International Journal of Advanced Culture Technology Vol.9 No.4 110-117 (2021)
DOI https://doi.org/10.17703/IJACT.2021.9.4.110

IJACT 21-12-12

Proposal of Electronic Engineering Exploration Learning Operation Using Computing Thinking Ability

[1]Seung-Woo LEE, [2]Sangwon LEE

[1]Prof., Dept. of Electronic Engineering, Seokyeong Univ., Korea
[2]Prof., Dept. of Computer & Software Engineering, Wonkwang Univ., Korea
swlee@skuniv.ac.kr, sangwonlee@wku.ac.kr

Abstract

The purpose of the study is to develop effective teaching methods to strengthen the major learning capabilities of electronic engineering learners through inquiry learning using computing thinking ability. To this end, first, in the electronic engineering curriculum, we performed teaching-learning through an inquiry and learning model related to mathematics, probability, and statistics under the theme of various majors in electronic engineering, focusing on understanding computing thinking skills. Second, an efficient electronic engineering subject inquiry class operation using computing thinking ability was conducted, and electronic engineering-linked education contents based on the components of computer thinking were presented. Third, by conducting a case study on inquiry-style teaching using computing thinking skills in the electronic engineering curriculum, we identified the validity of the teaching method to strengthen major competency. In order to prepare for the 4th Industrial Revolution, by implementing mathematics, probability, statistics-related linkage, and convergence education to foster convergent talent, we tried to present effective electronic engineering major competency enhancement measures and cope with innovative technological changes.

Keywords: *Artificial Intelligence, Bigdata, Case Study, Computing thinking, Inquiry Learning, Linkage, Modeling*

1. INTRODUCTION

The period when inquiry and learning methods were highlighted in the school field was from the 3rd curriculum (1973-1981) featuring an academic-centered curriculum, and through this, inquiry and learning methods that place more importance on learners' active inquiry activities than conventional cramming education [1]. Exploratory learning is an active form of learning in which learners do not simply accept various knowledge or information, but solve questions based on data or information, derive new knowledge, and explore the validity of the generated knowledge. Exploratory learning is a process of evaluating and verifying certain assumptions established to solve the uncertain problems raised, and is a systematic teaching method for the process of searching for problems, hypothesis setting, hypothesis verification, and generalization [2]. The advantages of inquiry learning from a learner's perspective are, first, to understand major knowledge and concepts through the inquiry process, to learn the process of creating knowledge through direct experience, and third to develop inquiry functions. As an instructor's inquiry and learning method, first, the subject of study must be proved by observation or experiment, second, the generation of knowledge must be based on scientific

Manuscript received: October 26, 2021 / revised: November 12, 2021 / accepted: December 7, 2021
Corresponding Author: sangwonlee@wku.ac.kr
Tel: +82-63-850-6566
Professor, Dept. of Computer & Software Engineering, Wonkwang Univ., Korea

methods, and third, the result must have a cause, and fourth, a logical curriculum that can prove a causal relationship is needed. As an application principle of inquiry learning method, first of all, teaching-learning for inquiry learning takes a lot of time and effort, so it is efficient to operate the curriculum to reorganize the subject to be learned into cramming, explanatory, and inquiry classes. In the inquiry class, it is more important to cultivate the ability of learners to acquire inquiry methods on their own in a series of inquiry processes and to induce learners' interest. In particular, inquiry classes require not only cognitive aspects but also learners' curiosity, patience to solve problems, and objective academic attitude toward problems. As an expected effect of inquiry learning, it is possible to cultivate inquiry process ability, active and autonomous learning posture, cooperative posture through interaction between learners, tolerance and listening to others, mathematical expression, and logical thinking skills in the process of discovering new knowledge through trial and error.

2. APPLICATION OF AN INQUIRY LEARNING MODEL IN THE CURRICULUM OPERATION OF ELECTRONIC ENGINEERING

In the past, mathematics, probability, and statistics were used as essential tools for studying electronic devices and their application technologies, while now convergence thinking through linkage between mathematics, probability and statistics is an important key. However, the operation of electronic engineering major subjects is not an effective education that induces learners' interest through systematic inquiry learning, but a major learning environment that relies on intuitive thinking and cramming education.

