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Introducing Engineering to High School Curriculum: Effects of an Introductory Engineering Program*

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Technology and engineering greatly influence our lives, and global citizenship in technological society should involve a proper understanding of technology and engineering as well as a cultivation of related literacy. Technology education has been implemented in the K-12 education system in the Republic of Korea. Engineering content is included in the national curriculum. The goal of this research was to develop an engineering program for high school students and implement it in technology education classrooms. This study was conducted with a mixture of development and implementation research. This study developed an engineering education program and then investigated its effect on students' attitudes toward engineering and engineering learning using a single group pre-test and post-test design. The program was implemented with 180 first year high school students to evaluate for changes in attitude toward engineering, attitude toward engineering learning, and attitude toward the engineering careers. Results showed statistically significant changes in all three measurements: attitude toward engineering, attitude toward engineering learning, and attitude toward engineering careers. The engineering program not only changed students' attitude toward engineering and but also improved attitude toward engineering learning. In addition, the engineering program affected the career orientation of students toward engineering, increasing the proportion of students wishing to pursue an engineering career. Based on this study, it is necessary to develop engineering education programs in elementary and middle schools and conduct further studies to verify effectiveness.

Keywords: engineering education; technology subject; attitude; engineering career; Republic of Korea

1. Introduction

Technology and engineering are key factors that greatly influence our lives, and everyone should properly understand them and cultivate related literacy [1]. Many countries around the world have made continuous research and investment in the field of engineering, and engineering is highly regarded as an important discipline that serves as the foundation of the country [2]. In addition, engineering is a factor that affects not only the value of engineering itself, but also computational thinking (CT) [3]. However, in a study on the perception of engineers among elementary school students, it was found that engineers were perceived as people who create and design ships and robots, displaying a general lack of understanding of engineering [4].

The Ministry of Education in the Republic of Korea introduced a new high school credit system and implemented policy to open a variety of subjects and guarantee students the right to select classes. The introduction of the high school credit system created the need for subjects that can provide students with opportunities to understand and experience engineering in technology. However, the current course offerings in high school technology is insufficient, so it is necessary to develop various educational programs that consider the needs of students and connection with university careers [5]. In addition, although engineering education in high school has career elective courses in general engineering and intellectual property, student participation is low due to the fact that it is a non-admission subject and a lack of publicity for the engineering program [6].

Given the importance of engineering education and the introduction of the high school credit system, technology subjects also require the development of engineering-related programs to reflect the needs of students preparing for engineering careers and nurture talent for future society, and the opening of elective courses for engineering careers. According to a study by Lee (2015) [7]. who analyzed research trends in elementary and secondary engineering education in Korea, most of the research related to engineering consists of current status survey studies and trend analysis, while research related to model effect verification is proportionally underrepresented, and there are also cases in which the effectiveness of the program was not verified in the research on teaching methods and model design. Therefore, efforts are required to verify the effectiveness of engineering-related

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programs after development and application. In addition, to improve the perception of engineering, it is necessary to develop programs and education on the work, working environment, and prospects for engineers [8].

Therefore, the purpose of this study is to develop an engineering program for high school students and to investigate the effect of the program on the students' attitudes toward engineering careers. Specific details of this study are as follows. First, the researchers developed an engineering program for high school students and implemented it in a high school setting. Second, the effectiveness of the program was verified by measuring changes in the students' attitudes toward engineering, engineering learning, and engineering career orientation before and after the implementation of the developed program.

2. Theoretical Background

2.1 Engineering in High School Technology Education

Various attempts have been made to address engineering in Korean technology education. First, when engineering was initially introduced to technology curriculum, a subject entitled ''Engineering Technology'' was organized as an elective in the 2007 revised curriculum. This title was used through the 2009 revised curriculum and changed in the 2015 revised curriculum to ''General Engineering.''

The educational goal of the 2007 revised curriculum was to understand engineering content areas. The 2009 revised curriculum added, goals of engineering literacy, creative problem-solving ability, and convergence between engineering technology along with understanding of the content area. Furthermore, the 2009 revised curriculum included the addition of goals of understanding of the engineering-related world of work and establishing career plans. The educational goals of the 2015 revised curriculum emphasized engineering design, understanding of the emerging engineering areas, and convergence between engineering. Additionally, while in the 2009 revised curriculum, career areas were emphasized, the 2015 revised curriculum emphasized the ability to design a career that takes into consideration a student's interests, aptitudes, and abilities.

