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# Artificial Intelligence Curriculum Development for Intelligent System Experts in University

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***Abstract*— Artificial intelligence (AI) has emerged as a pivotal technology for enhancing national and industrial competitiveness in the digital transformation era. Consequently, the cultivation of specialized talent in AI has garnered significant attention. This study analyzed AI-related department curricula at major universities worldwide, identifying critical courses for each academic semester. The data we collected included course titles, syllabi, and learning objectives, which were refined and analyzed afterward. Furthermore, we comparatively examined university AI education programs based on the content of Computer Science Curricula 2023, a widely recognized framework for computer science education. The insights gleaned from our analysis revealed that AI curricula are built upon a foundation of computer science, emphasizing the importance of a deep understanding of various related domains within the field of computer science. Based on these findings, we proposed a curriculum for AI departments, considering the need for a comprehensive understanding of computer science alongside specialized AI courses. This study aims to provide foundational data for advancing AI education and guide educational program improvements. Ultimately, it aspires to contribute to developing specialized professionals in the AI field, thereby bolstering national and industrial competitiveness in the rapidly evolving digital landscape.**

***Keywords*—AI major; artificial intelligence education; course data analysis; CS2023 framework; curriculum analysis; curriculum improvement.**

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## I. INTRODUCTION

Artificial intelligence (AI) has emerged as a core technology for national and industrial competitiveness in this digital transformation era. Amid the rapid expansion of the global AI market, major companies worldwide are competitively increasing their investments to secure leading positions in this field [1], [2]. In this context, where the importance of AI is growing, cultivating AI expertise, considered the cornerstone of its competitiveness, is paramount. However, the current situation regarding the cultivation and supply of AI specialists is critically insufficient [3]. It is predicted that there will be a demand for more than 40,000 additional specialists in AI-related fields in South Korea by 2025. However, the supply of talent is challenging [4].

One of the most critical measures for cultivating AI talent is educating students to become specialists with AI expertise. In response, leading universities worldwide are attempting to nurture AI specialists, including departmental restructuring and curriculum revisions [5]. However, qualitative studies on AI specialization curricula in universities remain insufficient. Examining studies related to AI curricula reveals that most focus on general education courses designed for all students. Additionally, studies aimed at specialists often face limitations owing to their adherence to outdated standards [6].

This study aims to assist universities in developing more systematic AI specialization curricula and deriving educational implications for the future. To achieve this, we analyzed the curricula of AI specialization departments at software-focused universities in Korea and leading universities worldwide to draw relevant insights. Furthermore, we analyzed and presented standard courses for AI education based on the classification system of Computer Science Curricula 2023 (CS2023).

## II. MATERIALS AND METHOD

### A. Previous Studies on AI Education in Universities

Studies on AI education curricula in universities can be broadly divided into two categories. First, studies aimed at AI

education focusing on general education in universities exist. Park utilized interpretative phenomenological analysis to explore the direction of AI education in general education by performing a demand analysis with approximately 170 university students, the main targets of general education. The study suggested covering AI's social impact and ethical issues and areas related to data and machine learning [7]. Lee and Park established the concept of AI literacy by discussing the essential competencies university students should possess and proposing directions for general education [8]. Additionally, specific studies related to the curriculum were conducted. Kim et al. [9] proposed an AI curriculum model that could be used in general education. Jeon [10] applied an experiential learning-based AI education program structured on experience, reflection, conceptualization, and application to assess its effectiveness in general education.

Second, studies related to education majors at the undergraduate and graduate levels. A review of critical studies shows that Sung et al. [11] analyzed the AI-related curricula of nine universities centered on software, revealing that five were mandating specific AI courses. Search theories, knowledge representation, and reasoning have been highlighted as essential AI content. Lee [12] developed an industry-academic cooperation education program for training AI specialists, suggesting key topics and detailed content that can be referenced in major courses. Yoo [13] proposed a direction for AI specialist education in graduate schools, suggesting tracks for technological specialization and interdisciplinary expansion.

Previous studies show that university AI education studies can be divided into general and major education. However, further analysis of the overall research volume reveals that studies related to general education are predominant. Consequently, this study analyzes the current AI education and curricula of major universities in Korea and worldwide to develop AI education standards at the primary university level. Additionally, it seeks to modify and supplement these using the international standard CS2023. This study aims to provide insights that can guide curricula design considering specialists' future job roles and competencies.

### *B. Software-Focused Universities*

South Korea is advancing the software-focused University initiative, led by the Ministry of Science and ICT and the Institute for Information & Communications Technology Planning & Evaluation, to cultivate creative software and AI talent that is pivotal for the Fourth Industrial Revolution. Software-focused universities aim to establish institutions that train software professionals through university education and actualize the value of software expansion [14].

Software-focused universities impart knowledge to students majoring in specific fields and construct an integrated education system that teaches basic software skills to students from diverse academic backgrounds. Emphasis is placed on delivering skills and knowledge that can be directly applied in practice instead of theory-centric education, supporting students' competitiveness in the industrial field. This is achieved through various educational methods, such as project-based learning, on-site internships, and industry-academic cooperation projects. With the increasing importance of AI, these universities are also revising their curricula and establishing AI departments, supporting students in becoming experts in the field of AI through core courses in machine learning, deep learning, and big data processing [15]. This study selected 29 departments related to AI specializations in software-focused universities to examine their AI curricula.

### *C. Computer Science Curricula 2023*

The objective of this study is to compare and analyze the curricula of university AI majors. To this end, we performed an analysis based on the contents of CS2023, aiming to examine the reflection of the core content of AI from an academic lineage perspective. The Computer Science Curricula series, initiated by 'Curriculum 68' in 1968, is a standard for computer science education programs developed jointly by the Association for Computing Machinery (ACM) and the Institute of Electrical and Electronics Engineers Computer Society (IEEE-CS) in the United States. It aims to define the standards related to computer science education and provide guidelines for educational institutions to structure their courses based on these curricula. These standards are intended to improve the quality of education and help students have the same learning experiences across different schools and countries [17]-[19].

CS2023 is the latest in the computing curriculum series, developed with the participation of the Association for the Advancement of Artificial Intelligence (AAAI), along with ACM and IEEE, to reflect AI content. This computing technology has recently garnered significant attention. Consequently, it has been updated from the intelligent systems knowledge area in CS2013 to use the term AI broadly, including actual applications of AI, generative models, and issues related to AI ethics, fairness, reliability, and explainability. It also presents explicit goals for developing AI literacy and critical thinking skills. Table 1 lists the new major areas of computer science introduced in CS2023. This study classifies university courses based on the major areas presented by CS2023.

