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Development of Teaching Methods to Improve Mathematical Capabilities for Electronics Engineering

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Abstract

The importance of mathematics is emerging to create new values and secure competitiveness in an intelligent information society based on the Fourth Industrial Revolution. This study was conducted with the aim of improving the academic performance and increasing interest of electronics majors in mathematics subjects. In order to develop learners' mathematical capabilities in major fields that utilize mathematics that electronics majors do not prefer, we have proposed a new teaching method to promote employment in mathematics-based electronics fields. In addition, to enhance learners' self-directed learning, we developed teaching methods for efficient mathematics subjects with programming languages as tools in electronics engineering and applied them to real-world teaching sites to effectively cultivate academic performance improvement of majors. Finally, we conducted a survey and statistically analyze the effectiveness of the developed teaching methods to present effective operational measures for mathematics education, an essential tool in intelligent information technology.

Keywords: *Teaching Method, Surveys, Mathematics, Employment Rate, Programming Language*

1. Introduction

In recent years, the Fourth Industrial Revolution means that all machines and components are connected to the Internet to perform tasks automatically by the judgment of computers or systems. As a result, the importance of artificial intelligence (AI) and data science has been highlighted, and the combination of machine learning and big data is creating opportunities for innovative industries and the possibility of wealth creation [1]. In the era of the Fourth Industrial Revolution, major technologies of AI are generated as innovative mathematical algorithms, and mathematics is drawing attention as a key competitive edge. Mathematics is becoming increasingly important in many ways, including language processing of AI technology, and global companies are developing original technologies based on their math capabilities and expanding their influence. Due to this change in the environment, mathematical methodologies and approaches support central research in the field of electronic engineering and are directly applied, so it should be actively used for technology development and industrial innovation through strengthening mathematical capabilities. As the employment rate of graduates is used as a key evaluation indicator during university evaluations and the resulting restructuring of universities is in full swing, interest in the

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employment rate of schools and departments is improving in universities. As the employment rate drops significantly, competitiveness among universities and government budget support is reduced, private universities are facing a management crisis and forced out, so improving the employment rate is absolutely important.

The goal of this study is to reflect this reality and suggest ways to improve employment rates in departments. In this study, we intend to contribute to the improvement of the employment rate by identifying and improving the problems by analyzing the employment rate of Department E in the electronic engineering field of S University in Seoul. It is a reality that electronics graduates are not employed in various majors but only in certain fields, and students are found to be giving up their jobs in the field by avoiding taking courses that utilize mathematics [2].

In order to improve employment rates in the future, we would like to teach electronics majors in mathematics-related teaching methods to improve interest in the field of mathematics and thereby increase employment rates from three perspectives. Firstly, electronics engineering majors wanted to develop optimal teaching methods that contribute to improving the academic performance of mathematics subjects under a strategy to improve their interest in mathematics and induce employment. Secondly, by strengthening self-directed learning for electronic engineering majors through teaching methods that utilize computers as tools, the employment rate was intended to be improved to major areas that utilize mathematics. Finally, through the information derived from the survey and analysis results of this study, we propose an efficient operation of mathematics-related teaching methods and curriculum that can ultimately promote creativity and problem-solving skills in the field of electronics.

2. Status of Mathematics Education and Suggestions for Improvement

2.1 Mathematics Education Status

Above all, the fundamental purpose of mathematics education in electronics curriculum is to train engineers with mathematical-based logical thinking and problem-solving skills and creative circuit design skills. In addition, the curriculum should be designed to train research personnel who can mathematically formulate and organize creative abilities and technical problems to conduct original academic research in electronics. This design will link the major knowledge of mathematics to actively solve technical problems in the industry and train technical personnel leading the development of new technologies. In addition, these talents will be able to strengthen the technological competitiveness of electronic engineering by converging their major knowledge of mathematics in the 4th Industrial Revolution and maintain their competitive capabilities.

For first-year science and engineering majors, the university provides courses according to their ability to study due to differences in the individual level of mathematics learning skills. Therefore, as an improvement for under-standard students, Kim [3] proposed efficient teaching guidance for professors in college mathematics, Kim [4] proposed specific teaching methods for functions and graphs in the first year of engineering, and Jun [5] proposed operating mathematics courses. However, since the above existing research is a professor-centered method of mathematics education, we would like to develop mathematics-related teaching methods with programming language in electronic engineering curriculum and present an efficient improvement system through question-and-answers. Factors that increase the efficiency of mathematics education include curriculum, teaching methods, faculty qualities, learner learning, learner's interest in mathematics, mathematical confidence, recognition of mathematical value, and motivation to learn.

