

Vertically Integrated Projects (VIP) at Inha University

The Effect of Convergence Project Education on Learning Satisfaction

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Abstract—Due to the advent of the 4th Industrial Revolution in the 21st century, people with abilities based on convergence thinking are required in various fields of society. In addition, there is a growing interest in emphasizing the innovation of knowledge through academic, industrial, and technological convergence, and in how to foster convergent human resources as the scope of creativity expands. To this end, it has become necessary to change educational practices in higher educational institutions. Inha University began developing a convergence education curriculum at the Innovation Center for Engineering Education in 2013 to cultivate undergraduate students with convergence competency. This paper describes the implications of the results of multi-year, multi-disciplinary convergence education and the effectiveness of various convergence education methods for continuous education improvement. The VIP (Vertically Integrated Project) course, which has been run every semester at Inha University since the spring semester of 2014, is designed to give students practical research experiences connected with the industry in advance and apply actual projects in which professors participate to undergraduate education. The curriculum is designed to improve students' major knowledge, research skills, and collaboration skills by teaming up multi-year and multi-disciplinary students. In addition, the effectiveness of convergence education is analyzed through various student evaluations every semester, and based on the results, the students' understanding of convergence education and the need for training convergent human resources in educational institutions are further expanded.

Keywords—multi-disciplinary; multi-year; convergence education; team-based learning; project-based learning

I. INTRODUCTION

Society has continuously evolved through the industrial revolutions and brought unprecedented changes in roles of universities. The core competencies of convergent human resources that can contribute to society are, i) "relationship-building competency (communication, collaboration)," which is a human basis for connecting and integrating knowledge and skills of people from different disciplines, ii) "critical thinking competency (convergent minds, divergent minds, coping capacity)," which provides motivation to the action of convergence research and activity, and iii) "intellectual ability

(flexible thinking, systems thinking, field expertise, pragmatic problem-solving abilities, humanities literacy)," which is a source for generating creative outcomes through convergence research [1]. Furthermore, industries have stated that the prospect of the 4th Industrial Revolution requires specific guidelines for university education in the era of digital transformation [2].

Inha University is putting ongoing effort to contribute to the growing industry in South Korea by cultivating human resources with convergence education in alignment with the trends in technology and social development. The VIP program, which has originated from the School of ECE at Purdue University US [3-9], has been restructured according to the educational standards and procedures of Inha University and implemented since the spring semester of 2014. So far, the VIP courses conducted by the Innovation Center for Engineering Education at Inha University are the only multi-year / multi-disciplinary courses offered in South Korea as a convergence education program.

The satisfaction evaluation of the students affiliated with the VIP courses, confirms the necessity of convergence education, the importance of team projects, and the satisfaction of learning progression. Based on the results of the learning satisfaction evaluation, it is confirmed that learners can better contribute and participate in course of multi-semester studies. The results support the productive effects of convergence education programs that can facilitate future path or career of the undergraduate students.

II. INTERNATIONAL VIP CONSORTIUM¹

The VIP Consortium was established in 2015 with a five million dollar grant over three years from the Helmsley Charitable Trust [10, 11]. The main goals of the VIP Consortium are to expand VIP to all STEM fields and a wide variety of institutions, to further evaluate its impact on the students and faculty, and to organize an annual meeting for the Directors of all VIP sites [12]. The Consortium initially included five institutions with existing VIP programs and programs similar to VIP including Georgia Tech (Lead), Purdue

¹ <http://www.vip.gatech.edu/vip-consortium>

University, Texas A&M, the University of Michigan, and the University of Strathclyde from UK. The programs at Georgia Tech, Purdue, and Strathclyde were similar in structure [12].