2.1 Mathematics-related Inquiry and Learning Model in the Curriculum Operation of Electronic Engineering

The purpose of electronic engineering's mathematics curriculum operation is to creatively increase problem-solving and logical thinking skills to develop new technologies based on basic theories on electronics and electricity, and secondly to cultivate engineering problem analysis skills for mathematical models [3]. Mathematical modeling consists of four steps. The first step is model establishment, the second step is quantitative analysis of the phenomena of interest using mathematical methods suitable for the established model, the third step is verification of the accuracy of analysis through experiments, and the fourth step is modification of the model by verification results. Through this procedure, it is possible to secure the proximity between the actual electronic engineering phenomenon and mathematical modeling. In electronic engineering, mathematical models are applied in the fields of circuit theory and circuit design, and are a series of equations that express in mathematical structure what happens when various electrical elements are used in the process of moving a constant circuit.

2.2 Probability-related Inquiry and Learning Model in the Curriculum Operation of Electronic Engineering

The purpose of electronics' probability curriculum operation is to first learn how to solve engineering problems as a tool to analyze signals and output noises in an environment where uncertainty exists, and secondly to interpret and implement probabilistic changes in time progress. In electronic engineering, stochastic models are applied in the fields of digital communication, electromagnetic radiation, control engineering, computer networks, and system reliability. The stochastic model is a series of equations expressed in a stochastic structure to predict changes and actions of systems or irregular objects with elements of uncertainty.

2.3 Statistics-related Inquiry and Learning Model in the Curriculum Operation of Electronic Engineering

The purpose of electronic engineering's statistical curriculum operation is to first acquire a statistical method system that can make effective decisions by observing large amounts of engineering data, organizing and analyzing information through scientific methods [4]. In electronic engineering, statistical models are applied in the fields of voice signal, image segmentation, image conversion, image compression, image restoration, digital image, and pattern recognition. The statistical model is a series of equations expressed in a statistical structure that removes noise and minimizes information loss by developing various algorithms using statistical techniques such as smoothing, discriminant analysis, cluster analysis, and principal component analysis. The optimal teaching-learning strategy using inquiry learning in the operation of electronic engineering subjects is presented in Figure 1.