The contents of the curriculum are structured around the latest engineering areas such as information, automation, and energy from the traditional technology subject. In addition, beginning with the 2009 revised curriculum, content elements were added to introduce engineering-related career paths to support students' choice of engineering as a career. Efforts have been made to emphasize engineering by changing the subject title to ''General Engineering,'' excluding the word technology. In terms of teaching and learning methods, projects and problem-solving learning are emphasized by reflecting the characteristics of technology subjects that focus on practice. In terms of evaluation, the engineering problem-solving process is highlighted along with the evaluation of the results.

In elementary and secondary education, engineering education has not been implemented independently and was only limitedly implemented as a part of STEM education, and there is an increasing national and social demand that engineering education be conducted in primary and secondary education [9]. The integration of engineering into the technical curriculum is a response to that demand. The need to improve engineering education presents many challenges requiring research and implementation of changes to the curriculum, teacher training, and elective subjects [10].

Engineering received a lot of response on the K-12 level, but there are many complexities in dealing with engineering in curriculum. One suggestion has been to focus on engineering design [11]. In addition, there is a discrepancy between the creative background subject knowledge of teachers and the technology subject knowledge required for engineering education, and a need for greater STEM awareness among teachers.

2.2 Development and Application of Engineering Education Programs

Diverse studies have been conducted in the field of engineering program development and application. The Make-A-Thon program centered on students solving engineering problems, and students' attitudes toward engineering showed a significant improvement [12]. This confirmed that the educational method applied with engineering design helps students to improve their learning and motivates them and has a positive effect on cooperative learning and career education [13]. In addition, because the program uses virtual reality technology, students' engineering achievement improved [14]. In a study of elementary school teachers' thoughts on the nature of engineering (NOE) after participating in an engineering program, the participants analyzed the nature of engineering and described the NOE as engineering design process, empirical basis, tentativeness, creativity, etc. after participating in the program. Additionally, it was confirmed that the level of understanding of engineering has increased [15]. In addition, in applying the STEM program based on engineering design to pre-service technology teachers, it was found that there were significant changes in problem defini-

tion, idea generation, design, and analysis abilities of the teachers, suggesting additional program development for others is essential [16].

Various engineering education programs have been developed and applied for elementary, middle, and high school students, and confirmed that the engineering education program has a significant impact on students' creativity, problem-solving ability, perception of engineering, and perception and choice of engineering-related careers.

3. Method

This study was conducted as a mixture of development and implementation research (See Fig. 1). In the development stage, this study established a draft program consisting of goals, content, teaching and learning methods of the engineering program. The draft was reviewed and revised by two experts in the field of K-12 STEM educational research to validate the program. In the implementation research, this study applied the program to first-year high school students who had not previously taken an engineering class. This study investigates the effect of the engineering educational program on students' attitudes toward engineering and toward engineering learning using a single group pre-test and post-test strategy.

3.1 Participants

In order not to apply a separate control to a single school, the study was set for the entire first year of high school in Korea. Participants had never taken any engineering subject and were students who want to pursue a variety of careers including in the engineering field. A total of 180 participants were included, 88 male students and 92 female students.

3.2 Instruments

After developing a draft of the instruments used in this study, the validity was checked by one technology education professor and two in-service teachers with more than 10 years of experience in technical education. As a result, the draft was supplemented by corrections or deletions of items that were not suitable for the goal of this study or had unclear meaning. Using this modified instrument, a preliminary survey was conducted targeting 102 students in the K high school located in Korea. The final inspection tool was manufactured by clearly correcting what was not clear. The composition and contents of the instrument are shown in Table 1.