TABLE I
BODY OF KNOWLEDGE AREA AS SUGGESTED BY CS2023 GAMMA VERSION

| **The Body of Knowledge Area** |
|---|
| Algorithmic Foundations (AL) |
| Architecture and Organization (AR) |
| Artificial Intelligence (AI) |
| Data Management (DM) |
| Foundations of Prog. Languages (FPL) |
| Graphics and Interactive Techniques (GIT) |
| Human-Computer Interaction (HCI) |
| Mathematical and Statistical Foundations (MSF) |
| Networking and Communication (NC) |
| Operating Systems (OS) |
| Parallel and Distributed Computing (PDC) |
| Security (SEC) |
| Society, Ethics and Professionalism (SEP) |
| Software Development Fundamentals (SDF) |
| Software Engineering (SE) |
| Specialized Platform Development (SPD) |
| Systems Fundamentals (SF) |
| Computational Science (CN) |

*D. Research Method*

To achieve the objectives of this study, the following steps were followed to present a standard curriculum:

*1) Selection of Universities:* Universities with operating departments directly related to AI within Korean software-focused universities, where the educational curriculum could be verified, were selected.

*2) Course Selection Using Term Frequency–Inverse Document Frequency (TF–IDF):* The TF–IDF technique selected courses primarily covered by year and semester in the selected departments. Because the TF–IDF method yields results considering the importance across the entire corpus (data per semester) instead of just frequency counts [20], it aids in extracting critical courses for each semester. This method analyzed major courses by semester in AI-related departments currently operating in South Korea.

*3) Comparison with Major Universities Worldwide:* Courses from leading universities' AI-related departments were examined and compared with critical courses identified in Korea. The selected international universities were in the top ten in the 2023 Computer Science World University Rankings compiled by 'Times Higher Education [21].

*4) Course Similarity Test*: A course similarity test was performed to verify the connectivity between the major courses identified through data analysis. Each course was documented along with its introduction and syllabus data. After extracting keywords, a cosine similarity test was performed based on the contents of the CS2023 beta version to determine the connectivity between courses.

*5) Proposal of a Standard Curriculum Model:* A standard curriculum model for AI departments was proposed based on the research findings.

*E. Data Analysis*

To select universities for the analysis, we selected software-focused institutions. In addition, we targeted those that offered an AI primary curriculum and provided online access to their curriculum. Table 2 lists the selected universities and their respective departments.

TABLE II
AI MAJORS AT SOFTWARE-FOCUSED UNIVERSITIES IN KOREA

| University - Major |
|---|
| • Suncheon University - Department of Artificial Intelligence Engineering |
| • Gyeongnam National University of Science and Technology - Department of Information and Communication AI Engineering |
| • Kyung Hee University - College of Software Convergence Studies - Department of Artificial Intelligence |
| • Dongguk University - College of AI Convergence - Department of Artificial Intelligence |
| • Dong-A University - Department of Computer and AI Engineering |
| • Pusan National University - College of Information Science and Engineering - Department of Computer Science and Engineering (Artificial Intelligence Major) |
| • Yonsei University - AI Convergence College - Department of Artificial Intelligence |
| • Chonbuk National University - College of Engineering - Department of Computer AI Engineering (Artificial Intelligence Major) |
| • Kookmin University - College of Software Convergence - Department of Artificial Intelligence |
| • Korea Aerospace University - College of AI Convergence - Department of AI Autonomous Driving System Engineering |
| • Samyook University - College of Future Convergence - Department of Artificial Intelligence Convergence |
| • Chungnam National University - College of Engineering - Department of Artificial Intelligence |
| • Chonnam National University - College of AI Convergence - Department of Artificial Intelligence |
| • Kyungpook National University - College of IT - Department of Computer Science (Artificial Intelligence Computing Major) |
| • Kyonggi University - College of Software Management - Department of AI Computer Engineering (Artificial Intelligence Major) |
| • Hoseo University - College of AI Convergence - Big Data AI Department |
| • Dongseo University - College of Software Convergence - Department of Applied Artificial Intelligence |
| • Gachon University - College of IT Convergence - Department of AI and Software Engineering (AI Artificial Intelligence Major) |
| • Sangmyung University - College of Convergence Engineering - Department of Human Intelligence and Information Engineering |
| • Ewha Womans University - College of Artificial Intelligence - Department of Artificial Intelligence |
| • Catholic University of Daegu - College of Software Convergence - Department of AI Big Data Engineering |
| • Jeju National University - College of Engineering - Department of Software Engineering (Artificial Intelligence Major) |
| • Wonkwang University - College of Creative Engineering - Department of Artificial Intelligence Convergence |
| • Sunmoon University - College of Software Convergence - Department of AI Software Engineering |
| • Dongmyung University - College of AI Convergence - Department of Artificial Intelligence |
| • Hanyang University ERICA Campus - College of Software Convergence - Department of Artificial Intelligence |
| • Hanlim University - College of Information Science - AI Convergence Department |
| • Soongsil University - College of IT - AI Convergence Department |
| • Kangwon National University - College of Engineering - Department of AI Software Engineering |

Major universities worldwide were examined for objective analysis. These major global universities were selected based on the top ten from the 2023 Computer Science World University Rankings, compiled by 'Times Higher Education.' The universities selected, and their major AI courses are listed in Table 3.

TABLE III
MAJOR COURSES IN AI AT LEADING GLOBAL UNIVERSITIES

| University | Representative Course |
|---|---|
| University of Oxford | Discrete mathematics, Design and analysis of algorithms, Advanced Algorithms, Introduction to Artificial Intelligence, etc. |

| University | Representative Course |
|---|---|
| Massachusetts Institute of Technology | Introduction to Algorithms, Design and Analysis of Algorithms, Cryptography and Cryptanalysis, Computer Graphics, etc. |
| Stanford University | Design and Analysis of Algorithms, Mathematical Foundations of Computing, Advanced Algorithms, Robotics, etc. |
| ETH Zurich | discrete mathematics, algorithms and data structures, Advanced computer graphics, etc. |
| Carnegie Mellon University | Parallel and Sequential Data Structures and Algorithms, Mathematical Foundations for Computer Science, Machine Learning for Problem Solving, etc. |
| University of Cambridge | Discrete Mathematics, Algorithms 1, Algorithms 2, Advanced Graphics, etc. |
| National University of Singapore | Discrete Structures, Data Structures and Algorithms, Topics in Algorithmic Game Theory, etc. |
| University of California at Berkeley | Discrete Mathematics and Probability Theory, Computer Graphics, etc. |
| Harvard University | Discrete Mathematics for Computer Science, Introduction to Artificial Intelligence, etc. |
| Technical University of Munich | Discrete structures, Discrete probability theory, Advanced Topics in Cryptography, etc. |