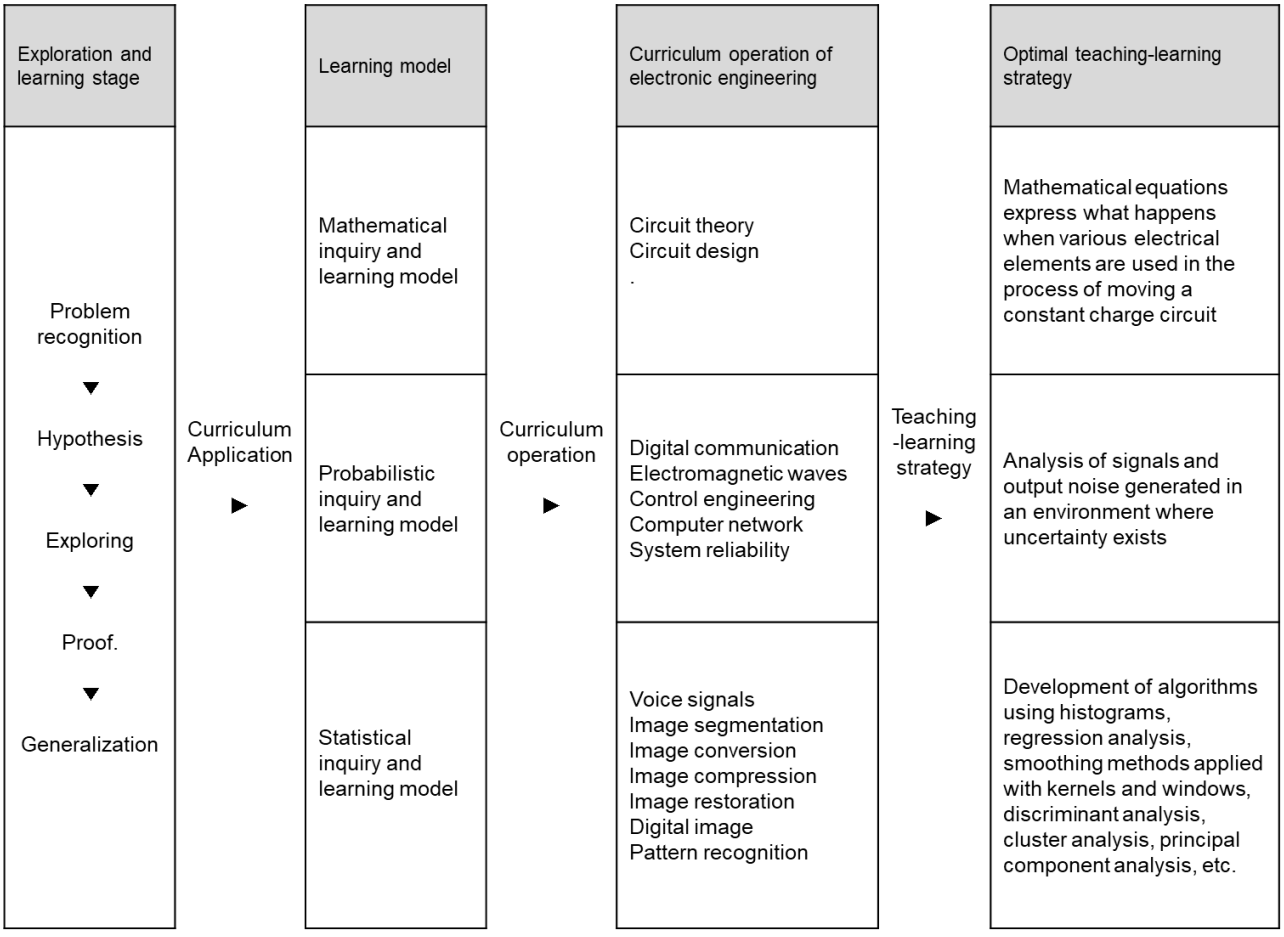

Figure 1. Optimal electronic engineering curriculum operation strategy using exploration learning

3. EFFICIENT ELECTRONIC ENGINEERING CURRICULUM OPERATION USING COMPUTING THINKING SKILLS

Components of computing thinking presented by International Society for Technology in Education (ISTE) and Compute Science Teachers Association (CSTA) systematically structure problems, analyze data logically, organize data, model or simulate abstracts, and automate them. Components of computing thinking can

maximize computing thinking capabilities through linkage training in mathematics, probability, and statistics. The roles of mathematics, probability, and statistics to increase computing thinking are presented in Table 1.

Table 1. Contents of electronic engineering-linked education based on the components of computing thinking

Components of computing thinking	Curriculum	Contents of linked education
① Analyzing data and organizing it logically ② Expressing data ③ Perform and verify efficiently	Probability Statistics	- Classification of collected data - Extracting information using graphs and chart-related tools - Verification of whether the extracted information effectively expresses the characteristics of the entire data
④ Modeling	Mathematics Probability	- Simplifying the complex real world into a certain form of notation - Ability to quantify observable phenomena
⑤ Abstract painting	Mathematics	- After decomposing and analyzing the complex structure of reality, briefly setting it as a core concept and function
⑥ Algorithmic thinking	Mathematics	- Thinking about ways to solve the problem - A series of sequential calculation procedures to solve the problem
⑦ Problem solving process	Mathematics Probability Statistics	- Experience in high-quality math activities through the problem-solving process - Increase creativity, logic, and criticism through mathematics - Probabilistic approach to engineering uncertainty - Data selection method by selecting appropriate factors through statistical analysis - Data analysis through experimental planning and implementation

In addition, systematically structuring problems in detailed components of computing thinking ability to solve problems using computers, expressing data through simulations, automating solutions, and applying and generalizing them to other problems through problem-solving processes can maximize computing thinking capabilities [7].

The contents of electronic engineering major subjects can be divided into theoretical education and practical education. Major theory education can increase problem-solving ability, which is based on computing thinking ability, through basic and linked education on mathematics, probability, and statistics. And problem-solving skills are developed based on inquiry learning. Major practical training is organized into programming education to implement control and automation.

Therefore, electronic engineering major subject teaching-learning can be effectively operated as inquiry learning and programming education through computing thinking capabilities. In other words, first, it is possible to pursue mathematics, probability, and statistical capabilities through inquiry learning based on computing thinking, second, programming capabilities can be strengthened through detailed components of computing thinking, and third, electronic engineering major education can be maximized through synergy effects.

