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Strategic Model Design based on Core Competencies for Innovation in Engineering Education

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Abstract

As the direction of education in the fourth industry in the 21st century, convergence talent education that emphasizes the connection and convergence between core competency-based education and academia is emerging to foster creative talent. The purpose of this paper is to present the criteria for evaluating the competency of learning outcomes in order to develop a strategic model for innovation in engineering teaching-learning. In this paper, as a study to establish the direction of implementation of convergence talent education, a creative innovation teaching method support system was established to improve the quality of convergence talent education. Firstly, a plan to develop a teaching-learning model based on computing thinking. Secondly, it presented the development of a teaching-learning model based on linkage and convergence learning. Thirdly, we would like to present educational appropriateness and ease based on convergence learning in connection with curriculum improvement strategies based on computing thinking skills. Finally, we would like to present a strategic model development plan for innovation in engineering teaching-learning that applies the convergence talent education program.

***Keywords**: Computing, Convergence, Core Competencies, Curriculum, Thinking.*

1. Introduction

In order to prepare for the future society and solve various problems in various contexts, including real-world phenomena, the ability to integrate, apply, and utilize various forms of knowledge is required. Convergence education is aimed at increasing interest and understanding in science and technology and fostering convergent thinking and real-life problem-solving skills based on science and technology. Therefore, as the direction of future education, core competency-based education and convergence talent education to foster convergent and creative talent are emphasized. Korea began strengthening convergence talent education to foster creative convergence talent in 2011, and accordingly, it is promoting curriculum development, future science and technology teaching-learning system, and class model development. Convergence talent education

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began to improve the problems of general knowledge transfer and memorization-oriented teaching methods. Convergence talent education presents real-life problems, not artificial situations that only regenerate knowledge that learners know, and emphasizes the ability of basic and practical skills to experience, produce knowledge, and handle it efficiently. Currently, convergence talent education aims not only to induce interest in science and technology, but also to understand the principles of science and technology and achieve the achievement standards of science and mathematics subjects to grow into talent in related fields.

This study proposes the development of a strategic model for innovation in engineering teaching-learning based on the core competencies necessary for convergence talent education to change from the perspective of ‘what will it teach?’ to ‘what experience will it provide?’ The instructor encompasses the entire learning content but presents the problem situation considering real life to the learner. In addition, by recognizing learning activities as problems arising from the learner’s own real life, learners want to include not only knowledge but also the use of practical reflection in learning activities. Convergence talent education consists of three stages of learning criteria: situation presentation, creative design, and emotional experience. Situation presentation allows students to feel the need to solve problems in detail. Creative design fosters problem-solving skills by finding solutions to problems by learners themselves. Learners feel the experience of success by solving problems and try to challenge new problems through emotional experiences [1]. In the series of convergence talent education, there is a problem that few prior studies have been conducted to provide a deep understanding and insight into the educational evaluation (assessment) such as instructors’ educational purpose, content, and method, and learners’ achievement, effectiveness, and efficiency. In order to cultivate convergent talents required by the 21st century, this paper proposes an educational plan to foster creative convergent thinking and real-life problem-solving skills based on science and technology.

2. Engineering teaching-learning design through reinforcement of innovation capabilities

2.1. Core competencies required to improve the curriculum

The 2015 revised curriculum presented the ability to develop the practical ability to do something in the actual life of learners throughout the curriculum, creative experience activities, and school life. In other words, there are six common core competencies of the 2015 revised curriculum general theory: self-management competency, knowledge information processing competency, creative thinking competency, aesthetic emotional competency, communication competency, and community competency. In particular, in mathematics and science subjects, competencies suitable for the subject are presented in connection with the above six common core competencies, and a curriculum suitable for the characteristics of the subject is operated. Knowledge information processing capability is the ability to process and utilize knowledge and information in various areas to reasonably solve problems. ‘Creative Thinking Competency’ is the ability to create new things by converging knowledge, skills, and experiences in various specialized fields based on a wide range of basic knowledge [2]. The core competencies of mathematics and science subjects necessary for engineering teaching and learning are as follows. First, the core competencies of the mathematics curriculum are problem solving, reasoning, creativity and convergence, communication, information processing, attitude, and practice. Second, the core competencies of the science curriculum are scientific thinking ability, scientific inquiry ability, scientific problem solving ability, scientific communication ability, scientific participation and lifelong learning ability.

