# Implementing Engineering Based STEM Programs in High School Classroom in the Republic of Korea

Hyuksoo Kwon, Kongju National University
Correspondence: hskwon@kongju.ac.kr
Eojin Kim, Osan Middle School
Jaehoon Jeong, Gyeongsangnamdo office of education Future Education Cente
Yubin Lee, Jusan Middle School

## ABSTRACT

In 2022, South Korea announced a new national curriculum that implement it from 2025. The high school curriculum is about to fully implement the high school credit system, which allows students to choose subjects that suit their needs and career paths. In South Korea, Technology education in middle school is a common compulsory subject, but high school technology education is a selective subject and has the name of technology and home-economics. Secondary technology education experiences difficulties that are not selected in many schools due to the confusion of the identity of subject names and social negative perception of technology. This aims to develop engineering-based integrative STEM education programs that can be used in secondary school technology education and verify its effect on students. To achieve the purpose of this study, an engineering education program was developed and students' changes through the program were measured. This study was based on a single-group pre-test and post-test design and was conducted with 10th grade students. As a result of this study, this study developed five programs that allow students participation-oriented activities. Through the field application research on the program, students improved their attitude toward convergence education and showed high satisfaction. This study provides great implications for actively including and utilizing engineering in technology education. In addition, it will give great implications for the direction and program development of high school technology education.

*Key Words: Engineering, High School, Students, Effects, STEM*

## 1. INTRODUCTION

Due to the development of artificial intelligence and the shortening of the expiration date of knowledge and information, the social and economic structures are rapidly changing, and the future is becoming difficult to predict. To adapt to a changing society, the need to develop new competencies such as convergence, creativity, problem-solving, and cooperation is increasing (OECD, 2018). Society needs to transform school education into convergence competency development education that can solve complex problems in the context of learners' lives through

self-directed and cooperative exploration, rather than one-sided teaching of fragmented knowledge (Son & Jung, 2019; Kwon et al., 2021).

In line with these educational changes, Korea is promoting the full introduction of the high school credit system by 2025(Ministry of Education, 2021). With the full implementation of the high school credit system, the demand for convergence education (integrated STEM) contents so that students can experience science and technology sites and connect with career education is increasing (Hong, Lee, & Lim, 2022; ). It is necessary to develop and distribute class guides and student workbooks that can be applied by in-service teachers by studying the convergence class plan in preparation for the high school credit system and reviewing the effectiveness of the corresponding programs (Woo & Kim, 2019; Kim, 2021; Kim & Hong, 2021; Lee, Yoon, & Yoon, 2022).

The main purpose of this study is to develop a Korean-style convergence education program that can develop the convergence competency that can adapt to the full introduction of the high school credit system and the changes of the future society. In addition, effectiveness analysis will be conducted through the development and application of convergence education (Korea's STEM education) program in relation to representative future occupations that can be used in the high school credit system. Through this study, it is possible to develop a convergence education program to increase students' interest in technology and engineering and provide them with opportunities to explore careers linked to engineering-related subjects.

## 2. LITERATURE REVIEW

### *2.1. Convergence (Integrative STEM) Education in Korea*

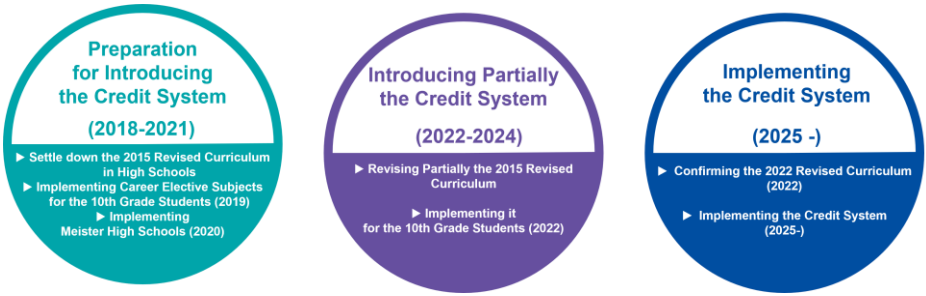
Since 2011, the Korean government has promoted the development and diffusion of STEAM education programs. Currently, it is in the stage of increasing the dissemination and field utilization of convergence class models and programs. First, the government and local education offices have selected and operated leading schools for convergence education and have promoted professional learning community support for teachers' convergence education and school makerspace projects (Baek. et al., 2011; Lee, et al., 2012).