4. AN EMPIRICAL STUDY ON THE OPERATION OF ELECTRONIC ENGINEERING INQUIRY LEARNING

4.1 Research Methods

In this study, an exploratory teaching method using computing thinking ability was developed as a teaching method for major subjects related to mathematics, probability, and statistics in the electronic engineering curriculum, and case education was conducted through this.

The purpose of the exploratory teaching method using computing thinking is to clarify that mathematics, probability, statistics, and electronic engineering majors and the importance of mathematics, probability, and statistics in electronic engineering are essential subjects. Second, after understanding how mathematics, probability, and statistics are applied and applied in the field of electronic engineering, it is intended to select topics that can be fused and to cultivate learners' ability to perform problem-solving processes by themselves. Third, we intend to cultivate computing thinking through a method of implementing and demonstrating this linkage and convergence process in various programming languages.

In order to increase the understanding of the overall subject content, the flow chart of inquiry-style teaching methods using the developed computing thinking ability was divided into three stages: introduction, development, and termination.

In the first step, the introduction, class goals and motivation were presented to learners. In the second step, the development, the learner was presented with understanding the conceptual principle, individual problem-solving process, and project-type problem-solving process. In the third step, the conclusion, learning organization and assignment were presented to learners.

4.2 Research Results

This section aims to verify whether it is effective in improving the academic achievement of students studied by teaching-learning topics related to mathematics, probability, and statistics in the second semester of the electronic engineering curriculum in 2019. In particular, in the electronic engineering curriculum, it was intended to show that the academic achievement of students in the 1st to 4th grades was higher when learning through exploratory teaching using computing thinking than traditional lecture-style teaching methods. Second, an experimental study was conducted based on the hypothesis that students' voluntary changes in consciousness about math, probability, and statistics can be induced by teaching and learning topics related to mathematics, statistics. Third, in order to verify whether exploratory teaching using computing thinking skills is effective for first to fourth graders, the characteristics of the above teaching method were examined through a survey.

For this study, the E department of electronic engineering at S University located in Seoul was selected, and 40 students from each grade voluntarily participated in the study, and surveys were conducted from December 9 to 20, 2019.

Table 2 shows the analysis of the results of the questionnaire on the satisfaction level of inquiry-style teaching methods using computing thinking skills by grade of electronic engineering majors. Electronic engineering majors were found to have improved their ability to systematically structure using data analysis, graph and chart through exploratory teaching using computing thinking ability as a tool in the second semester.

In particular, it was found that the systematic structuring-related capabilities were greatly improved by utilizing modeling, algorithm thinking, problem-solving processes, and computers. Therefore, it was found that the exploratory teaching method using computing thinking ability was effective.

Table 2. Analysis of satisfaction results with exploratory teaching methods using computing thinking skills (units: frequency (%))

Type	Grade	N	Lecture teaching method (semester 1)	Exploration teaching method (semester 2)
Data analysis	1	40	13 (32.5%)	15 (37.5%)
	2	40	18 (45.0%)	25 (62.5%)
	3	40	20 (50.0%)	32 (80.0%)
	4	40	25 (62.5%)	36 (90.0%)
Extracting information through graphs and charts	1	40	15 (37.5%)	17 (42.5%)
	2	40	20 (50.0%)	22 (55.0%)
	3	40	22 (55.0%)	34 (85.0%)
	4	40	24 (60.0%)	35 (87.5%)
Verification	1	40	14 (35.0%)	14 (35.0%)
	2	40	19 (47.5%)	20 (50.0%)
	3	40	21 (52.5%)	30 (75.0%)
	4	40	23 (52.5%)	32 (80.0%)
Modeling	1	40	13 (32.5%)	26 (65.0%)
	2	40	18 (45.0%)	31 (77.5%)
	3	40	25 (62.5%)	36 (90.0%)
	4	40	26 (65.0%)	37 (92.5%)
Abstract painting	1	40	12 (30.0%)	16 (40.0%)
	2	40	17 (42.5%)	23 (57.5%)
	3	40	20 (50.0%)	33 (82.5%)
	4	40	21 (52.5%)	34 (85.0%)
Algorithmic thinking	1	40	15 (37.5%)	25 (62.5%)
	2	40	21 (52.5%)	34 (85.0%)
	3	40	22 (55.0%)	37 (92.5%)
	4	40	23 (57.5%)	39 (97.5%)
Problem solving process	1	40	19 (47.5%)	24 (60.0%)
	2	40	21 (52.5%)	32 (80.0%)
	3	40	26 (65.0%)	36 (90.0%)
	4	40	26 (65.0%)	38 (95.0%)
Systematically structured using computers	1	40	15 (37.5%)	26 (65.0%)
	2	40	25 (62.5%)	33 (82.5%)
	3	40	27 (67.5%)	38 (95.0%)
	4	40	29 (72.5%)	39 (97.5%)