Professors should develop a variety of teaching methods to improve academic performance through self-directed learning, taking into account learners' motivations, positive perceptions of learning, self-efficacy, satisfaction and awareness of learning into account. The electronic engineering curriculum consists of a major education course, a major basic course, a major deepening and application course, and a

major practice course and a new technology application course. The electronics curriculum is divided into five major tracks: information and communications and signal processing tracks, systems and control tracks, semiconductor and electronics tracks, microwave and optical tracks, and computer and circuit design tracks [7].

2.2 Satisfaction in Mathematics Education

Mathematics is widely used for detailed major tracks in electronics. The curriculum includes a wealth of mathematical expertise in the order of information and signal processing tracks, systems and control tracks, semiconductor and electronic material tracks, microwave and optical tracks, and computer and circuit design tracks. Therefore, the importance of mathematics is understood in the order of each major track above. In particular, information and signal processing tracks, systems and control tracks require profound mathematics major knowledge and linkage as well as university mathematics, engineering mathematics, probability and random signals. Graduates of electronics engineering have been employed or are hoping to get a job on semiconductor and electronic materials tracks, microwave and optical wave tracks, and computer and circuit design tracks, which are areas where math subjects are underutilized. In particular, semiconductor and electronic material tracks, microwave and optical wave tracks, and computer and circuit design tracks require general knowledge acquired from university mathematics and engineering mathematics and probability knowledge related to noise processing. Therefore, Section 3 aims to promote effective mathematics education in electronics curriculum by developing teaching methods that increase electronics majors' interest in mathematics, value recognition, motivation to learn, mathematical confidence, and interest in mathematics.

3. Development of Mathematics Teaching Methods in Electronics Curriculum

The subjects of university mathematics and engineering are the first and second-year majors and are compulsory at the department level. Third grade subjects are designated with probability and random signals. In this study, we developed teaching methods suitable for mathematics subjects in electronic engineering to diversify educational programs. Second, we analyzed the feasibility of learning effects to improve the quality of mathematics education.

3.1 Contents of Teaching Methods Applied Computer Programming Language to Mathematics Subjects.

The goal of programming tool teaching is to effectively develop advanced engineering, not just basic subjects, by identifying the connection between mathematics and electronics majors and the importance of mathematics in electronics. In this study, a programming tool teaching method was developed as a teaching method for mathematics-related subjects in electronic engineering curriculum, and case education was conducted through this. Programmatic teaching is a method of presenting teaching instructions on electronic blackboards to streamline class time, explaining how mathematics is applied in electronic engineering and software, and then a professor implements and demonstrates simple examples in various programming languages.

The advantage of the above teaching method is that it utilizes difficult examples and exercises to increase concentration and efficiency of learners subject to education. As the professor solves the questions directly on the blackboard, questions are solved through questions between the professor and the learner. By lecturing various uses of mathematics in electronics, including software, the quality of classes can be improved through the curiosity of learners and understanding interdisciplinary connections. In addition, by coding examples taught by professors in various programming languages, learners' creative thinking, problem solving skills, programming coding skills, and software development skills are cultivated.

The flow chart of the developed programming tool teaching method was divided into four stages to

enhance the overall understanding of the curriculum. In particular, the teaching syllabus provided to learners is optimized as a lecture improvement plan for the development of mathematics-related major skills and can be applied to learners. The developed syllabus has the advantage of improving the concentration of lectures through repeated learning by enabling mobile learning such as smartphones, and being able to use it without space constraints outside the classroom. Figure 1 shows the learning methods that are linked to develop mathematics and engineering for educational development.