Due to interest in technology and engineering in Korean convergence education, there has been a demand for engineering-focused high school programs. Existing developed programs were found to be too focused on science or mathematics and lacked the flexibility to be used in school settings. To solve these problems, the convergence program should start from a problem situation based on the real life of students. In addition, high school students can improve their attitude toward the field of convergence through a convergence program related to engineering-related jobs (Park. et al., 2012; Jung, Jun, & Lee, 2015; Kwak & Ryu, 2016; Gang & Jin, 2019).

### *2.2. High School Credit System in Korea*

The high school credit system is a new education policy that guarantees learners the right to choose their subjects, allowing students to choose and complete the subjects they want by their career path or interest, and graduate when the minimum achievement level for each subject is met and the required credits are met (Ministry of Education, 2021; Lim, 2022). The implementation plan for the credit system is presented in Figure 1. In 2018, a total of 105 research and leading schools were piloted, and from 2019, it has been expanded to 354 schools and is being piloted. It will be first introduced in Meister high schools in 2020, partially introduced in specialized high schools and general high schools in 2022, and fully implemented in all high schools in 2025(Hong, 2018; Lee, 2018).

*Figure 1.*
*Implementation Plan for the High School Credit System*




### *2.3. Technology Education in the 2022 Revised National Curriculum*

With the introduction of the high school credit system in 2025, the 2022 revised curriculum will be implemented, which will restructure subjects focused on student career, aptitude, and competency, and will implement future-oriented instruction and assessments. In the revised curriculum, elective subjects are composed of subjects that allow subject convergence learning, career guidance learning, in-depth learning by subject, and real-life experience learning. Elective courses in high school consist of general electives, convergence electives, and career electives. Among them. convergence elective subjects have been newly established, and their importance has been emphasized as subjects for convergence of subjects within and between subjects, as well as for real-life experience and application(Ministry of Education, 2022a; Gang, 2023).

In the 2022 curriculum, high school technology education is not a compulsory subject, and as a general elective subject, technology subject and home-economics subject are combined and operated under the title of technology and home-economics. There are ‘Robot and Engineering World’ as career elective courses, and ‘General Intellectual Property’ and ‘Creative Engineering Design’ courses as convergence elective courses as Table 1(Ministry of Education, 2022b, Kim, 2023).

*Table 1.*
*High School Technology Education in 2022 Revised National Curriculum.*

| General Electives | Career Electives | Convergence Electives |
|---|---|---|
| Technology & Home-Economics | Robot and Engineering World | General Intellectual Property<br>Creative Engineering Design |

'Robot and Engineering World' utilizes basic knowledge in various subjects such as science, mathematics, and information to deepen and expand the content and level of technology, and to understand, design, and manufacture robots, which are representative examples of the convergence of various technologies and engineering. It is a subject that provides an opportunity to solve robot-related problems and at the same time explore various career paths in the world of robot-related engineering (Ministry of Education, 2022b).

The 'Creative Engineering Design' subject experiences the problem-solving process of engineering, understands engineering, explores convergence engineering problems, and learns engineering problem-solving and creative design, which are the basic competencies of engineering. It aims to cultivate attitudes (Ministry of Education, 2022b).

## 3. METHODOLOGY

### *3.1. Research Design*

The goal of this study is to verify the effect of an engineering-focused STEAM education program applied to high school students on students' attitudes toward STEM, and the research procedure is shown in Figure 2.

To carry out this study, a basic research framework was prepared by analysing previous studies of the STEAM program. The program development team, mainly composed of in-service high school teachers, identified promising future occupations through repeated discussions with the basic research team and developed the program through consultation with external experts. The procedure of program development is shown in Figure 3. The field application team, composed of in-service high school teachers, analyses the effectiveness of the program by pilot-applying the developed program to students in 4 schools.