The program at Michigan was a part of their large Multi-Disciplinary Design Program (MDP), organizing industry-sponsored projects. The one at Texas A&M which is called the Aggie Challenge Program [13], was created to support the National Academy of Engineering's Grand Challenge Scholars Program (NAE GCSP). Thus, the most significant difference between programs was whether VIP project was created with the request of faculty (the standard VIP model) or the request of an organization (a variation on the model)[13]. The Consortium has grown to twenty-four institutions in just three years, nineteen in the U.S. and five in other countries. Six out of the twenty-four institutions are establishing VIP programs with their own resources [12].

Inha University opened the VIP courses in 2014 with the financial support from a government-funded project received by Inha Innovation Center for Engineering Education, and has become a member of the VIP Consortium since 2015. As shown in Figure 1, the VIP Consortium holds an annual meeting where the faculty and researchers participating in the VIP programs share their information and experiences to make the program more effectively and efficiently in various educational aspects. The individual VIP programs have conducted various types of student evaluations, and continue to improve their own programs by analyzing the educational effectiveness based on the student evaluations.

III. VIP OF INHA UNIVERSITY

A. Background and purpose of VIP course development

The VIP courses are designed to improve professional knowledge and research capacities of undergraduate students by participating in the professors' research projects. The professors and graduate students as mentors, guide the activities of the undergraduate students to reinforce teamwork and to facilitate the integration of their differentiated skills by collaborating with students from various fields. The program aims to strengthen the self-driven learning abilities, the communication skills, and the trouble-shooting capabilities of the students by minimizing instructor-driven lectures and encouraging team works. Since the VIP program conducts project-based learning to identify open-ended problems requiring multi-disciplinary knowledge, students from various majors and in different years need to work together as a team.



Figure 1. The 2017 VIP Consortium meeting at Georgia Tech, GA, US.

B. VIP Program Overview

The operation method of the VIP courses was reconstructed in response to the educational criteria of Inha University. At the beginning of each semester, the orientation about the VIP program is scheduled for all students taking the courses. It is recommended that each team consists of three to five members, however, the team structures are subjected to change depending on the number of total students and the scale of their projects. The students are encouraged to participate in the same project group over the semesters. A graduate student can also participate as a mentor for each formed team.

As shown in Table 1, students can earn credits for up to six semesters of participating in the same research topic proposed by their professor. The VIP program is envisioned as one course to be taken every semester from the second semester of freshmen year until the spring semester of the senior year. The students from participating departments can receive major and design credits, while the ones from the rest of the departments will receive general elective credits. The courses, VIP 1 / VIP 3 / VIP 5 are offered in the spring semester and the rest, VIP 2 / VIP 4 / VIP 6, in the fall semester. Such way of offering courses allows the students to continue participating in the same project and progress favorably.

All the projects are carried out through team presentations, invited lectures, and observations on project-related exhibitions (Table 2). Figure 2 depicts the project outputs including the final oral presentation, visual representation such as posters, and project demonstration. Further, the annual poster and presentation session, with all the students participated throughout the year, will be held on the last week of the second semester every year. It will provide opportunities for students from different disciplines to acquire more abundant knowledge of different majors by sharing the contents of various projects.

Table 1. Credit recognition and participating department.

Course name	Credit	Participating Department
VIP 1 (ACE9501)	Major & Design 1 credit	Mechanical Eng., Naval Architecture & Ocean Eng., Chemical Eng., Polymer Science and Eng., Applied Organic Materials Eng., Civil Eng., Geo-informatic Eng., Architectural Eng., Information and Communication Eng., Visual Communication Design
VIP 2 (ACE9502)	Major & Design 1 credit	
VIP 3 (ACE9503)	Major & Design 1 credit	
VIP 4 (ACE9504)	1 credit	
VIP 5 (ACE9505)	1 credit	
VIP 6 (ACE9506)	1 credit	
Total	6 credits	

C. VIP Program Operation Status

As shown in Figure 3, Inha University's VIP courses started with 46 undergraduate students, 3 professors, and 4 projects in the spring semester of 2014. During the spring semester of 2017, 152 undergraduate students and 10 faculty members undertook 10 projects. This reveals that the number of participating students and professors in 2017 has increased more than threefold since the first semester. Thus, both students and faculty are increasingly becoming aware of the importance and necessity of convergence education.