2.2. Teaching-learning system diagram for effective major learning capabilities

This chapter presents the core competencies necessary for engineering majors and emphasizes the core competencies for training as certified engineers through teaching-learning. The teaching-learning system diagram for effective major learning capabilities is presented in Table 1 [3].

Table 1. Teaching-learning system diagram for effective major learning capabilities

Key competencies required by engineering majors
① Ability to apply knowledge of mathematics, science, and engineering
② Ability to analyze and interpret data, as well as to design and implement experiments
③ Ability to design systems, parts, and processes to meet your needs
④ Ability to work on an interdisciplinary team
⑤ Ability to recognize, formulate, and solve engineering problems
⑥ Understanding Professional and Ethical Responsibilities
⑦ Ability to communicate effectively
⑧ Ability to understand the impact of engineering solutions from a macro perspective
⑨ Recognizing the necessity of lifelong learning and the ability to do lifelong learning
⑩ Basic knowledge of current issues such as economics, management, environment, and law
⑪ Techniques and methods required for engineering practice, Ability to use the latest engineering tools
▼▼▼
Key competencies for registration as an authorized engineer
① Ability to identify the complexity of a problem
② Ability to define theoretical and practical methods appropriate to the model
③ Ability to define strategies for problem solving
④ Ability to combine design development, realization and appropriate choices for continuous improvement
⑤ Ability to assess implementation performance

3. Establishment of support system for creative innovation teaching method

3.1. Development of a teaching-learning model based on computing thinking skills

Components of computing thinking include first, structuring into computer-solving problems, second, logical data analysis, third, data representation by modeling or simulation, fourth, automation of solutions by algorithmic thinking, fifth, verification after efficient solution, and sixth, generalization by problem-solving process [4]. In this paper, we would like to develop a teaching-learning model based on computing thinking ability, which is a thinking ability that can efficiently solve problems based on basic concepts and principles of computing. By dividing computing thinking into decomposition, pattern, abstract, algorithm, and automation, we would like to guide programming courses to cultivate thinking skills that solve problems and link them to the teaching-learning model [5]. The procedure for developing a teaching-learning model based on computing thinking is to proceed with teaching-learning in the order of first, the concept of computing thinking, second, the practice of computing thinking, and third, the perspective of computing thinking. The teaching-learning model design based on computing thinking education in creative programming education is presented in Table 2.

Table 2. Design of teaching-learning model based on computing thinking education

Components of computing thinking				
Decomposition	Pattern	Abstract	Algorithm	Automation

▼▼▼

Composition of computing thinking	Computing teaching-learning	How to use it
Concept of computing thinking	* Explain programming concepts and principles * Present how to use a programming language * Analyze and create programs * Encourage learners to participate in the class with questions and answers	① sequence ② Repeat ③ Parallel processing ④ Events ⑤ Conditions ⑥ Arithmetic operation ⑦ Data
▼▼▼		
Practice of computing thinking	* Promote convergent thinking and creative thinking through various programming, etc. * Provide a variety of problems for learners to practice designing and implementing programs	① Progressive attempts and development ② Testing and debugging ③ Reuse and recombination ④ Abstract and modularization
▼▼▼		
Perspective of computing thinking	* Communication, sharing, and cooperation between instructors and students or between students * Organize the course to experience the meta-thinking process of self-assessment and awareness of inner thinking	① Expressing ② Connecting ③ Asking

3.2. Development of a teaching-learning model based on linkage and convergence education

In this chapter, we would like to develop a teaching-learning model based on linkage and convergence. Interdisciplinarity refers to research that participates in various academic fields when studying an object, and convergence education refers to education that integrates knowledge or skills in various fields to cultivate talents with integrated and creative thinking. The need for convergence education in the academic world is due to the need for a new educational paradigm that allows learners to experience and think more comprehensive and creative perspectives beyond the boundaries of individual studies. As an attitude of instructors and learners who practice linkage and convergence education, instructors teach integrated education obtained by combining various academic fields, while learners learn to cultivate capabilities to create new knowledge from various perspectives with an open attitude.

