get information about various missions each project requires. The teaching manual provides additional explanation and will help the students understand the guidebook better. Each team found out the most crucial issue of TMB village and defined the problem by themselves. They derived several ideas and made products for solving local problems. Participants of Creativity Station 2013 satisfied this program in many points, such as service for local people using their major, improving communication skill and teamwork, making foreign friends, experience of various cultures and etc. Through surveys done before and after the project, same questions per program outcomes can be used to analysis the achievement of several missions. According to calculate the average from four questions in each program outcome, all achievement degrees are increased, especially global capability and communication skill are increased more.

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