### *F. Course Keywords and Refinement*

This study applied the keyword network method to analyze the educational curricula currently implemented in AI departments by extracting the names of the courses operated in each department. A keyword network was constructed by extracting keywords from the literature on a specific course area, calculating the co-occurrence frequency of these keywords, and thereafter calculating the similarity between keywords based on this co-occurrence frequency [22]. The network comprises 'nodes' as individual entities and 'links' as the connections between nodes. Centrality in connections measures the degree to which a particular node is connected to the surrounding nodes and is quantified by the number of links connected to that node. Betweenness centrality emphasizes the role of nodes as intermediaries in relationships between other nodes. Unifying and refining keywords considered different expressions of courses covering the same content across schools and departments. For objectivity, representative courses were classified based on the definitions of the major areas presented in CS2023. Additionally, the nature and content of the courses offered by the schools were compared and aligned with these major areas. Table 4 lists an example of grouping related courses into representative courses within the AI area. Notably, AI-related mathematics and statistics courses were included in the major areas of mathematics and fundamental statistics; data science and big data courses were placed in the data management (DM) area; and AI ethics courses were included in the society, ethics, and professionalism area.

TABLE IV
REFINEMENT TO CS2023 MAJOR AREAS AND REPRESENTATIVE COURSES

| Artificial Intelligence | |
|---|---|
| AI has traditionally combined symbolic and sub-symbolic methods. These solutions encompass perception, problem-solving, action, and supportive architectures. AI studies equip students to apply, implement, and evaluate AI approaches, considering their broader societal impacts. | |
| **Representative Courses** | **Actual Course Names** |
| Introduction to Artificial Intelligence | Introduction to Artificial Intelligence, AI and Computing, Understanding AI Technology, Introduction to AI, Introduction to AI Software, Intelligent Information Technology, Understanding Computers and AI, Understanding AI, Introductory AI, Basics of AI, AI Systems, AI Engineering, AI Software, Special Topics in AI, Artificial Intelligence |
| Reinforcement Learning | Reinforcement Learning, Introduction to Reinforcement Learning, Applied Reinforcement Learning, Deep Reinforcement Learning |
| Machine Learning | Machine Learning, Fundamentals of Machine Learning, Machine Learning, Practical Machine Learning, Introduction to Machine Learning, Machine Learning Programming, Optimization and Machine Learning, Pattern Recognition and Machine Learning, Machine Learning Lab, Machine Learning in Practice, Machine Learning Applications, Artificial Intelligence/Machine Learning Frameworks |
| Deep Learning | Deep Learning, Basics of Deep Learning, Advanced Deep Learning, Advanced Deep Learning Lab, Neural Networks, Deep Learning Applications, Computational Neuroscience, Deep Learning Frameworks, Deep Learning Programming Lab, Deep Learning in Practice, Introduction to Neural Networks, Deep Learning Programming, Neural Engineering |
| Natural Language Processing | Natural Language Processing, Introduction to Natural Language Processing, Natural Language Learning, Natural Language Question-Answering Systems, Artificial Intelligence and Sound, Intelligent Audio Processing, Speech Recognition, Speech and Language Processing, Text Processing |

Although not all representative courses are listed in Table 4, 17 courses related to AI, including Introduction to AI, were classified as representative courses. To categorize the domains defined by CS2023, secondary classification was performed based on specific areas. The classified areas included an introduction to AI, AI learning, knowledge representation and reasoning, natural language processing, cognition and computer vision, AI application programming, and agents with the keyword network applied. The application of the network involved analyzing the courses offered each semester and classifying and analyzing them from the first semester of the first year to the second semester of the fourth year.

## III. Results and Discussion

### A. Semester-Wise Major Courses in AI Department

Frequency analysis calculates the occurrence frequency of keywords within a document, identifies words that appear most frequently across the entire document through TF analysis, and determines the relative frequency of words in specific documents to ascertain the importance of specific words through TF–IDF analysis [17]. IDF is the inverse document frequency that assigns a higher weight to words that are important but occur in a few documents, and TF–IDF can be considered an indicator that shows the frequency of use of a word in a specific document relative to its rarity across all documents. In other words, using TF–IDF allows for results that consider not only the frequency of words but also their importance across all documents (semesters), thus aiding in the extraction of key courses for each semester. In this study, the TF–IDF metric was utilized to extract major courses for each semester. The semester-wise TF–IDF results are summarized in Tables 5–12.

TABLE V
MAJOR COURSES IN THE 1ST SEMESTER OF THE 1ST GRADE

| Rank | Course | TF | IDF | TF-IDF |
|---|---|---|---|---|
| 1 | Programming Basic | 0.0938 | 1.06 | 0.0994 |
| 2 | Differential Integral | 0.0625 | 1.28 | 0.0797 |
| 3 | Common Basic Mathematics | 0.0833 | 0.785 | 0.0654 |
| 4 | Discrete Mathematics | 0.0729 | 0.785 | 0.573 |
| 5 | Computational thinking | 0.0625 | 0.909 | 0.0568 |
| 6 | C Programming | 0.0625 | 0.785 | 0.0491 |
| 7 | General Physics | 0.0521 | 0.909 | 0.0473 |
| 8 | Computer Introduction | 0.0417 | 0.909 | 0.0379 |
| 9 | Python Programming | 0.0417 | 0.785 | 0.0327 |
| 10 | Introduction to AI | 0.729 | 0.0405 | 0.0296 |

The major courses for the first semester of the first year include introductory programming, calculus, basic common mathematics, discrete mathematics, and computational thinking. The first semester of the first year appears to focus on programming and basic mathematics. This can be considered the initial stage for laying the foundation of the AI major, emphasizing the importance of programming and basic mathematical knowledge and aiming to enhance students' ability to solve real-world problems based on this knowledge.

TABLEL VI
MAJOR COURSES IN THE 2ND SEMESTER OF THE 1ST GRADE

| Rank | Course | TF | IDF | TF-IDF |
|---|---|---|---|---|
| 1 | Programming Basic | 0.0734 | 1.06 | 0.0778 |
| 2 | Linear Algebras | 0.0642 | 0.785 | 0.0504 |
| 3 | Probability and Statistics | 0.0826 | 0.581 | 0.0480 |
| 4 | Discrete Mathematics | 0.0550 | 0.785 | 0.0432 |
| 5 | Object-oriented programming | 0.0459 | 0.785 | 0.0360 |
| 6 | C Programming | 0.0367 | 0.785 | 0.0288 |
| 7 | Common Basic Mathematics | 0.0367 | 0.785 | 0.0288 |
| 8 | Python Programming | 0.0367 | 0.785 | 0.0288 |
| 9 | Programming Advanced Practice | 0.0367 | 0.785 | 0.0288 |
| 10 | AI Mathematics | 0.0550 | 0.491 | 0.0270 |

The major courses in the second semester of the first year were basic programming, linear algebra, probability and statistics, discrete mathematics, and object-oriented programming. In the second semester of the first year, the focus appears to move beyond the basics of programming to emphasize advanced mathematics, such as linear algebra and probability and statistics, along with object-oriented programming.