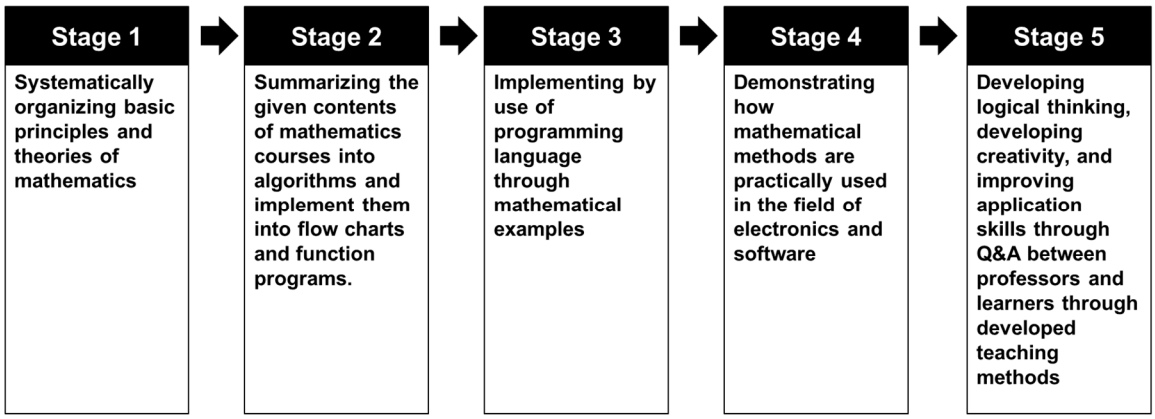

Figure 1. Developing Efficient Mathematical and Engineering-linked Learning Teaching Methods

3.2 Research on Computer Programming Teaching Method

We have applied the programming tool teaching method proposed above to mathematics-related subjects each opened in the second semester of the electronics curriculum in 2019. The purpose of this study is to verify whether it is effective in improving the academic performance of students under study and to reveal the educational effect. In particular, it was intended to show that the academic achievement of mathematics-related subjects in the electronic engineering curriculum is higher if they are studied using programming tools than traditional teaching methods. Second, by teaching and learning programming tools through mathematics-related subjects, experimental research was conducted based on the hypothesis that students could gain more employment in the field of electronic engineering related to mathematics by inducing voluntary changes in their mathematics preferences. Third, the characteristics of the above teaching method were examined through a survey to verify whether the programming tool teaching method was effective for first- and fourth-grade majors.

By setting up students from Department E in electronics engineering at S University as research subjects, we organized 40 students each grade and conducted a survey from December 2 to 13, 2019. After teaching and learning each of the electronics majors, analysis of the results of the questionnaire on learning efficiency and interest in mathematics, recognition of the importance of mathematics, and employment desire in mathematics is presented in Table 1. Comparing the survey data by grade with the change in grade, the first grade survey data means that the satisfaction of the developed teaching method was high in all categories, and the second grade showed an upward trend, so the satisfaction of the developed teaching method increased. Therefore, the developed teaching method is considered effective. Based on this, the significance of this study is that it actively introduces mathematics utilization and connectivity in electronics and software fields to mathematics' teaching-learning, providing a clearer representation of mathematics values, which can positively change the perception of mathematics education.

Table 1. Analysis on Satisfaction Survey Results for Mathematical Competency (units: frequency (%))

Item	Year 1	Year 2	Year 3	Year 4	N
Learning Efficiency in Mathematics	30 (75.0%)	33 (82.5%)	35 (87.5%)	34 (85.0%)	40 each
Interest in Learning Mathematics	29 (72.5%)	32 (80.0%)	35 (87.5%)	33 (82.5%)	40 each
Recognition of the Importance of Mathematics	33 (82.5%)	35 (87.5%)	38 (95.0%)	38 (95.0%)	40 each
Employment as a Field of Electronic Engineering that uses Mathematics	30 (75.0%)	32 (80.0%)	34 (85.0%)	33 (82.5%)	40 each

After teaching and learning each of the above methods, Table 2 shows an analysis of the results of the questionnaire on scientific thinking, scientific creativity, scientific exploration, scientific problem solving, and scientific convergence. Comparing the survey data by grade with the change in grade, the first grade survey data means that the satisfaction of the developed teaching method was high in all categories, and the second grade showed an upward trend, so the satisfaction of the developed teaching method increased. Therefore, it is judged that the programming tool teaching method developed was effective. Based on this, the significance of this work is that it provides the potential to efficiently communicate the utilization and connectivity of mathematics related to Al, deep learning techniques, big data analysis, security cryptographic algorithms, etc. by actively introducing computer programming as a tool. It is expected that this will positively change the perception of convergence between the mathematics and electronics sectors.