Figure 2. The VIP course activities

Table 2. Example of VIP course syllabus (15 weeks).

Week	Class
1	VIP Course Orientation
2	Introduction of the project Presentations from past semesters
3	Team formation, team project topic selection Introduction to Vision-based ADAS, Introduction to Deep learning-based ADAS
4	Team discussion on detailed research topic and goal Team presentation, Purchase of materials, Team survey on intelligent vehicle technology
5	Invited lecture or Team work Study on related subjects provided by experts, Sensor tutorial: Stereo camera, LIDAR, Vision camera
6	Team work Project design
7	Team work Project design
8	Interim report and presentation
9	Team work Project implementation
10	Team work Project implementation
11	Field trip to Exhibition of related technology
12	Team work Project implementation
13	System integration
14	System integration
15	Final presentation and demonstration, Peer evaluation Final report and Poster

The VIP program at Inha University includes students from 19 different majors in the departments of Engineering, Natural Science, Business, and Arts and Sports. Figure4 shows that the participation of students from mechanical engineering (ME) is dominant because ME serves as the basis in the most of the VIP projects. Other faculties such as polymer science and engineering (PSE), applied organic material engineering (AOME), civil engineering (CiE), Geo-informatic engineering (GE), electrical engineering (EE), electronics engineering (EIE), and information and communication engineering (ICE) have shown relatively high participation.

Figure5 shows the number of students in different years participating over the last 7 semesters. The enrollment of first year students is fairly low and this can be attributed to the fact

that the compulsory courses of the freshmen max out the number of credits that can be taken per semester. Meanwhile, the number of junior students is significantly increasing over time, showing more interest in convergence education. The juniors are more likely to be open to research studies with team-based and project-based learning. The experiences earned from the VIP courses would allow them to prepare for the capstone design course in the upcoming year. Throughout the time period, 80% of the total students participated in the VIP program were male and the rest were female. Table 3 shows the number of students participating in the projects in 2017.

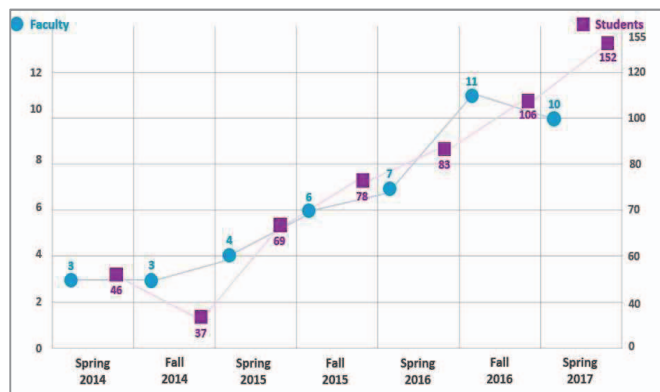


Figure 3. The number of faculty members and students.

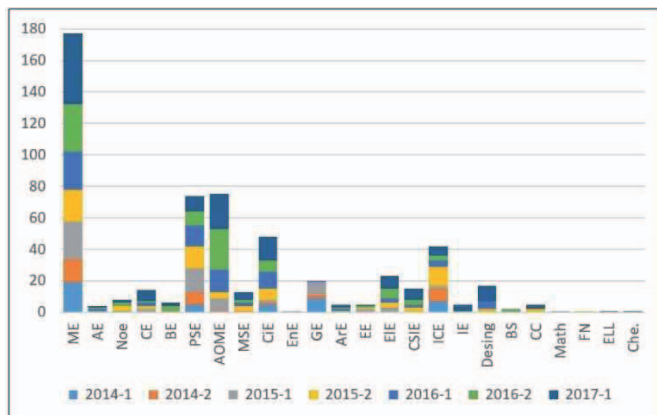


Figure 4. The VIP participating students by major.