TABLEL VII
MAJOR COURSES IN THE 1ST SEMESTER OF THE 2ND GRADE

| Rank | Course | TF | IDF | TF-IDF |
|---|---|---|---|---|
| 1 | Data structure | 0.146 | 0.909 | 0.133 |
| 2 | Object-oriented programming | 0.0828 | 0.785 | 0.065 |
| 3 | Linear Algebra | 0.0637 | 0.785 | 0.05 |
| 4 | Probability and Statistics | 0.0701 | 0.581 | 0.0407 |
| 5 | Logic Circuit | 0.0382 | 0.785 | 0.03 |
| 6 | Computer Structure | 0.0382 | 0.785 | 0.03 |
| 7 | Discrete Mathematics | 0.0318 | 0.785 | 0.025 |
| 8 | Circuit Theory | 0.0191 | 1.06 | 0.0203 |
| 9 | C++ Programming | 0.0191 | 0.909 | 0.0174 |
| 10 | AI Programming | 0.0382 | 0.405 | 0.0155 |

In the first semester of the second year, the major courses include data structures, object-oriented programming, linear algebra, probability and statistics, and digital logic circuits. The first semester of the second year appears to focus on more advanced aspects of programming, particularly data structures and object-oriented programming, along with hardware knowledge, such as digital logic circuits.

TABLE VIII
MAJOR COURSES IN THE 2ND SEMESTER OF THE 2ND GRADE

| Rank | Course | TF | IDF | TF-IDF |
|---|---|---|---|---|
| 1 | Data structure | 0.146 | 0.909 | 0.133 |
| 2 | Object-oriented programming | 0.0828 | 0.785 | 0.065 |
| 3 | Linear Algebra | 0.0637 | 0.785 | 0.05 |
| 4 | Probability and Statistics | 0.0701 | 0.581 | 0.0407 |
| 5 | Logic Circuit | 0.0382 | 0.785 | 0.03 |
| 6 | Computer Structure | 0.0382 | 0.785 | 0.03 |
| 7 | Discrete Mathematics | 0.0318 | 0.785 | 0.025 |
| 8 | Circuit Theory | 0.0191 | 1.06 | 0.0203 |
| 9 | C++ Programming | 0.0191 | 0.909 | 0.0174 |
| 10 | AI Programming | 0.0382 | 0.405 | 0.0155 |

The major courses in the second semester of the second year were algorithms, data structures, databases, probability and statistics, and digital logic circuits. In the second semester of the second year, the focus was on algorithms and data structures, emphasizing courses related to DM and storage, such as databases, while also focusing on courses that utilize hardware resources.

TABLEL IX
MAJOR COURSES FOR THE 1ST SEMESTER OF THE 3RD GRADE

| Rank | Course | TF | IDF | TF-IDF |
|---|---|---|---|---|
| 1 | Machine Learning | 0.0723 | 0.678 | 0.0490 |
| 2 | Database | 0.0602 | 0.785 | 0.0473 |
| 3 | Operating System | 0.0542 | 0.785 | 0.0426 |

| Rank | Course | TF | IDF | TF-IDF |
|---|---|---|---|---|
| 4 | Deep Learning | 0.0422 | 0.678 | 0.0286 |
| 5 | Image Processing | 0.0361 | 0.678 | 0.0245 |
| 6 | Natural Language Processing | 0.0361 | 0.678 | 0.0245 |
| 7 | Computer Vision | 0.0361 | 0.785 | 0.0237 |
| 8 | Network | 0.0361 | 0.678 | 0.0204 |
| 9 | Introduction to AI | 0.0482 | 0.405 | 0.0195 |
| 10 | Computer Structure | 0.0241 | 0.785 | 0.0189 |

The major courses in the first semester of the third year include machine learning, databases, operating systems, deep learning, and image processing. Most of these courses are related to AI, indicating a focus on core AI technologies, including machine learning and deep learning, as along with specialized areas such as image processing, during the first semester of the third year.

TABLEL X
MAJOR COURSES FOR THE 2ND SEMESTER OF THE 3RD GRADE

| Rank | Course | TF | IDF | TF-IDF |
|---|---|---|---|---|
| 1 | Data Mining | 0.0681 | 0.909 | 0.0618 |
| 2 | Computer Vision | 0.0681 | 0.785 | 0.0535 |
| 3 | Deep Learning | 0.0628 | 0.678 | 0.0426 |
| 4 | Image Processing | 0.0576 | 0.678 | 0.0390 |
| 5 | Machine Learning | 0.0419 | 0.678 | 0.0284 |
| 6 | Big Data | 0.0366 | 0.678 | 0.0248 |
| 7 | Reinforcement Learning | 0.0262 | 0.909 | 0.0238 |
| 8 | Embedded System | 0.0262 | 0.909 | 0.0238 |
| 9 | Network | 0.0314 | 0.678 | 0.0213 |
| 10 | Natural Language Processing | 0.0314 | 0.678 | 0.0213 |

The major courses in the second semester of the third year include data mining, computer vision, deep learning, image processing, machine learning, and big data. It appears that the focus for the second semester of the third year is on data analysis techniques, such as data mining, and the application areas of AI, such as computer vision and image processing.

TABLE XI
MAJOR COURSES FOR THE 1ST SEMESTER OF THE 4TH GRADE

| Rank | Course | TF | IDF | TF-IDF |
|---|---|---|---|---|
| 1 | Real Life Application Project | 0.135 | 0.405 | 0.0549 |
| 2 | Computer Vision | 0.0452 | 0.785 | 0.0355 |
| 3 | Natural language processing | 0.516 | 0.678 | 0.035 |
| 4 | Deep Learning | 0.0452 | 0.678 | 0.0306 |
| 5 | Embedded System | 0.0323 | 0.909 | 0.0293 |
| 6 | Field Practice | 0.0323 | 0.785 | 0.0253 |
| 7 | VR | 0.0194 | 1.06 | 0.0202 |
| 8 | IOT | 0.0323 | 0.581 | 0.0187 |
| 9 | Robotics | 0.0323 | 0.581 | 0.0187 |
| 10 | Reinforcement Learning | 0.0194 | 0.909 | 0.0176 |

The major courses in the first semester of the fourth year include real-life application projects, computer vision, natural language processing, deep learning, and embedded systems. The focus of the first semester of the fourth year was on AI projects connected to real life, along with advanced application technologies such as computer vision and natural language processing.

The major courses for the second semester of the fourth year include real-life application projects, field training, the latest technologies in AI, natural language processing, reinforcement learning, and AI convergence. It appears that the focus of the second semester of the fourth year is on projects and field training that solve real-world problems and on the latest technologies in AI.