*Figure 2.*
*Research Procedure*

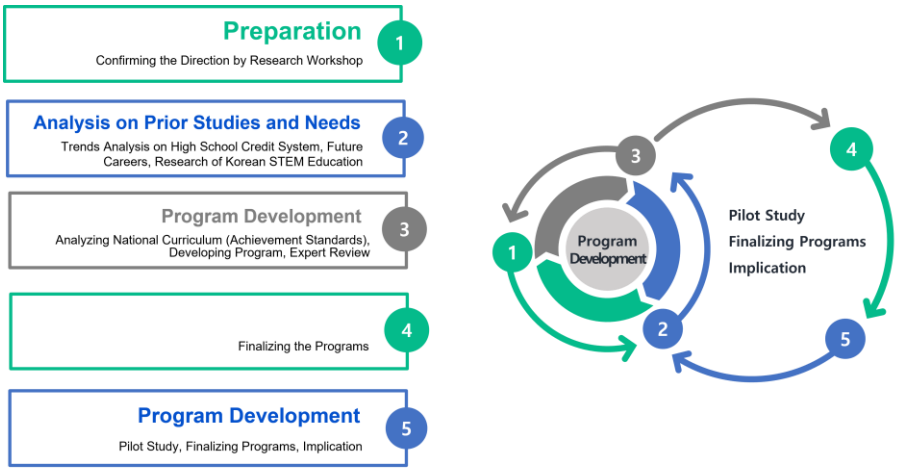
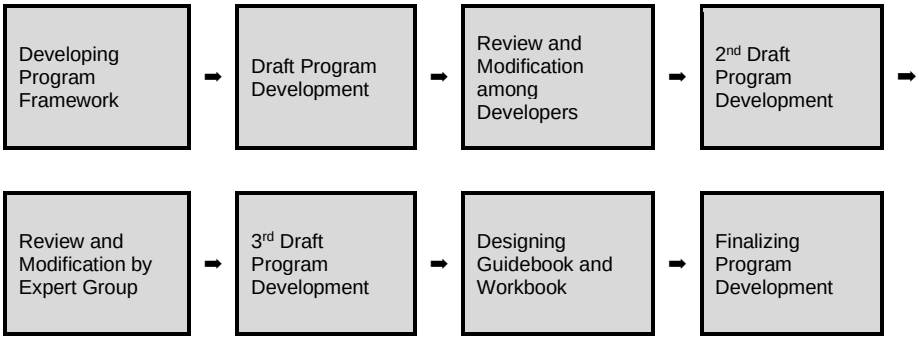



*Figure 3.*
*Program Development Procedure*




### *3.2. Participants*

This study was composed of a single group pre-test and post-test design and applied to 900 students from 4 high schools as Table 2. For a single group, the attitude toward STEM was verified before and after the class, and the satisfaction level of the STEM class was investigated after the class.

*Table 2.*
*Pilot studies: Implementation in schools*

| Program | class time | School | Application period | Main Subjects | Number of students |
|---|---|---|---|---|---|
| I am an Expert for Regenerative Energy | 6 | A High School | 9.12.~9.30. | Introductory of Engineering (12th) | 100 |
| | 8 | B High School | 8.2.~10.4. | Introductory of Engineering (11th) | 41 |
| Dream Comes True: Planning to buy my Own Housing | 6 | C High School | 8.29.~9.30. | Technology &Home-economics (10th) | 319 |
| I am a creative tarf designer | 6 | C High School | 8.29.~9.30. | Career (11th) | 116 |
| Air and sound pressure fluctuations | 4 | B High School | 9.26.~11.8. | Scientific exploration experiment (10th) | 250 |
| Into the World of Data Literacy | 5 | D High School | 8.30.~9.20. | Technology &Home-economics (10th) | 100 |
| Total participants | | | | | 926 |

### *3.3. Data Collection and Analysis*

An online survey was conducted targeting 900 students from 4 schools participating in STEM classes. This study analysed the data of 691 students who participated in both the pre-test and post-test for the STEM attitudinal instrument. Also, for exploring student satisfaction with convergence education (STEM) class, this study analysed the data of 736 students who faithfully participated in the satisfaction survey after the program ended. Prior to the survey, the purpose of the survey was sufficiently explained to the students, and consent was obtained in advance to conduct an online survey targeting students who wished to participate. The survey was conducted before the program started, and the post-survey was conducted within a week after the program ended.