As a teaching-learning method that practices linkage and convergence education, first, instructors comprehensively understand and synthesize knowledge in other academic fields as well as their major fields, and teach learners to experience limitations such as the need for linkage and convergence. Second, learners learn from the perspective of having the experience of converging themselves rather than the transfer of knowledge generated in the past linkage and convergence process. Through linkage and convergence education, learners feel the need for linkage and convergence exploration in various problem-solving processes, and in this process, they learn in the direction of providing opportunities to experience intellectual exchanges and various disciplines other than majors.

In order to develop a curriculum to strengthen linkage and convergent thinking capabilities, we intend to teach and learn to cultivate linkage and convergence capabilities, which are essential capabilities for future talents in the fourth revolution of the 21st century. The procedure for developing a teaching-learning model based on linkage and convergence education is to first conduct instructor-led linkage and convergence education, second, linkage and convergence education based on learner problem-oriented learning, and third, linkage and convergence education based on cooperative learning [6]. The design of the teaching-learning model based on linkage and convergence education is presented in Table 3.

Table 3. Design of teaching-learning model based on linkage and convergence education

Organization of linkage and convergence education	Educational design plan
Instructor-led linkage and convergence education	① Gain expertise in the field of study ② Cultivate creative problem-solving skills ③ Understanding of diversity among disciplines ④ Cooperative attitude with other disciplines ⑤ Learning experiences that make up a variety of knowledge through linkage and convergence ⑥ Create environments and conditions for learners to lead the learning process, and systematically support them ⑦ Capacity development through effective linkage and convergence inquiry activities
▼▼▼	
Linkage and convergence education based on learner problem-oriented learning	① The core of linkage and convergence education starts with recognizing that learners are the subject ② Induce in-depth learning of learners for the results of linkage and convergence education ③ Learners create and organize various learning experiences through the process of leading learning ④ In the process of solving problems, learners experience linkage and convergence that mobilizes various knowledge
▼▼▼	
Linkage and convergence education based on cooperative learning	① Learning experiences through dynamic exchanges with students from different academic backgrounds and perspectives ② Learners increase problem-solving skills through communication skills and critical thinking among students ③ Proceeding in the form of problem-solving learning that pursues learning goals through the joint efforts of students

4. Strategic model development plan for engineering teaching

4.1. Learning-based curriculum improvement strategy

From the perspective of computing thinking, it aims to increase major understanding and interest in engineering by designing algorithms based on computing thinking and implementing them through coding to creatively solve engineering problems. The advantages of coding education based on learning computing thinking skills are as follows. First, coating is a problem-solving learning method in which learners select and plan their own activities and derive results with new processes. Second, coding requires not only curiosity but also non-frustrating persistence to implement it as a creative idea, so a willingness to solve it until the end without giving up with high concentration is essential. Third, the meaning of computing thinking can be considered through the process of planning, design, production, and review of programs through coding [7]. The plan to improve computing thinking in programming education for creative computing education is presented in Table 4.

Table 4. Study on the improvement of computing thinking in Korea

1. Programming overview
① Programming description ② Description of content and concepts ③ Run screen
▼▼▼
2. Computing thinking
① Decomposition (data decomposition; function decomposition) ② Pattern ③ Abstract painting
▼▼▼
3. Program algorithms
[Step 1] Algorithm design; cultivating the ability to structure the operations required for problem solving. [Step 2] Algorithm representation; cultivation of the ability to code necessary operations. [Step 3] Algorithm analysis; cultivation of the ability to analyze necessary operations in terms of execution time.
▼▼▼
4. Core module (function)
▼▼▼
5. Coding
▼▼▼
6. Learners' ability to solve coding-related problems
① Can learners design using conditions, iterations, and control structures? ② Can the learner represent the necessary operations step by step? ③ Can learners represent algorithms in code? ④ Can learners express algorithms in flow charts? ⑤ Can learners find various solutions to minimize the performance time of the operation?