TABLE XII
MAJOR COURSES FOR THE 1ST SEMESTER OF THE 4TH GRADE

| Rank | Course | TF | IDF | TF-IDF |
|---|---|---|---|---|
| 1 | Real Life Application Project | 0.133 | 0.405 | 0.0541 |
| 2 | Field Practice | 0.05 | 0.785 | 0.0393 |
| 3 | The latest AI Technology | 0.0417 | 0.909 | 0.0379 |
| 4 | Natural language processing | 0.05 | 0.678 | 0.0339 |
| 5 | Reinforcement Learning | 0.0333 | 0.909 | 0.0303 |
| 6 | Artificial Intelligence Convergence | 0.0333 | 0.909 | 0.0303 |
| 7 | AI Programming | 0.0667 | 0.405 | 0.0270 |
| 8 | Information Security | 0.0417 | 0.581 | 0.0242 |
| 9 | Deep Learning | 0.0333 | 0.678 | 0.0226 |
| 10 | AI Ethics | 0.025 | 0.785 | 0.0196 |

### *B. Analysis of Course Groups Operated by AI Departments in Software-Focused Universities*

In this study, the courses operated by AI majors were analyzed by examining those offered in the selected departments, matching them with the major areas presented in CS2023, and visualizing the analysis. The visualization results are shown in Fig. 1.

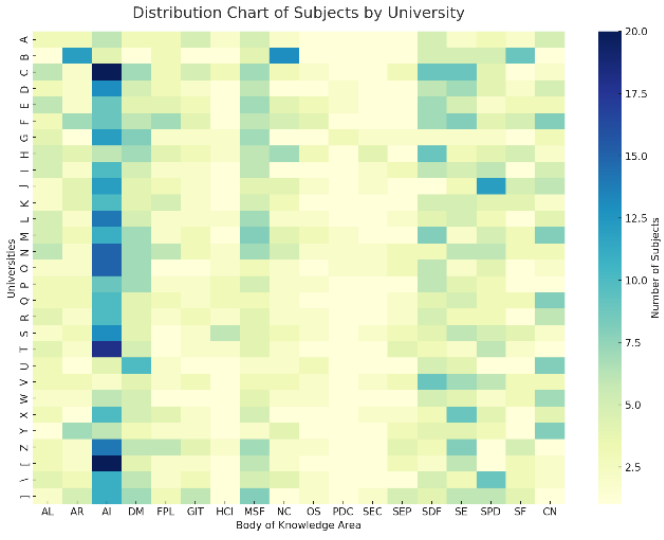


Fig. 1 Distribution of AI Major Courses in Korean Software-Focused Universities

Upon examining Fig. 1, it is observed that most courses are directly or indirectly related to the AI area. The areas primarily covered outside the AI domain are mathematical and statistical foundations (MSFs) and DM. This indicates that most universities include mathematical courses, such as

calculus, probability and statistics, and linear algebra, essential for developing AI competencies, along with courses entailing data processing and management, such as DM and big data. While relatively few schools covered fundamental programming languages and algorithms, there was a major presence of courses related to software engineering (SE), software development fundamentals, and special platform development. This reflects the characteristics of software-focused universities in supporting competitiveness in the industrial field through various educational methods such as project-based learning, field training, and industry-academic cooperation projects.

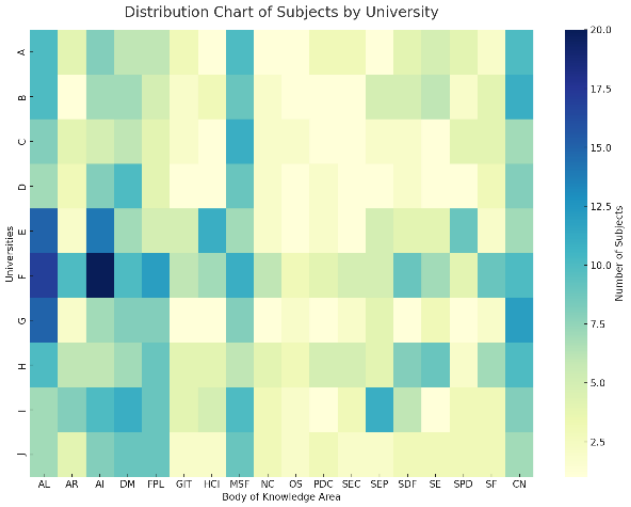


Fig. 2 Distribution of courses in major departments related to AI at major universities abroad.

For objective data analysis, courses offered by universities worldwide were classified according to the major category divisions presented in CS2023. A heatmap is shown in Fig. 2. Upon examining major universities worldwide. It was observed that most do not operate dedicated undergraduate departments for AI; instead, AI-related courses are covered by computer science majors. This indicates a characteristic emphasis on understanding the fundamental principles of computer science and algorithms before delving into AI courses.

The insights from the analysis suggest the following implications for university AI education: Broad Focus on AI Within Education Programs: Universities are heavily focusing on the AI domain, reflecting its significance in line with modern technological trends. Although this focus is commendable, ensuring students have a deep understanding of various IT areas is crucial. Balance is needed to ensure diversity in the curriculum, extending beyond AI to include major areas such as security and distributed computing.

The Importance of Fundamental Skills in CS and AI Majors: Foundational skills play a vital role in computer science and AI studies. A thorough understanding of the principles and concepts of advanced technologies is essential for their practical application. Courses on algorithms and data structures are indispensable as they form the basis of problem-solving methodologies. Furthermore, basic programming principles and various programming paradigms are crucial for enhancing code quality and efficiency and solving complex problems. Thus, core areas such as algorithms and basic programming should be emphasized equally when focusing on advanced areas such as AI.

Emerging Importance of Social, Ethical, and Professional (SEP) Issues: With the advancement of technology, issues related to society, ethics, and professionalism have become increasingly significant. CS2023 also emphasizes social and ethical competencies. Education in these areas must be strengthened to help students understand the societal impacts of technology. When considering improvements from the first semester of the first year to the second semester of the fourth year, the following areas need to be enhanced:

Connection to Real-world Applications: Several courses are theory centered. Integrating the practical skills and technologies required in the industry is necessary, including exercises that bridge theory and practice. The curriculum should evolve to include advanced topics such as GANs, transformers, and BERT models in later semesters.

Strengthening Education on Latest Technological Trends and Ethics: The fast-paced development of AI necessitates courses that reflect the latest technological and research trends. Additionally, education on the ethical and societal aspects of the advancement of AI technology is crucial. Courses that allow students to consider the adverse effects of AI, data privacy, and ethical applications should be emphasized early in the program.