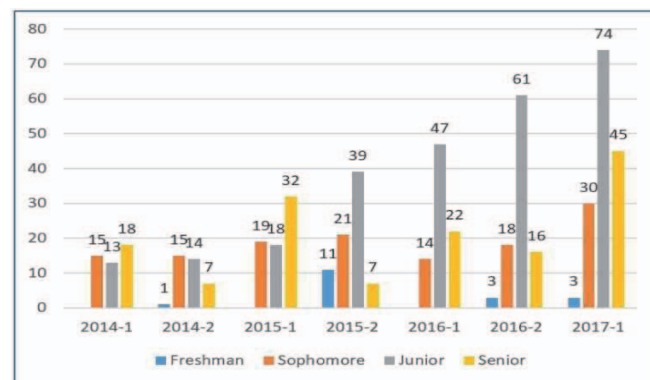


Figure 5. The number of students enrolled in the VIP courses.

Table 3. The number of students participating in the 2017 project.

Projects	Majors (Number of students)
ADAS using multi sensor and deep learning	Mechanical Eng. (7), Electronic Eng. (3), Computer Eng. (5), Info. & Comm. Eng. (4)
Personal Urban Mobility and Accessibility Project	Mechanical Eng. (12), Industrial Eng. (3), Electronic Eng. (2), Naval Architecture & Ocean Eng. (1), Aerospace Eng. (1)
Development of Chemical sensitive SAW sensor	Polymer Science & Eng. (6), Applied Organic Materials Eng. (3), Computer Eng. (1), Chemical Eng. (1)
Planning and designing creative products using a Micro controller unit	Mechanical Eng. (6), Visual Comm. Design (10), Materials Science & Eng. (1), Applied Organic Materials Eng. (4), Electrical Eng. (1), Electronic Eng. (3), Info. & Comm. Eng. (1), Chemical Eng. (1), Culture & Contents (3)
Convergence of ceramic products and 3D printing technology	Mechanical Eng. (15), Polymer Science & Eng. (1), Applied Organic Materials Eng. (8), Architectural Eng. (1), Materials Science & Eng. (2), Naval Architecture & Ocean Eng. (1)
Energy Harvesting	Civil Eng. (2), Material Science & Eng. (2), Mechanical Eng. (1), Polymer Science & Eng. (1)
Smart Sensing	Civil Eng. (8), Chemical Eng. (3), Polymer Science & Eng. (2), Applied Organic Materials Eng. (5), English Language & Literature (1)
Insect-Computer Hybrid Interface	Chemical Eng. (2), Biological Eng. (2), Computer Eng. (1)
Development of Minimum Viable Product (MVP) using Lean Startup	Mechanical Eng. (4), Industrial Eng. (1), Applied Organic Materials Eng. (1), Chemistry (1)
Big Data Analysis for Urban Infrastructure	Architectural Eng. (1), Civil Eng. (5), Applied Organic Materials Eng. (1), Information & Communication Eng. (1)

D. Engineering Design Courses and Team Composition

Since 2004, College of Engineering at Inha University has been accredited by ABEEK². The ABEEK program requires the program outcomes (PO) that align with program education objectives (PEO) [14]. Inha University sets up the following 10 core abilities and skills: knowledge application (PO1), analytical experiment (PO2), problem solving (PO3), tool utilization (PO4), engineering design (PO5), teamwork (PO6), communication (PO7), societal impact (PO8), professional ethics (PO9), and life-long learning (PO10). In particular, the PO5 is an important core ability of the engineering design courses. The design courses of Inha University are divided into three levels: *introductory*, *general*, and *capstone*.