Table 3 shows the analysis of the results of the questionnaire on the satisfaction of inquiry-style teaching methods through mathematical inquiry learning by grade of electronic engineering majors. Electronic engineering majors were found to have increased their mathematical capabilities in Circuit Theory, Circuit Design, Electromagnetics, Electronic Circuit, and Electromagnetic Radiation through exploratory teaching

methods in the second semester.

Table 3. Analysis of satisfaction results in exploratory teaching methods through mathematical inquiry learning (units: frequency (%))

Type	Grade	N	Lecture teaching method (semester 1)	Exploration teaching method (semester 2)
Mathematical inquiry learning	1	40	19 (47.5%)	30 (75.0%)
	2	40	18 (45.0%)	33 (82.5%)
	3	40	22 (55.0%)	37 (92.5%)
	4	40	24 (60.0%)	37 (92.5%)

Table 4 shows the analysis of the results of the questionnaire on the satisfaction level of inquiry-style teaching methods through probabilistic inquiry learning by grade of electronic engineering majors. Electronic engineering majors were found to have increased probabilistic modeling-related abilities in signal and systems, digital communication, digital signal processing, and control engineering through exploratory teaching methods in the second semester.

Table 4. Analysis of satisfaction results in exploratory teaching methods through probabilistic inquiry learning (units: frequency (%))

Type	Grade	N	Lecture teaching method (semester 1)	Exploration teaching method (semester 2)
Probabilistic inquiry learning	1	40	17 (42.5%)	15 (37.5%)
	2	40	18 (45.0%)	30 (75.5%)
	3	40	20 (50.0%)	36 (90.0%)
	4	40	23 (57.5%)	39 (97.5%)

Table 5 shows the analysis of the results of the questionnaire on the satisfaction level of inquiry-style teaching methods through statistical inquiry learning by grade of electronic engineering majors. Electronic engineering majors were found to have increased their statistical modeling-related abilities in digital image processing, intelligent system, and pattern recognition through exploratory teaching methods in the second semester.

Table 5. Analysis of satisfaction results in exploratory teaching methods through statistical inquiry learning (units: frequency (%))

Type	Grade	N	Lecture teaching method (semester 1)	Exploration teaching method (semester 2)
Statistical inquiry learning	1	40	14 (35.0%)	13 (32.5%)
	2	40	15 (37.5%)	27 (67.5%)
	3	40	23 (57.5%)	37 (92.5%)
	4	40	22 (55.0%)	38 (95.0%)

5. CONCLUSIONS

First, this study attempted to propose an efficient operation of inquiry learning related to mathematics,

probability, and statistics by utilizing computing thinking skills in electronic engineering curriculum. Second, it was intended to present a strategy to successfully perform the inquiry learning model by presenting an inquiry learning case. Third, we tried to develop modeling problems suitable for the electronic engineering curriculum as an inquiry learning model in the educational field and apply them to the classroom.

The significance of this study was, first, effective in active instructional activities of learners by actually applying inquiry classes using mathematics, probability, and statistical modeling. Second, the learner's thinking process has been increased to the ability to understand and acquire math, probability, and statistical learning contents on their own through inquiry classes using computing thinking skills. Third, since inquiry learning modeling classes express real-world situations, mathematical situations, and scientific situations, it is considered that they can cultivate not only math, probability, and statistical skills, but also problem-solving and critical thinking skills in real life.

Through this electronic engineering major teaching-learning process, learners tried to present synergies in major education based on improved academic achievement in major theory subjects related to mathematics, probability, and statistics and programming through inquiry learning through computing thinking.

ACKNOWLEDGEMENT

This Research was supported by Seokyeong University in 2021.

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