Diverse Tools and Frameworks: Learning and studying AI involves various tools and frameworks. Courses should include education in primary languages such as Python and frameworks such as TensorFlow, PyTorch, and Keras. These insights highlight the need for a comprehensive approach to AI education that focuses on technical skills and incorporates ethical considerations and real-world applications to ensure well-rounded graduates capable of navigating the complexities of modern AI challenges.

### *C. Course Association Analysis*

A course similarity test was performed to verify the connectivity between the major courses extracted through the data analysis. Each course was documented along with its introduction and syllabus data, and keywords were extracted based on the contents of the CS2023 gamma version, followed by a cosine similarity test to determine the connectivity between courses. The association analysis procedure was as follows: The selected courses included logic circuits, embedded systems, discrete mathematics, algorithms, practical projects, field practice, latest AI technology, reinforcement learning, basic programming, data structures, object-oriented programming, differential integral calculus, basic common mathematics, computational thinking, linear algebra, deep learning, machine learning, probability and statistics, data mining, databases, operating systems, natural language processing, computer vision, image processing, AI ethics, and robotics. The results of the cosine similarity test for these courses are shown in Fig. 3.

Upon examining Fig. 3, it is evident that algorithms, robotics, and machine learning are centrally positioned and interconnected with several other courses, playing a pivotal role. This interconnectivity allows an understanding of the relationships between core topics in computer science and the influence of these topics on each other. Algorithms are fundamental to computer science and are crucial across all

related fields, indicating that the concepts of algorithms are utilized in various forms in topics such as data structures, machine learning, and robotics. basic programming, data structures, and object-oriented programming address programming fundamentals and methods for efficiently organizing and managing data. Machine learning is linked to various applications, including data mining, computer vision, and natural language processing. Fields, such as embedded systems and robotics, are related to developing systems in which hardware and software are closely integrated. Mathematical knowledge from discrete mathematics, linear algebra, probability, and statistics provides an essential foundation for developing algorithms and machine learning models. Deep learning, natural language processing, and computer vision, as subfields of machine learning, demonstrate the use of complex neural network models for AI to learn similarly to humans, understand languages, and process visual data. AI Ethics is a critical course that considers the impact of AI technologies on society and is closely associated with machine learning and other AI technologies. Practical projects and field practice emphasize applying theoretical knowledge to solving real-world problems, with field training being crucial for practicing and validating learned skills in natural environments. Latest AI technology and reinforcement learning indicate the latest technologies and trends in AI. Overall, this analysis outlines the interrelations and interactions between various disciplines of computer science and AI.

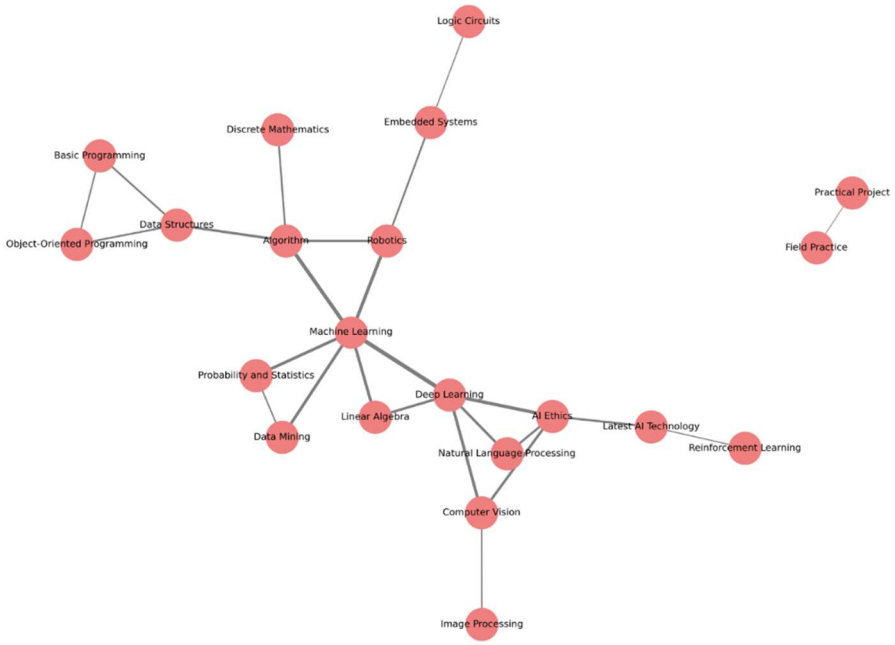


Fig. 3 Association Analysis Network Results for AI Major Courses

## *D. AI Department Curriculum Proposal*

Based on an analysis of the courses offered by the AI-related departments by year, a year-by-year operational strategy for the AI department was proposed, as summarized in Table 13. This plan was designed to equip students with basic-to-advanced knowledge and practical skills through a curriculum structured by year.

TABLEL XIII
THE OPERATIONAL STRATEGY OF AI MAJOR DEPARTMENT BY GRADE BY GRADE

| Grade | Operational Strategy |
|---|---|
| 1st grader | Establish basic knowledge and basic concepts. |
| | Goal: Provide students with basic programming, mathematics, and computer science knowledge.<br>Strategy:<br>Development of programming fundamentals and computing thinking skills.<br>Reinforcing logical thinking skills through basic mathematical knowledge (differential calculus, discrete mathematics).<br>Building mathematical foundations through common basic mathematics. |
| 2nd grade | Advanced programming and theoretical depth enhancement |
| | Goal: Deepen students' programming skills and educate them on crucial computer science theories.<br>Strategy:<br>Advanced programming skills (object-oriented programming, etc.) training.<br>Enhance problem-solving capabilities through data structure and algorithms.<br>Promote theoretical depth through probability and statistics, logic circuits, etc. |
| 3rd grade | Exploring AI Core Technologies and Applications |
| | Goal: To explore the core concepts and technologies of AI in depth.<br>Strategy:<br>Focus on core AI technologies such as machine learning, deep learning, and data mining.<br>Various applications of AI, such as computer vision, image processing, and natural language processing, were introduced.<br>Strengthen the connection between theory and practice through projects utilizing real data. |

| Grade | Operational Strategy |
|---|---|
| 4th grade | Practical application, practical experience, and comprehensive project |
| | Goal: Develop real problem-solving skills and develop students' comprehensive understanding.<br>Strategy:<br>Promote practical experience through application projects linked to real life.<br>Field practice, a comprehensive project to solve real-world problems.<br>Promote understanding of the latest technological and ethical aspects of AI. |

The first-year curriculum focuses on laying the foundation of programming and mathematical reasoning for students. It includes basic programming, discrete mathematics, differential, integral calculus, common mathematics, and computational thinking courses. Through these courses, students develop algorithmic thinking and mathematical problem-solving skills.