Figure 6 shows the flow of engineering design courses for convergence education at Inha University. Introductory Design course in the freshman year includes *Creative Engineering Design* course. The purpose of this course is to introduce to engineering students creative thinking, design process, and problem solving methods. VIP courses falls in General Design course. These courses can be taken from the spring semester of sophomore up to the spring semester of senior years. Finally, Capstone Design course can be taken in the senior year. The students who have taken the VIP courses are encouraged to continue their VIP project in the capstone design course.

The individual supervising professors decide the subject of the VIP project and restrict the major of the participating students according to the scope of the project. Each project can

be divided into smaller sub-project depending on the size of the scope. The students choose first the VIP project and then the sub-project for their interest. The professors intervene the composition of teams for sub-projects so that each team consists of students from multi-years and multi-disciplinary.

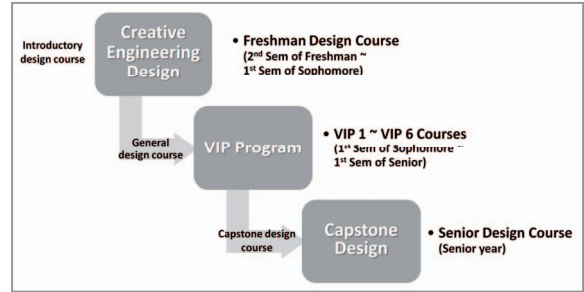


Figure 6. Design process for convergence program.

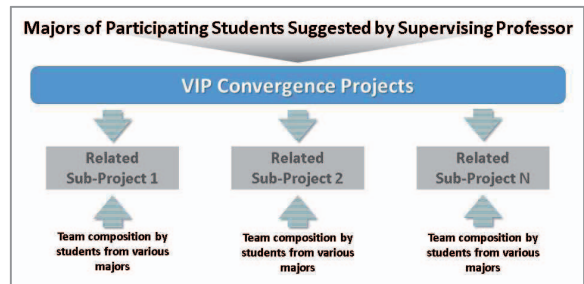


Figure 7. Project Team Composition Process.

E. VIP Community

Communication and collaboration among team members are important factors in convergence education. The VIP courses at Inha University use an online blog where students can share their projects with others, regardless of their project topics. The Naver Cafe³ shares the outputs of each project from every semester, and the Facebook page⁴ shares information on various aspects, such as project introduction, final presentation, and photos of VIP activities for publicity display. In addition, the Facebook page is an essential tool for communication among students because they can easily acquire the information of the VIP programs operated by other universities abroad.



Figure 8. Naver online café and Facebook page for Inha VIP program.

² ABEEK: Accreditation Board for Engineering Education of Korea
<http://www.abEEK.or.kr/abEEK/vision>

³ <http://cafe.naver.com/inhavip>

⁴ <https://www.facebook.com/inhavip/>

IV. VIP STUDENTS EVALUATION

A. Annual Poster Session

The Inha VIP program holds a project result presentation at the end of each year. The event provides an opportunity for students to acquire knowledge of different disciplines by sharing their contents of study. The third VIP Annual Poster and Presentation Session was held in December, 2016 (Figure 9). At the Annual Poster and Presentation Session, project results are produced as posters, oral presentations, and demonstrations. The session is held together with students, faculty members, and industrial experts. The experts from various specialized fields come together to assess and evaluate each project presented at the session.



Figure 9. 2016 Annual Poster and Presentation Session.

B. Students Evaluation

Students have the choice to select between a lecture taught in English with absolute evaluation and a lecture taught in Korean with Pass/Fail evaluation. Course grading consists (Figure 10) of project diary (20%), final report (or presentation materials) (30%), oral presentation (30%), and peer evaluation (20%). Inha University uses the peer assessment tool shared by the VIP Consortium. Peer evaluation items are shown in Table 4, covering the students' major competencies, teamwork, contribution to document preparation, and team management abilities. The peer evaluation is critical in order to confirm each team member's contribution to the team project.