3.2.1 Attitude Towards Engineering

To measure the participants' attitude toward engineering, the Pupil's Attitude Toward Technology (PATT) validated by Lee (2008) [17] in Korean was modified and used for engineering. The Korean PATT (2008) consists of a total of six factors (interest in technology, gender role of technology, difficulty of technology, results of technology, technology and school curriculum, technology and career) with 58 items. In this

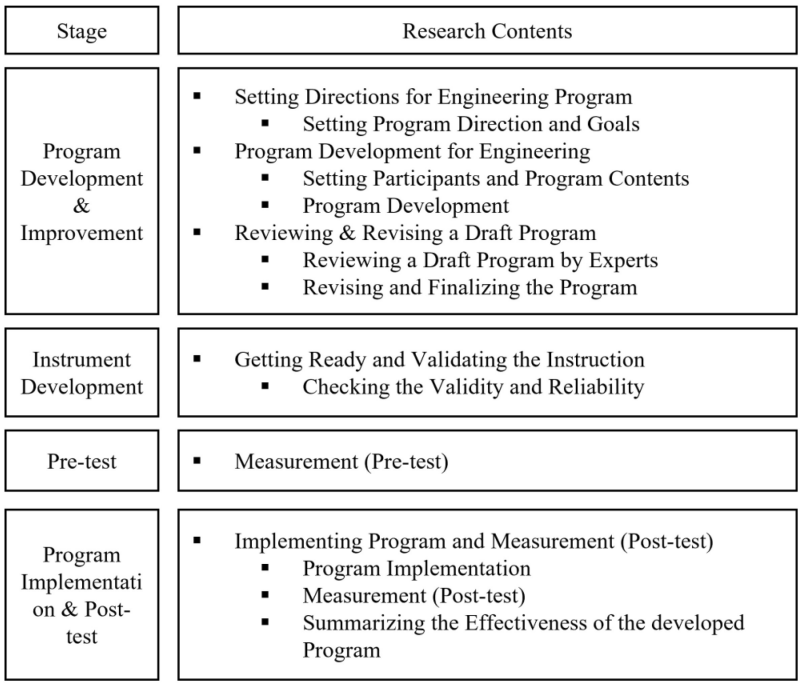

Fig. 1. Research Procedure and Flow.

Table 1. Composition and contents of the instrument

Instrument	Item Number	Item Contents
Attitude toward Engineering	5 Items	Interest in Engineering
	5 Items	Results of Engineering
Attitude toward Engineering (Technology) Learning	5 Items	Interest in Engineering (Technology) Learning
	5 Items	Perceived Value for Technology Learning, and Persistence
Engineering Career Orientation	5 Items	Perceived Value for Engineering Career
	5 Items	Preference for Engineering Career
	5 Items	Need of Providing Opportunities for Developing Engineering Competencies

study, among the six factors, technology-related factors were modified by engineering, focusing on interest in engineering and results of engineering. There were a total of 10 items, including 5 items of interest in engineering and 5 items on results of engineering. This instrument utilized a Likert 5-point scale, and the higher the score, the better the attitude toward engineering. The reliability of this instrument (Cronbach's α) is 0.88 for engineering interest, 0.88 for engineering results, and the overall reliability is 0.98.

3.2.2 Attitude Towards Engineering (Technology) Learning

To measure the attitude toward engineering learning, a tool for measuring interest in technology subjects used in [18] research was modified and used. The measurement tool used by the previous work [18] consisted of a total of 10 items and was modified by classifying them into two factors: interest in technology classes and perceived value for technology learning, and persistence. Considering that the students to whom the study was applied are first-year high school students, the term technology was used instead of the term engineering. The response style was composed on a Likert 5-point scale, with higher the scores reflecting a higher interest in technology (engineering) learning. The reliability (Cronbach's α) of this instrument was 0.91. Specifically, the Cronbach's α was 0.94 for the interest in technology instruction and 0.82 for perceived value and persistence for technology learning.

3.2.3 Engineering Career Orientation

To measure engineering career orientation, the science career orientation instrument used by the previous work [19] was modified and used in this study. This test tool consists of a total of 20 items with four factors including preference for science learning, preference for science career, perceived value of a science career, and need for science career information. In this study, science was modified to fit engineering, and preference for science learning was excluded because an attitudinal instrument for technology learning was separately performed. In the end, the instrument consisted of 15 questions on three factors: perceived value of engineering career, preference for engineering career, and the need to provide opportunities to develop engineering competency. It was composed of a Likert 5-point scale, and the higher the score, the higher the degree of career orientation in the engineering field. The reliability of this instrument (Cronbach's α) was 0.82 for the perceived value of engineering career, 0.93 for engineering career preference, and 0.88 for the need to provide opportunities to develop engineering competency, and the overall reliability was 0.93.