The students were exposed to more advanced theory and practice in the second year. Data structures, object-oriented programming, and linear algebra enable students to acquire more complex programming and mathematical techniques. At the same time, logic circuits provide an understanding of the basic hardware structures of computing. The probability and statistics course lays the groundwork for data analysis.

The third year is dedicated to mastering core technologies in AI, with balanced theoretical and practical offerings in machine learning, deep learning, data mining, databases, and operating systems. In addition, computer vision and image processing deepen our understanding of the processing and analysis of visual data. The AI ethics course explores social responsibility and ethical issues in technology, enhancing students' ethical judgment.

The fourth year focuses on advanced learning linked to real industry and project execution. Students can apply theoretical knowledge to real-world problem-solving through practical projects and field practice. The latest AI technology and reinforcement learning provide knowledge on cutting-edge technologies and algorithms. Additionally, courses such as natural language processing, embedded systems, and robotics broaden understanding of various applications of AI technology.

This curriculum was designed to equip students with practical knowledge and skills, from basic programming abilities to advanced AI technologies applicable to solving real-life problems. This educational path will enable students to adapt flexibly to a rapidly changing technological landscape and develop creative and ethical AI solutions.

The primary goal of this study is to develop a curriculum for the AI department based on the CS2023 computer science education standards. The CS2023 standards reflect the latest trends and requirements in computer science education and propose a systematic curriculum that enables students to acquire the necessary skills and knowledge.

### *E. Curriculum Structure and Course Placement*

As summarized in Table 14, the educational curriculum is structured into the following key areas: Algorithmic foundations, architecture and organization, AI, DM, foundations of programming languages, graphics and interactive techniques, human–computer interaction, MSFs, networking and communication, operating systems, parallel and distributed computing, security, society, ethics and professionalism, software development fundamentals, SE, specialized platform development, and systems fundamentals. The courses were arranged within each area according to three difficulty levels (beginner, intermediate, and advanced). For instance, AI, Introduction to AI is offered as a beginner course, image processing and neural networks are intermediate courses, and natural language Processing and computer vision are advanced courses. This structure was designed to allow students to start with the basic concepts and gradually move to more advanced content, building expertise.

TABLEL XIV
AI MAJOR DEPARTMENT REQUIRED COURSE OPERATION EXAMPLE

| Area | Introductory | Intermediate | Advanced |
|---|---|---|---|
| Algorithmic Foundations (AL) | • Algorithm | • Data Structures | • Advanced Algorithms |
| Architecture and Organization (AR) | • Logic Circuits | • Computer Organization | • Parallel and Distributed Computing |
| Artificial Intelligence (AI) | • Introduction to AI<br>• Machine Learning | • Image Processing<br>• Deep Learning<br>• Computer Vision | • Natural Language Processing<br>• Latest AI Technology<br>• Reinforcement Learning |
| Data Management (DM) | • Database | • Big Data<br>• Advanced Database Systems | • Data Mining<br>• Big Data Analytics and Management |
| Foundations of Programming Languages (FPL) | • Basic Programming | • Object-Oriented Programming | • Programming Applications |
| Human-Computer Interaction (HCI) | • HCI Fundamentals | • User Interface Design and Evaluation | • Ubiquitous and Interactive Computing |
| Mathematical and Statistical Foundations (MSF) | • Basic Common Mathematics<br>• Differential Integral Calculus<br>• Discrete Mathematics | • Linear Algebra<br>• Probability and Statistics | • Advanced Mathematical Modeling |
| Operating Systems (OS) | • Operating Systems Principles | • Systems Programming and Operating Systems Design | • Distributed Systems and Networks |

| Area | Introductory | Intermediate | Advanced |
|---|---|---|---|
| Society, Ethics and Professionalism (SEP) | • Artificial Intelligence and Social Influence | • AI Ethics | • Application of Artificial Intelligence Ethics |
| Software Development Fundamentals (SDF) | • Introduction to Software Development | • Open-Source Software | • Software Design and Development |
| Specialized Platform Development (SPD) | • Web and Mobile Application Development | • Embedded Systems | • Robotics<br>• Game Development and Virtual Reality |
| Software Engineering (SE) | • Software Engineering Basics | • software engineering | • Field Practice<br>• Practical Project |
| Systems Fundamentals (SF) | • Computing System | • Network Fundamentals | • Security and Cryptography |
| Computational Science (CN) | • Introduction to Computational Science<br>• Computational Thinking | • Computing Thinking and problem solving | • Computational Models and Simulations |

The placement of courses by difficulty level enables students to accumulate knowledge progressively, understanding complex concepts and technologies step by step. Beginner courses help students grasp the fundamental concepts and principles of the respective areas, intermediate courses build on this knowledge to explore more complex problem-solving methods, and advanced courses delve into the latest research and technologies, enhancing academic depth and practical skills.

## IV. Conclusion

By analyzing the AI education programs of major universities worldwide, the current state of AI education curricula and areas for improvement were identified. It was found that major universities approach AI education as part of their computer science courses, emphasizing practical applications, hands-on training courses, and theoretical foundational knowledge. This suggests that curricula in Korean universities need to move beyond a theory-centric approach to enhance the technical skills and integrative thinking required in the actual industrial field.

The association analysis of courses revealed that core courses such as algorithms, robotics, and machine learning should be at the heart of educational programs, and these courses should provide students with a deeper academic understanding and practical abilities through their linkage with other courses. Based on this analysis, the proposed AI curriculum was structured to offer a systematic and phased educational process each year. It was designed to equip students with practical knowledge and skills, starting with basic programming abilities to understand and apply the latest AI technologies to solve real-life problems.

This study is expected to contribute to the development of education for AI majors by providing foundational data, offering directions for improving educational programs for educational institutions and policymakers, and aiding the cultivation of specialized personnel in AI.

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## References

[1] E.G. Popkova, K. Gulzat, "Technological Revolution in the 21st Century: Digital Society vs. Artificial Intelligence," *in the 21st Century from the Positions of Modern Science: Intellectual, Digital and Innovative Aspects, edited by E. Popkova, B. Sergi, Lecture Notes in Networks and Systems*, vol. 91, pp. 339–345, 2020, doi:10.1007/978-3-030-32015-7_38.

[2] E. A. Nabila, S. Santoso, Y. Muhtadi, & B. Tjahjono, "Artificial Intelligence Robots and Revolutionizing Society in Terms of Technology, Innovation, Work and Power," *IAIC Trans. Sustain. Digit. Innov.*, vol. 3, no. 1, pp. 46–52, 2021, doi:10.34306/itsdi.v3i1.526.