Students must keep records of project progression in their project diaries (Figure 11). The supervising professor is expected to check each team's project diary periodically. The project diary reveals the individual contribution, dedication, and major competencies of the students which can be evaluated by the professor through a thorough review. The final presentation material and the final poster are submitted and these can be shared among different faculties and students. These two outputs will be used in the final project evaluation by the professors and the industrial experts at the annual poster and presentation session.

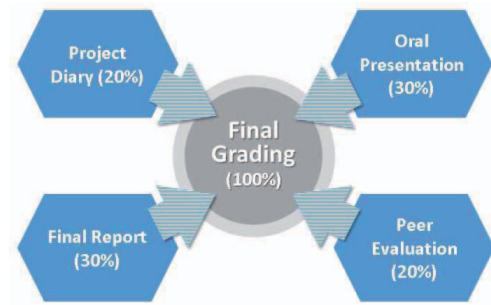


Figure 10. Final Grading Policy of VIP courses.

Figure 11. Project Diary of VIP.

Table 4. Peer evaluation lists

No	Contents
1	How often do you interact with each person in your team?
2	How often do you get suggestions/advice from your team members?
3	How often do you give suggestions/advice to your team members?
4	Participation in team meeting/class
5	Participation in sub-team meetings or discussions
6	Documentation writing
7	Quality of work
8	This person listens to and communicates well with the team
9	Is this person dependable and reliable?
10	Independent learning
11	When encountering obstacles, how does each person react?
12	Team management ability

C. Students Satisfaction Evaluation

The most important elements in the operation of the VIP courses are the continuous analysis of the trends in student participation in the program and the improvement of the course each semester. A questionnaire survey was done by the undergraduate students who participated in the VIP courses from 2014 to 2017. The survey includes questions about the general design of the VIP courses and general satisfaction about of the VIP subject (Table 5). The satisfaction survey was completed by the students with a 5-point Likert scale, 1 being "Strongly Disagree" and 5 being "Strongly Agree". To examine the effectiveness of this course, the satisfaction survey

was conducted every month on 19 undergraduates who were working on the “ADAS using multi sensors and deep learning” project during the spring semester of 2017. This was done to improve the management method of the project through monitoring the monthly learning progress of the semester. Also, to improve the quality of the team project, interviews were asking about the advantages and disadvantages of the team project.

Table 5. The VIP students survey questions.

Category	Questions
General Design	A. The project was presented as an open-ended problem.
	B. Teamwork among team members was great throughout the project.
	C. Communication between team members was satisfying.
	D. I would like to continue to work on the project in the next semester.
VIP Subject	1. The course content was what I wanted to learn.
	2. Course material was interesting
	3. The level and amount of the project in class were appropriate for me.
	4. The level of difficulty of the class was appropriate for me.
	5. I am confident about the contents of my project after taking this course.
	6. The professor was passionate about the course content
	7. The professor showed sufficient care to students.
	8. The professor was available for help.

V. RESULTS OF EVALUATION

During the last three years, students were asked about the necessity of the VIP convergence education at Inha University. In Figure 12, the responses to the question asking about the VIP necessity ranged from 4.07 to 4.33, indicating that the need for convergence education was highly recognized each semester. Figure 13 shows the results of the learning satisfaction about the general design of the VIP courses, the questions A to D in Table 5. With the exception of the year 2016, the response to the question A asking about whether project was presented as an open-ended problem was larger than 4.

Teamwork and communication among the team members are considered to be an essential learning element for group projects such as the VIP, where multi-year and multi-disciplinary students come together as a class. In response to the question B asking about the teamwork throughout the project, many responded with a high satisfaction level of 4.00 or higher every year since 2015. The responses to question C, which asks about the communication between team members, confirm that cooperation of the members was satisfactory with the scores ranging 3.90 to 4.19, at the highest level. However, the question D asking whether they would want to continue working on the project in the upcoming semester, the responses remained relatively low. However, in Figure 13, it is presented that the response level for question D is showing an increasing trend.