3.3 Data Collection and Analysis

The data collection was done through an online survey took place August 16–20, 2021 for the pretest survey and October 25–29 for the post-test survey. Out of a total of 180 responses, a total of 171 copies were used for analysis, excluding 9 copies that responded insincerely or did not respond to some questions. During the data collection and analysis in this study, this study had an approval from the university Institution Review Board and followed the relevant process by ethical consideration.

To investigate the effect of the program on students' attitudes toward engineering careers, a pre- and post-test was conducted for testing the differences in the pre- and post-results of attitudes toward engineering, attitudes toward engineering (technology) learning, and engineering career orientation in a single group. A paired t test was performed. For the statistical analysis, the SPSS 25.0 program was used.

4. Results

Through a literature review, the purpose and content elements of the high school engineering education program were examined. Based on this, the direction and content elements of the engineering education program to be developed in the study were selected. After the development of the draft

Table 2. Draft program contents and activity elements by class session

Session	Learning Stage	Learning Contents and Activities
1	Understanding Engineering	Introducing concept and scope of engineering
2	Providing Problem or Situation	Understanding technological polarization in global community Understanding problem for helping the underprivileged using appropriate technology
3	Creating Ideas and Choosing the Best Idea	Creating diverse ideas and choosing the best idea for the invention of helping the global underprivileged using appropriate technology
4	Creating a draft	Creating a draft for the implementation of the selected idea
5–6	Prototyping	Prototyping invention product
7	Writing and Presenting a Business Plan	Writing and presenting a business plan for a social enterprise that will sell the created invention for the public good
8	Career Exploration	Engineering-related career exploration activities

program, the program was revised through expert review, and the final program was confirmed. After applying the confirmed program to 180 high school students, the effectiveness of the program was verified by measuring the changes in the students' attitudes toward engineering careers. The results and interpretations of the research conducted at each stage are summarized as follows.

4.1 Setting the Direction for Engineering Education Program Development

The direction of the engineering education program was established through the review of prior research and expert consultation. First, this program aimed to understand engineering and use it to solve problems in daily life. Second, it reflected the curriculum and enabled the fusion of various content areas. Third, it used the creative problem-solving process based on engineering design. Fourth, it provided opportunities for exploration related to engineering-related departments and professions.

The goal of this program is to help students understand engineering and use it to solve problems, develop engineering literacy, and develop interest in engineering. In addition, by providing opportunities for career exploration related to engineering, this program emphasizes the development of the students' engineering career exploration capabilities and supports their entrance to engineering colleges. To achieve these goals, the following detailed goals were set. First, it helps students understand the concept of engineering and the importance of engineering in everyday life. Second, the program focus on the appropriate technology content elements of the curriculum so that the curriculum can be faithfully reflected. Third, it develops engineering knowledge and interest in engineering through developing inventions to help the underprivileged by applying the creative problem-solving process based on engineering design. Fourth, it encourages students to choose engineering careers by providing opportunities for exploration related to engineering-related college departments and careers.

4.2 Engineering Education Program Development

The content elements of the educational program were established to reflect the basic direction and detailed goals of the engineering education program as much as possible, as shown in Table 2. For this purpose, content selection criteria were established, and content elements were chosen according to the selection criteria. The detailed contents are shown as follows: (1) was it selected according to the direction and goal of the engineering education program? (2) are the content elements selected to keep students interested? (3) were the content elements selected in consideration of the school site?

The program consisted of content elements of a total of 8 sessions. In the first session, content elements were selected to encourage students to understand the concept of engineering, find examples of engineering in everyday life, and take an interest in engineering. In the 2nd–7th session, the content elements of the engineering problem-solving program with the theme of making inventions to help the underprivileged using appropriate technology were selected. In the 2nd–7th session, the content elements were changed by modifying the program that had been previously developed to be applied to the general high school engineering subject according to the school site. The reason for selecting the appropriate technology-related program was to emphasize the ethical aspects of engineering and technology education to develop students' sound attitude and solve social problems, and through this, expand the career education for students to develop desirable engineering ethics awareness and healthy work ethics. This is because there is a need to do so [20]. In the 8th session, content elements were selected for students to explore engineering-related departments and career paths. The draft of the developed program was reviewed by one technology education profes-