4.2. Curriculum improvement strategies based on linked and converged education

The necessity of engineering major education based on linkage and convergence is as follows. First, the academic system is too differentiated to understand the phenomenon that it is trying to explore in a segment, but it faces limitations in grasping the overall appearance and meaning. Second, it is time to create new knowledge by linking and integrating subdivided academic fields with each other. Third, there is an era in which talents with integrated thinking skills are needed to actively respond to rapidly changing environments and creatively solve the problems at hand. Fourth, many problems today are complexly intertwined, so an innovative attitude to derive creative ideas is needed to solve them. Fifth, it is necessary to develop the capabilities required by future society through various intellectual experiences and human exchanges, away from teaching-learning in which students acquire only knowledge in one field through convergence education. Plans to improve the curriculum through linkage and convergence education are presented in Table 5.

Table 5. Curriculum improvement by linkage and convergence education

1. Instructor's teaching plan
Transferring integrated education from a wide range of disciplines
▼▼▼
2. Learner's learning plan
* Be open and approach from multiple perspectives * Developing the ability to create new knowledge
▼▼▼
3. Interdisciplinary linkages and convergence processes
* Content and convergence in various disciplines * Find connectivity in each area * Attempt to develop something new
▼▼▼
4. Reality of linkage and convergence learning
* Develop problem-solving skills through linkage and convergence teaching-learning models * Cultivate creativity to generate new ideas * Experience a deep level of intellectual experience through linkage and convergence learning activities
▼▼▼
5. Increasing the enrollment rate and employment rate by strengthening major competencies
* Faithfully train the knowledge required for your major based on linkage and convergence learning * Develop sufficient ability to solve problems directly in the industrial field

5. Conclusions

Convergence talent education aims for competency-based education to prepare for a future society with knowledge information in the 21st century, but there are few prior studies that provide deep understanding and insight in class composition principles and creative design. To this end, this paper aims to establish a creative innovation teaching method for engineering teaching-learning innovation by extracting key competency components to increase learning outcomes such as strengthening learners' convergent cognition and creative capabilities. In this paper, engineering education should focus on fostering professional basic theory and basic engineering problem-solving skills in terms of computing thinking and academic convergence along with practical skills used in the field rather than abstract scientific problem-solving skills. Therefore, I would like to propose the development of a strategic model based on the core competencies for innovation in the curriculum of engineering teaching-learning in this regard.

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References

[1] Ministry of Education and Ministry of Science, ICT and Future Planning, “Promotion Plan for Human Resources Development for SW-centered Society,” Ministry of Education and Ministry of Science, ICT and Future Planning, 2015.

[2] S. LEE & S. LEE, “Development of Teaching Methods to Improve Mathematical Capabilities for Electronics Engineering,” International Journal of Internet, Broadcasting and Communication, 13(2), 120-126, 2021. DOI: https://doi.org/10.7236/IJIBC.2021.13.2.120

[3] M.K. LEE, “A Study on the Development of Competence-Based Curriculum for the 21st Century - OECD Education 2030,” Research Report, Korea Institute for Curriculum and Evaluation, RRC 2016-5, 2016.

[4] D. D. Riley and K. A. Hunt, Computational Thinking for the Modern Problem Solver, CRC Press, 2014.

[5] International Society for Technology in Education & Computer Science Teachers Association, Operational Definition of Computational Thinking for K–12 Education, 2011.

[6] S. LEE & S. LEE. “Development of Creative Convergence Talent in the era of the 4th Industrial Revolution through Self-Directed Mathematical Competency,” International Journal of Advanced Culture Technology, 10(4), 86-93, 2022.
DOI: https://doi.org/10.17703/IJACT.2022.10.4.86

[7] S. LEE & S. LEE. “Proposal of Electronic Engineering Exploration Learning Operation Using Computing Thinking Ability”, International Journal of Advanced Culture Technology, 9(4), 110-117, 2021.
DOI: https://doi.org/10.17703/IJACT.2021.9.4.110