Looking at the survey questions 1 to 8 in Table 5, it can be concluded that the learning satisfaction of the responding students is rising every year (Figure 14, 15). During the survey period, the responses to the question 2 ranged from 3.97 to 4.17, and it was revealed that the undergraduate students were interested in the project. In Figure 15, students' satisfaction

showed a high satisfaction level ranging from 4.21 to 4.56. It should be pointed out that the students' satisfaction with professor's care for students (question 7) and availability of the professor (question 8) was relatively high.

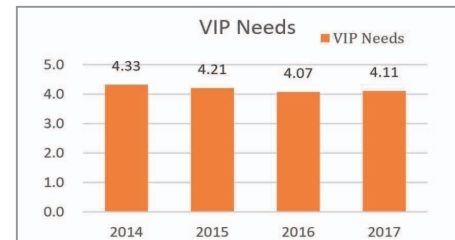


Figure 12. The VIP course needs results from 2014 to 2017.

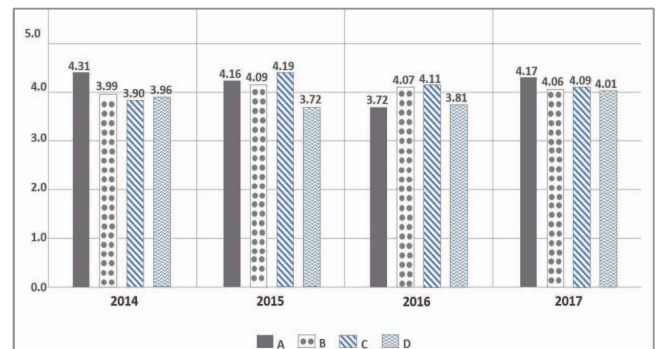


Figure 13. General design survey results.



Figure 14. The VIP subjects survey result (No. 1-4).

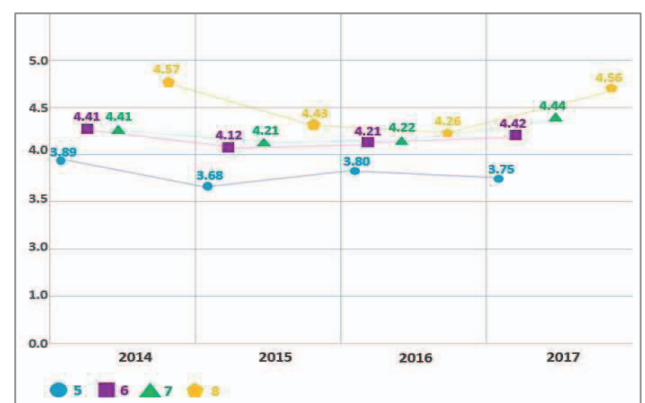


Figure 15. The VIP subjects survey result (No. 5-8).

To further investigate the effects of learning satisfaction on the convergence education, various questions were asked to undergraduate students. In this regard, 18 students in the VIP program with the topic, "ADAS using multi sensors and deep learning", were asked to do a monthly survey on their learning progress satisfaction levels in the spring semester of 2017. In this survey, the response scale was 0 to 1, 0 being non-satisfactory and 1 being satisfactory. In Figure 16, which is the average of satisfaction for all students (between March and May) was 0.6 then it rapidly increased as it reached the end of the semester.

In Figure 17, the results of the monthly learning progress satisfaction by the grade level seemed to be intermediate at first. However, as semester project reached the completion stage, the learner's satisfaction had increased rapidly. As shown in Figure 18, students from various majors were involved in the project and this graph also shows an increasing trend of satisfaction response. At the beginning of the semester, it is presumed that lack of understanding, information, and knowledge about the project could bring a result of somewhat lower satisfaction level of learning. Nevertheless, the responses became more favorable as the students get to progress through the course, as supported by the Figures 16, 17, and 18 which represents the gradual or rapid increase in satisfaction levels towards the end of the semester.