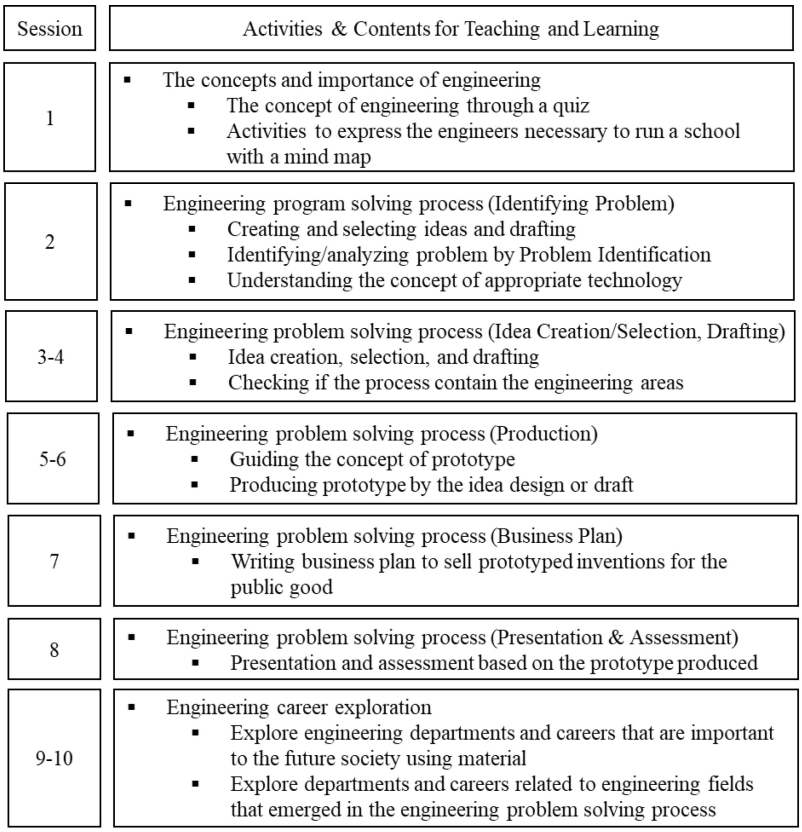

Fig. 2. Program Flow for the Final Engineering Program.

sor and three experienced in-service technology teachers, and the opinions of these experts were used to improve the draft program. The final program was finalized as shown in Fig. 2.

4.3 Results of Implementation of Engineering Education Program

The program was applied to 180 first-year high school students in Korea over a total of 10 sessions. Students' engineering career attitudes were measured through pre-and post-tests. The effectiveness of the program was verified by analyzing the pre- and post-tests with SPSS 25.0, and the detailed results are as follows.

4.3.1 Results of Attitude Toward Engineering

To measure attitude toward engineering, 10 items consisting of interest in engineering and the results of engineering were used. The results for each factor are shown in Table 3 and Table 4.

As a result of analyzing student interest in engineering, the average value of the post-test for all five questions was higher than that of the pre-test. Furthermore, the following five items had significant probability: "I want to know more about engineering" (t = –3.60), "I enjoy doing engineering-related activities" (t = –3.95), "I like to have hobbies related to engineering" (t = – 5.31), "I enjoy reading engineering-related books or watching videos" (t = –4.89), "I like to go to engineering-related hands-on learning" (t = –2.95). The analysis showed that there was a statistically significant change of 0.01. In the synthesis of interest in engineering, the mean value increased in the post-test compared to the pre-test, and analysis revealed that there was a statistically

Table 3. Analysis of interest in engineering (* $p < 0.05$, ** $p < 0.01$)

Item	M(pre-test)	M(post-test)	*t*	*p*
I want to know more about engineering	3.44	3.70	–3.60	0.000**
I enjoy doing activities related to engineering	3.46	3.77	–3.95	0.000**
I want to have a hobby related to engineering	3.06	3.47	–5.31	0.000**
I enjoy reading books related to engineering and watching videos	2.89	3.33	–4.89	0.000**
I like to go to hands-on learning related to engineering	3.51	3.74	–2.95	0.004**
Total	3.28	3.60	–9.30	0.000**