## 4. RESULTS

### *4.1. Program Development*

High school credit system STEM programs (Teacher guidebook, student workbook, teacher class PPT, media content materials) were developed. The developed programs were shown in Table 3.

*Table 3.*
*Title and Related Occupation for Final Programs*

| Program Title | Related Future Occupation |
|---|---|
| Into the World of Data Literacy | Data Literacy Expert |
| I am an Expert for Regenerative Energy | Regenerative Energy Expert |
| Air and Sound Pressure Fluctuations | Airflow Control Engineer |
| I am a Creative Tart Designer | Camping Business Expert |
| Dream Comes True: Planning to buy my Own Housing | Financial Expert |

### *4.2. Effects of Korean STEM Education Programs: Students' Attitude*

As a result of analysing the data of 691 students from 4 schools who responded both before and after, the student's attitude towards convergence education (STEM) class showed a significant change (t=-56.318, p=0.000). As a result of the overall comparison before and after the attitude test, it was found that student's attitude toward convergence education (STEM) class improved statistically significantly with the application of the program (t=-56.318, p=0.000).

Specifically, there are significant changes in the 'self-direction and reflection' and 'self-concept and efficacy' of the two constructs in the convergence education (STEM) class student attitude questionnaire. This indirectly indicates that students' self-directed learning and reflection took place in this program, and their self-concept and self-efficacy were increased through these convergence education programs. The convergence education (STEM) program developed in preparation for the high school credit system positively improves the attitude of high school students to STEM class learning.

#### *4.2. Student Satisfaction through STEM Class*

As a result of the student satisfaction survey, the average of the overall student satisfaction question was relatively high at 3.82, and the students participating in this study were satisfied with all the programs developed.

The item with the highest level of satisfaction in the survey was 'I listened to and respected the opinions of other friends,' with a score of 4.20. This was followed by 'I learned the importance of collaborating with other friends' on 4.12. It is judged that this is because most of the existing high school classes were lecture-type classes, but STEM classes are mostly group activities and discussion/debate activities. In addition, since the developed programs are based on collaboration in the process of generating and selecting ideas, it is a result that meets the intention of the program.

The lowest score was 3.29, which is the item 'I like reading books or articles related to science, technology, and information', which means that the program does not change much in a short period of time because it is a program that is operated in a short period of time at least 4 times and at most 6 times. imply that it was not However, this proves that gradual changes in the above

areas can be expected if the program is stably expanded and operated, and continuous support and verification are necessary.

As shown in Table 4, because of analysing the satisfaction level by job, the cooperative attitude showed the highest level of satisfaction. It is recognized that the STEAM class described above requires a cooperative attitude and that students feel satisfaction in the process of cooperation through the STEAM class.

It is judged that the students responded positively to this Convergence Education (STEM) class because there were few opportunities for problem-solving learning and cooperative learning in the entrance exam-oriented education. In addition, since collaboration with peers and communication skills are important in the present and future society in which students will live, the developed convergence education (STEM) program is judged to have led students to have a positive perception.

*Table 4.*
*Students Satisfaction Results for Individual Factor*

| Factor | Mean | Standard Deviation |
|---|---|---|
| Problem Solving and Convergence Thinking Ability | 3.89 | 0.7140 |
| Cooperative Attitude | 4.06 | 0.6922 |
| Challenge | 3.83 | 0.9687 |
| Concern toward Engineering | 3.83 | 0.9687 |
| Attitude toward STEM Subject | 3.50 | 1.0051 |

## 5. DISCUSSION

The developed program can be used in a variety of subjects by field teachers aiming for convergence education (STEM) classes within the high school credit system, which will be fully implemented in 2025. In addition, it is expected that it will provide opportunities to contemplate the changing aspects of the world of work and become creative problem solvers. In addition, based on practical experience and data on models and assessment methods for convergence classes, student participation-centered STEM instructional models and assessment methods will be created. This program is expected to have a positive effect on the conviction of convergence education based on its high field applicability.

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