[3] S. M. Hyrynsalmi, M. M. Rantanen, and S. Hyrynsalmi, "The War for Talent in Software Business - How are Finnish software companies perceiving and coping with the labor shortage?," *in Proc. 2021 IEEE Int. Conf. Eng., Technol. and Innov. (ICE/ITMC), Cardiff, United Kingdom*, pp. 1-10, 2021, doi:10.1109/ICE/ITMC52061.2021.9570207.

[4] Joint Government Ministries, "Comprehensive Plan for Digital Talent Development in 2022," *Ministry of Education, Republic of Korea*. [Online]. Available: https://www.moe.go.kr/boardCnts/viewRenew.do?boardID=72769&boardSeq=92573&lev=0&searchType=null&statusYN=W&page=1&s=moe&m=0315&opType=N, Accessed on: Jan. 4, 2024.

[5] Human-Centerd Artificial Intelligence, Stanford University, "Artificial Intelligence Index Report 2023," [Online]. Available: https://aiindex.stanford.edu/report/, Accessed on: Feb. 5, 2024.

[6] X. Zhai, X. Chu, C. S. Chai, M. S. Y. Jong, A. Istenic, M. Spector, J.-B. Liu, J. Yuan, Y. Li, "A Review of Artificial Intelligence (AI) in Education from 2010 to 2020," *Complexity*, vol. 2021, Article ID 8812542, p 18, 2021. doi: 10.1155/2021/8812542

[7] W P. Ju-yeon, "Analysis of needs for liberal arts artificial intelligence education: using IPA," *J. Soc. Comput. Educ*., vol. 24, no. 2, pp. 75–84, 2021, doi: 10.32431/kace.2021.24.2.007

[8] L. Yu-mi and P. Yoon-soo, "A study for the establishment of the concept of AI literacy and the design of liberal arts education," *A Coll. Lit. Texts*, vol. 85, pp. 451–474, 2021, doi:10.15565/jll.2021.03.85.451

[9] H. Kim, S. Jun, "Artificial Intelligence Curriculum Design for Liberal Arts Education," *J. Korean Assoc. Artif. Intell. Educ*., vol. 1, no. 1, pp. 93–100, 2020.

[10] S. Jun, "Development of Artificial Intelligence Education Program based on Experiential Learning for Liberal Art Education," *J. Korean Assoc. Comput. Educ*., vol. 24, no. 2, pp. 63–73, 2021, doi:10.32431/kace.2021.24.2.006

[11] H. Woo, H. Lee, J. Kim, & W. Lee, "Analysis of Artificial Intelligence Curriculum of SW Universities," *J. Korean Assoc. Comput. Educ*., vol. 23, no. 2, pp. 13–20, 2020, doi: 10.32431/kace.2020.23.2.002

[12] J. H. Lee, "A Study on the Development of Industry-Academic Project Education Program to Train AI Experts -Focusing on University Education-," *J. Korean Soc. Des. Cult.,* vol. 27, no. 2, pp. 375–383, 2021, doi: 10.18208/ksdc.2021.27.2.375

[13] Y. J. Ah, "A study on AI Education in Graduate School through IPA," *J. Korean Assoc. Inf. Educ.,* vol. 23, no. 6, pp. 675–687, 2019.

[14] "Accessed Web Content," [Online]. Available: https://www.swuniv.kr/33, Accessed on: Nov. 10, 2023

[15] E. Jang & J. Kim, "Contents Analysis of Basic Software Education of Non-majors Students for Problem Solving Ability Improvement - Focus on SW-oriented University in Korea," *J. Korean Soc. Internet Inf.*, vol. 20, no. 4, p. 81, 2019, doi: 10.7472/jksii.2019.20.4.81

[16] Joint Task Force on Computing Curricula, "Computer Science Curricula 2023: Version Gamma," *Association for Computing Machinery (ACM), IEEE Computer Society (IEEE-CS), Association for the Advancement of Artificial Intelligence (AAAI),* 2023.

[17] H. S. Kim, D. Kim, S. I. Kim, and W. J. Lee, "Analysis of the Current Status of the AI Major Curriculum at Universities Based on Standard of AI Curriculum," *J. Korea Soc. Comput. Inf.*, vol. 27, no. 3, pp. 25-31, 2024, doi: 10.9708/jksci.2022.27.03.025

[18] Y. Lee and J. Choi, "CS2013 analysis for the improvement of the university computer science curriculum," *KSCI Rev*., vol. 22, no. 2, pp. 35-40, 2014.

[19] H. Kim, Y. Seo, J. Song, and J. Lee, "Direction of K-12 SW·AI Education through Computing Curricula 2020," *Software Policy & Research Institute,* 2020.

[20] L. Zhang, "Research on case reasoning method based on TF-IDF*," Int. J. Syst. Assur. Eng. Manag.,* vol. 12, pp. 608–615, 2021, doi:10.1007/s13198-021-01135-6

[21] Times Higher Education, "World University Rankings," [Online]. Available: https://www.timeshighereducation.com/world-university-rankings, Accessed on: Oct. 23, 2023.

[22] E. H. Park and S. S. Han, "Research Trends on Education for Sustainable Development in Early Childhood in Korea Using Keyword Network Analysis," *J. Educ. Stud.,* vol. 53, no. 3, pp. 383-402, 2022, doi: 10.15854/jes.2022.09.53.3.383

[23] L. Chen, P. Chen, and Z. Lin, "Artificial Intelligence in Education: A Review," *IEEE Access,* vol. 8, pp. 75264-75278, 2020, doi:10.1109/access.2020.2988510.

[24] M. Lodi and S. Martini, “Computational Thinking, Between Papert and Wing,” Science & Education, vol. 30, no. 4, pp. 883–908, Apr. 2021, doi: 10.1007/s11191-021-00202-5.

[25] S. Papert, “Mindstorms: Children, Computers, and Powerful Ideas,” *Basic Books*, 1980.

[26] J. M. Wing, "Computational thinking," *Commun. ACM*, vol. 49, no. 3, pp. 33-35, 2006.

[27] J. Bae, J. Lee, and J. Cho, "Analysis of AI Ethical Competence to Computational Thinking," *Int. J. Inform. Visualization,* vol. 6, no. 2-2, 2022, doi: 10.30630/joiv.6.2-2.1126

[28] N. M. Safdar, J. D. Banja, and C. C. Meltzer, "Ethical considerations in artificial intelligence," *Eur. J. Radiol*., vol. 122, 2020, doi:10.1016/j.ejrad.2019.108768

[29] D. Zeng, "From Computational Thinking to AI Thinking [A letter from the editor]," *IEEE Intell. Syst.,* vol. 28, no. 06, pp. 2-4, 2013, doi:10.1109/MIS.2013.141.

[30] J. Borenstein and A. Howard, "Emerging challenges in AI and the need for AI ethics education," AI Ethics, vol. 1, pp. 61–65, 2021, doi:10.1007/s43681-020-00002-7