Table 4. Analysis of results of engineering (* $p < 0.05$, ** $p < 0.01$)

Item	M(pre-test)	M(post-test)	*t*	*p*
Engineering makes and advances human life	4.42	4.50	–1.32	0.192
Engineering is very important for the development of our country	4.53	4.53	0.000	1.000
Engineering is necessary for everyone	3.78	4.05	–3.73	0.000**
Engineering has disadvantages, but it has more advantages	3.99	4.17	–3.10	0.002**
Engineering is well worth learning systematically in school	3.74	4.04	–4.73	0.000**
Total	4.09	4.26	–6.01	0.000**

significant change with a significance probability of 0.000. Based on these results, it was found that the engineering education program is effective in increasing student interest in engineering.

The analysis of student perceptions on engineering showed there was a significant change of 0.01 for five items: "engineering is necessary for everyone" (t = –3.73). In the three items of "Engineering has disadvantages but has more advantages" (t = –3.10) and "Engineering is worth systematically learning at school" (t = –4.73). In addition, as a result of analyzing and synthesizing the results of engineering, the average of the post-test was higher than that of the pre-test, and it was found that there was a statistically significant change with a significance probability of 0.000.

4.3.2 Results of Attitude Toward Learning Engineering (Technology)

To measure the attitude towards engineering (technology) learning, 10 items with three factors consisting of interest in technology learning, perceived value for technology learning, and persistence were used. The analysis was conducted for each factor, and the results are shown in Table 5 and Table 6.

In the results on the questions relating to attitude toward learning engineering, the average of the post-test was higher than that of the pre-test for all five questions. For the items, "I like to learn technology" (t = –3.18), "I have no difficulty in technology subjects" (t = –2.23), and "I enjoy the activities in technology class" (t = –5.73), "I want to participate in technology-related clubs" (t = –5.70), "I like to read technology-related books" (t = –5.43), only "I am not difficult in technology," the significance probability was analyzed within 0.05, and the remaining 4 items were analyzed as statistically significant with a significance probability within 0.01. In the synthesis of interest for technology classes, the average of the post-test was higher than that of the pre-test, and a statistically significant improvement was observed with a significance probability of 0.000. Through these changes, it can be analyzed that the engineering program has a positive effect on interest in technology learning.

As a result of analyzing the perceived value and persistence, the average of the post-test for all five questions was higher than that of the pre-test. Furthermore, five items were analyzed to have statistically significant changes within a significance

Table 5. Analysis of interest in technology learning (* $p < 0.05$, ** $p < 0.01$)

Item	M(pre-test)	M(post-test)	*t*	*p*
I like to learn technology	3.42	3.67	–3.18	0.002**
I have no difficulty in technology subjects	3.49	3.67	–2.23	0.027*
I enjoy the activities in technology class	3.47	3.91	–5.73	0.000**
I want to participate in technology-related clubs	2.88	3.37	–5.70	0.000**
I like to read technology-related books	2.59	3.11	–5.43	0.000**
Total	3.17	3.52	–10.00	0.000**

Table 6. Analysis of perceived value and persistence for technology learning (* $p < 0.05$, ** $p < 0.01$)

Item	M(pre-test)	M(post-test)	*t*	*p*
Learning technology is practically worthwhile for me	3.70	3.92	–2.87	0.005**
Learning technology is more important than the grade I'll get in the subject	3.25	3.74	–5.36	0.000**
I want to continue learning technology	3.29	3.71	–5.83	0.000**
I want to go to technology-related festivals, universities, and business trips	3.17	3.64	–5.23	0.000**
I want to search for technology-related data on the Internet and in libraries to find out the value of technology and related knowledge	2.81	3.33	–5.70	0.000**
Total	3.25	3.67	–11.19	0.000**

Table 7. Analysis of perceived value of engineering career (* $p < 0.05$, ** $p < 0.01$)

Item	M(pre-test)	M(post-test)	*t*	*p*
Engineering-related occupations are rewarding	4.48	4.58	–1.70	0.091
Engineering-related occupations have a bright future	4.12	4.32	–4.02	0.000**
Engineering-related occupations are necessary for national and human development	4.58	4.57	–0.24	0.809
Engineering-related occupations should be highly respected by society	3.99	4.22	–3.61	0.000**
Engineering-related occupations should be given many benefits	3.69	3.92	–3.44	0.001**
Total	4.17	4.32	–5.73	0.000**