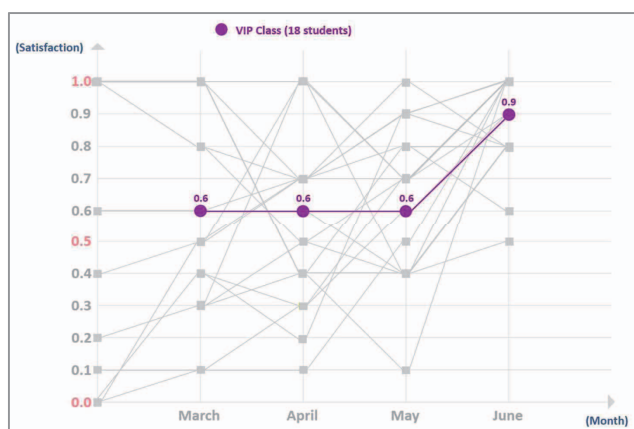


Figure 16. Monthly learning progress satisfaction.

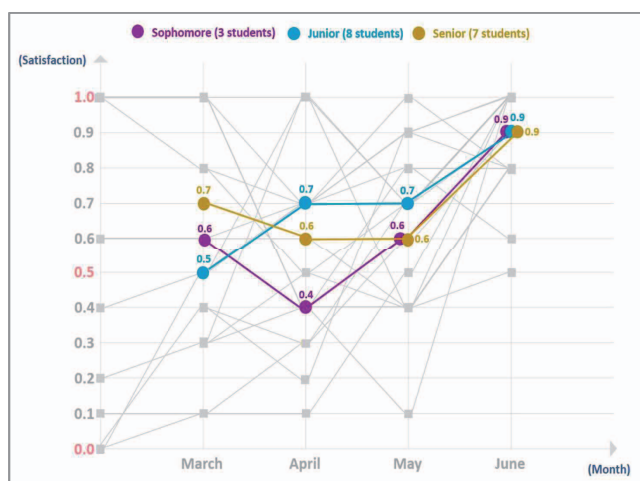


Figure 17. Monthly learning progress satisfaction (year).

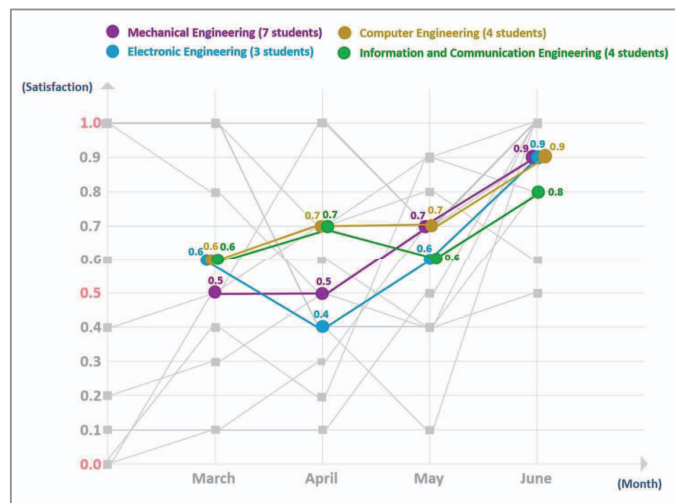


Figure 18. Monthly learning progress satisfaction based on student's major.

VI. CONCLUSIONS

As described in this study, the VIP Convergence Program provides students the opportunity to encounter various projects, and qualitative projects can be produced through their effort. Inha University provides a variety of activities within the VIP program to improve the collaborating skills, and problem-solving skills of each students. The program where students with various majors and backgrounds come together as a team, allows for the students to gain knowledge about different educational fields. The evaluation surveys conducted at the end of each semester help improve the course curriculums for future references. The convergence education of the VIP program at Inha University presented in this paper will contribute to a new direction for convergence education through the results regarding learning satisfaction.

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