Table 2. Analysis on a Scientific Competency-related Satisfaction Survey (units: frequency (%))

Item	Year 1	Year 2	Year 3	Year 4	N
Scientific Thinking	30 (75.0%)	31 (77.5%)	33 (82.5%)	32 (80.0%)	40 each
Scientific Creativity	29 (72.5%)	31 (77.5%)	35 (87.5%)	34 (85.0%)	40 each
Scientific Exploration Ability	31 (77.5%)	32 (80.0%)	36 (90.0%)	35 (87.5%)	40 each
Scientific Problem-Solving Power	30 (75.0%)	34 (85.0%)	35 (87.5%)	35 (87.5%)	40 each
Scientific Convergence	34 (85.0%)	35 (87.5%)	37 (92.5%)	38 (95.0%)	40 each

After teaching and learning each of the above teaching methods for electronics majors, analysis of the results of the questionnaire on preferences and job Preferences for each track is presented in Table 3. The first grade survey data means that the satisfaction of the teaching method was higher in all categories as mathematics advanced to higher grades on information and communication and signal processing tracks, systems and control tracks, and that the satisfaction of the developed teaching method increased. In addition, semiconductor and electronic material tracks, microwave and optical wave tracks, and computer and circuit design tracks, which have a low proportion of mathematics, have also risen slightly in grade-specific surveys and grade-changing trends, indicating increased satisfaction with developed teaching methods. Therefore, it is judged that the programming tool teaching method developed was effective.

Table 3. Analysis on Satisfaction related to Track and Job Preferences (units: frequency (%))

Item	Year 1	Year 2	Year 3	Year 4	N
Information and Communication and Signal Processing Track	30 (75.0%)	36 (90.0%)	33 (82.5%)	32 (80.0%)	40 each
Systems and Control Tracks	33 (82.5%)	37 (92.5%)	31 (77.5%)	30 (75.0%)	40 each

Semiconductor and Electronic Materials Track	32 (80.0%)	37 (92.5%)	35 (87.5%)	34 (85.0%)	40 each
Microwave and Light Wave Tracks	30 (75.0%)	32 (80.0%)	28 (70.0%)	26 (65.0%)	40 each
Computer and Circuit Design Track	30 (75.0%)	32 (80.0%)	28 (70.0%)	26 (65.0%)	40 each

Analysis on the results of the questionnaire on preferences and job preferences for each track is presented in Table 4, after each teaching method developed for electronics majors. The first grade survey data means that the satisfaction of the teaching method was higher as the programming was advanced, and the satisfaction of the developed teaching method increased as the programming was advanced. In addition, computer and circuit design tracks with a low proportion of programming, semiconductor and electronic material tracks, and microwave and optical tracks have also risen slightly in grade-specific surveys and grade-changing trends, indicating an increase in the satisfaction of developed teaching methods. Therefore, the developed interactive teaching method and team project teaching method are considered effective. Especially in the era of the Fourth Industrial Revolution, it is clear that only ICT-linked industries will expand and grow, so learners recognize themselves to cultivate coding skills and software knowledge, essential capabilities to prepare for employment.

Table 4. Satisfaction Analysis on Track Preferences and Job Preferences (units: frequency (%))

Item	Year 1	Year 2	Year 3	Year 4	N
Information and Communication and Signal Processing Track	27 (67.5%)	28 (70.0%)	33 (82.5%)	33 (82.5%)	40 each
Systems and Control Tracks	25 (62.5%)	29 (72.5%)	33 (82.5%)	32 (80.0%)	40 each
Semiconductor and Electronic Materials Track	33 (82.5%)	35 (87.5%)	39 (97.5%)	38 (95.0%)	40 each
Microwave and Light Wave Tracks	28 (70.0%)	29 (72.5%)	32 (80.0%)	33 (82.5%)	40 each
Computer and Circuit Design Track	32 (80.0%)	36 (90.0%)	39 (97.5%)	38 (95.0%)	40 each

5. Conclusions

This work presents mathematics teaching methods with the aim of improving the teaching and learning of mathematics subjects by introducing the utilization and linkage of mathematics in the field of electronics. To this end, we conducted training cases and surveys and conducted statistical analysis. In order to produce talent for the development of electronic engineering, electronic engineering curriculum must lay the foundation for major studies based on mathematics. In order to understand the role of mathematics in hardware, including software, specialized mathematics teaching methods associated with computer programming must be presented. A comprehensive analysis of the study's training cases and survey results allows professors to implement and guide mathematical solutions in programming language to foster scientific exploration and scientific connectivity as subjects of learning. In addition, we experience learning effects by understanding mathematical concepts and exploring various methods to implement coding through teaching methods developed with programming tools, which are considered effective in improving mathematical problem-solving and convergence skills such as ICT, AI, IoT, Bigdata, and so on [8-10].

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