Table 8. Analysis of preference for engineering career (* $p < 0.05$, ** $p < 0.01$)

Item	M(pre-test)	M(post-test)	*t*	*p*
I want to go to an engineering-related department.	2.94	3.32	–4.50	0.000**
I am a suitable person for an engineering-related job	2.71	3.12	–4.92	0.000**
I want to try an engineering-related job.	3.18	3.53	–4.76	0.000**
I want to recommend engineering-related departments and jobs to others	3.49	3.92	–5.16	0.000**
I like to explore information about engineering-related departments and jobs	2.81	3.35	–5.99	0.000**
Total	3.03	3.45	–11.35	0.000**

Table 9. Analysis of the need to provide opportunities for developing engineering competencies (* $p < 0.05$, ** $p < 0.01$)

Item	M(pre-test)	M(post-test)	*t*	*p*
More engineering-related subjects and clubs should be opened in schools	3.39	3.70	–3.61	0.000**
More information about engineering-related departments and occupations should be provided	3.74	3.94	–2.66	0.008**
More facilities (laboratories) should be given for engineering experiences.	3.94	4.06	–1.83	0.068
Engineering-related departments should be diversified.	3.80	4.02	–3.41	0.001**
Engineering should be designated as a compulsory subject so that all students can understand and experience engineering	3.05	3.54	–5.52	0.000**
Total	3.59	3.85	–7.78	0.000**

probability of 0.01: ''Learning technology is practically worthwhile for me'' (t = –2.87), ''Learning technology is more important than the grade I'll get in the subject'' (t = –5.36), ''I want to continue learning technology'' (t = –5.83), ''I want to go to technology-related festivals, universities, and business trips'' (t = –5.23), ''I want to learn the value of technology and related knowledge on the Internet and in the library. I want to find related data'' (t = –5.70). In addition, the average of the post-test increased compared to that of the pre-test in the perceived value and persistence, and analysis showed that there was a statistically significant change with a significance probability of 0.000.

4.3.3 Results of Engineering Career Orientation

To examine for a change in the degree of engineering career orientation, 15 items consisting of three factors were used: the perceived value of the engineering career, preference for the engineering career, and the need to provide opportunities to develop engineering competency. Analysis was conducted for each factor, and the results are shown in Tables 7–9.

The results show the perceived value of engineering career. Statistically significant changes were analyzed in 3 of 5 questions. The five questions evaluated these statements: ''Engineering-related occupations are rewarding'' (t = –4.02), ''Engineering-related occupations should be highly respected by society'' (t = –3.61), ''Engineering-related occupations should be given many benefits'' A statistically significant change was analyzed within the significance probability of 0.01 in the three items (t = –3.44). The other two items, ''Engineering-related occupations have a bright future'' (t = –1.70) and ''Engineering-related occupations are necessary for national and human development'' (t = –0.24) showed no significant change. However, in a comprehensive analysis of the perceived value for engineering career, the average of the post-test had increased compared to that of the pre-test, and there was a statistically significant change.

As a result of analysis of engineering career

preference, the average value of the post-test for all five questions was higher than that of the pre-test. Additionally, there was a statistically significant change with a significance probability of 0.000 for the following statements: "I want to go to an engineering-related department" (t = –4.50), "I am a suitable person for an engineering-related job" (t = –4.92), "I want to try an engineering-related job" (t = –4.76), "I want to recommend engineering-related departments and jobs to others" (t = –5.16), and "I like to explore information about engineering-related departments and jobs" (t = –5.99). Furthermore, the post-test showed a statistically significant change compared to the pre-test.

In the analysis of need to provide opportunities for developing engineering competencies, the average of the post-test for all five questions was higher than that of the pre-test. Moreover, there was a statistically significant increased agreement with the statements: "More engineering-related subjects and clubs should be opened in schools" (t = –3.61), "More information about engineering-related departments and occupations should be provided" (t = –2.66), "Engineering-related departments should be diversified." Students also showed a four times as much support for the statement, "Engineering should be designated as a compulsory subject so that all students can understand and experience engineering" (t = –5.52).

5. Discussion & Recommendations

This study developed an engineering education program for high school students and applied it to investigate changes in high school students' attitudes toward engineering careers. First, the finalized engineering education program consisted of understanding engineering, experiencing engineering problem solving on the topic of appropriate technology, and exploring engineering careers. In the first session, the understanding of engineering consisted of the concept of engineering, which is a quiz to help students understand the concept and importance of engineering, and the activity of expressing the engineers needed to run the school with a mind map. The 2nd to 8th sessions consisted of invention making activities to help the underprivileged under the theme of appropriate technology according to the engineering problem solving process. In the 2nd-8th class, the program developed to be applied to general high school engineering subjects was modified to fit the level of the first year of high school. Sessions 9–10 were intended to provide students with opportunities to explore engineering careers through activities that investigate engineering-related departments and occupations.

Second, high school students' attitudes toward engineering and engineering (technology) learning were significantly improved through the developed engineering educational program. As found in another study that supported that an integrated STEM program for high school students had a significant effect on students' engineering attitudes [21]. In particular, the average of items wishing to continue technology (engineering) learning and wishing for technology (engineering)-related experience activities increased significantly, indicating that students are open to various elective courses for technology (engineering) education in high school and technology (engineering). This means that they recognize the need to expand educational experience opportunities. In the case of engineering career orientation, the perceived value of the engineering career, preference for engineering career, the need for opportunities for engineering competency factors were analyzed as having statistically significant changes. This is a result similar to the study by Lee [2] that found technology experience for middle school students had a significant effect on the students' engineering career orientation.

Based on the results of the study, suggestions for follow-up research on the development of engineering education programs and attitudes toward engineering careers are as follows. First, research to develop various engineering education programs and engineering-related high school credit system elective subjects for students is required. Through the study, it was confirmed that after students participated in the engineering education program, the desire to continue and participate in technology (engineering) education increased. In addition, since research has confirmed that the engineering education program has a positive effect on students' perception of engineering and engineering career orientation, follow-up research is required to develop an engineering education program to nurture engineering talents and to open elective courses in the high school credit system.

Second, a follow-up study is required to analyze the correlation between the attitude towards engineering, the attitude toward technology (engineering) learning, and the engineering career orientation, which constitute the engineering career attitude. A limitation of this study is that it only identifies changes in students' attitudes toward engineering careers, and to overcome this, research is required to find the justification and direction of engineering education through correlation analysis of each factor. This study verified the effectiveness through a single group before and after design, and

to increase validity and verify the effectiveness of the program, it should be applied to various groups in subsequent research.

Third, development of engineering education programs for elementary and secondary school students other than high school is crucial. Efforts to establish the concept of engineering and increase understanding have been emphasized starting in elementary school [22]. To this end, it is important to develop an engineering education program for not only for high school but also for elementary and middle school students to improve their perception of engineering and to cultivate creativity, problem-solving ability, and engineering literacy through engineering problem-solving processes. Additionally, PBL and PROJECT teaching methods have been applied in various ways in engineering education to verify their effectiveness [23], various teaching methods and programs are needed to improve the effectiveness of engineering education.

6. Conclusion

The main conclusions of the study are as follows. First, the tenth engineering education program was centered on the achievement standards of the high school technology and home-economics and engineering general curriculum. The program completed the final program by modifying the draft program composed according to the criteria for selecting the contents of the engineering education program through expert review. For the development of the engineering program, it was necessary to organize the program based on experience to analyze the curriculum and to cultivate the engineering literacy of the students. In addition, it was found that it was necessary to reflect the career search elements presented in the engineering field of the 2009 and 2015 revised curriculum, and to include elements of the engineering career search content to cultivate students' engineering career exploration competency. Second, by applying the engineering education program and verifying its effectiveness, it was confirmed that the program had a positive effect on the students' engineering career interest. Specifically, among the factors that constituted the attitude toward engineering, interest in engineering, the results of engineering were analyzed as having statistically significant changes. This study confirms that students' attitudes toward engineering can be changed through educational programs. It has been statistically supported that the engineering education program has a positive effect on students' perception of engineering, their attitude toward engineering learning, and their engineering career orientation, and it can be said that the necessity of engineering education has been confirmed. Based on this, it was concluded that it is necessary to develop various engineering education programs to change students' attitudes toward engineering careers.

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