

Developing a Framework for the Integration of Artificial Intelligence in Technology Education: Enhancing Learning and Innovation

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Abstract: This study aimed to create a foundation for the integration of AI in technology education. The framework of this study was based on the important problem-solving learning process in technology education. The developed framework structures the problem-solving steps of such types of problems into problem solving, design, development, and evaluation. Each technological problem and problem-solving step area can be implemented using Intelligent Tutoring System (ITS), Dialogue-Based Tutoring System (DBTS), and Exploratory Learning Environment (ELE) of AI convergence education. Technology education supports learners develop Technological knowledge and develop critical and creative thinking when attempting to resolve real-life technological glitches. Since the process of solving technological problems is complex in itself, it was necessary to categorize technological problems in real life and organize the procedure for resolving technical issues into a series for formal education in schools. In this process of technological problem-solving learning, explicit knowledge may be necessary, and interpretive or procedural knowledge may be necessary. Methods of utilizing AI convergence education vary depending on the target knowledge. Therefore, structuring and presenting a plan to apply various AI convergence educations to the process of solving highly complex technological problems is meaningful in that it suggests the basis for educational direction. Based on the framework developed in this study, expected that AI convergence education methods appropriate for each problem-solving process of various technological problems will be systematically researched and implemented in the future.

Keywords: AI; AI convergence education; framework; technology education

1 INTRODUCTION

The term "industrial revolution" refers to the revolutionary shift in the way people live brought about by a computerized labor force or knowledge. The 4th Industrial Revolution, which is currently characterized by big data, virtual reality, IoT, and other innovations that describe an intelligent information society, is led by artificial intelligence [1]. AI is the capacity of electronic devices or robots to exhibit or mimic cognitive behavior, according to the Oxford English Dictionary [2]. All throughout the world, both private and public organizations are getting ready for and offering AI training programs. A non-profit group in the US called AI4AL (AI for ALL) maintains that all citizens ought to have access to artificial intelligence learning opportunities in order to address social problems. Since studies on AI and learning are still in its infancy, there are still numerous areas in which concepts and terminology lack clarity. AI was categorized as either "education about AI" or "education using AI. [1]" By enabling education beyond the constraints of time and geography, AI convergence learning is anticipated to be capable to accomplish qualitative as well as quantitative extension of learning. The development of tailored training that takes into account the unique qualities of each student will be one of the biggest modifications among them. But as research on AI education is still in its infancy, more needs to be done in the area of instruction in technology as well as other subject areas. In 2019, Holmes, Bialik, and Fadel presented the Intelligent Tutoring System (ITS), Dialogue-Based Tutoring System (DBTS), and exploratory learning environment (ELE) as part of the AI in Education (AIED) system [3]. The development of tailored training that takes into account the unique qualities of each student will be one of the biggest modifications among all. Study on individuality and confluence of artificial intelligence in the field of technology education is still scarce, nevertheless.

In the future, using artificial intelligence in the classroom will grow into a necessary educational practice. As a result, research on AI convergence education is ongoing throughout the educational spectrum. Kim, Oh, and Kim [4] examined how unplugged instruction improved third-grade elementary school students' computational abilities by analyzing algorithm execution times. Han investigated how voice-based AI chatbots affected the language proficiency of Korean EFL middle school students as well as the associated behavioral domains of opinion, motivation, level of interest, and felt worry [5]. In contrast to other disciplines, artificial intelligence technology in technology education, according to [1], has a somewhat more unique connotation. Possessing "technological literacy," which is defined as "technological understanding, abilities, and mindsets that improve adaptation to a changing technical society," is one of the objectives of technological education. According to [1], there is a striking similarity between the approaches and substance of technological literacy and artificial intelligence literacy, as well as the techniques and procedures involved in problem-solving. According to [6], in order to employ teaching approaches effectively, teachers need create a teaching-learning strategy. Thus, the study aimed to create a structure that could be applied in technology-related subject areas and serve as the foundation for AI convergence in technology learning.

2 LITERATURE REVIEW

2.1 Individualized Instruction and AI Convergence

When comparing AI convergence education to current educational practices, the following traits stand out: convergence, awareness, relationship, and understanding. Artificial intelligence is a path toward the development of students' personalized education, with practical teaching and practical individualization being achievable [7]. Shin and Shin [8] proposed automation, customization, growth, and

collaboration as key components of AI-based science education methodologies. Automation refers to AI's ability to continually manage and analyze every pupil's data over a period of time; individualization refers to AI's ability to supply each student with personalized learning recommendations based on their level; and diversity refers to the provision of each student with a unique curriculum and textbook. Furthermore, cooperation entails fostering a complex framework of cooperation among communities and schools. After determining whether the subject matter had a prior idea for the learning concept, Wu, Kuo, and Wang [9] gave the lesson's contents. Fig. 1 displays the AI convergence teaching algorithm developed by Wongwatkit, Srisawasdi, and Hwang [10].

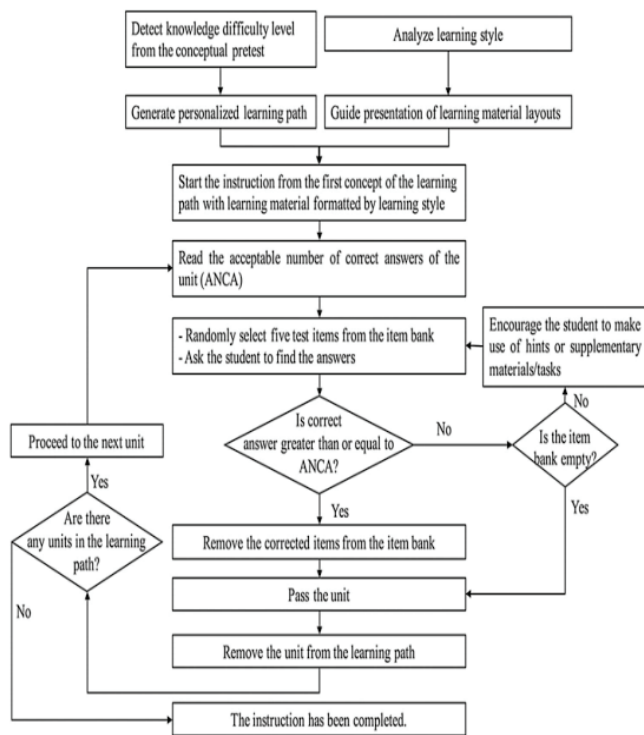


Figure 1 The personalized web learning system's process, which is based on formative evaluation and individualized information

AI convergence learning liberated learning and instruction from the confines of location and time by rejecting the conventional classroom teaching structure. As a result, it will be important to actively look into strategies to reflect student characteristics relevant to the subject matter and area in future AI convergence education.

2.2 Education of Artificial Intelligence

The Computer Science Teachers Association (CSTA) in the United States formed the Association for the Advancement of Artificial Intelligence (AAAI) with several research institutes and developed artificial intelligence for elementary and middle school students (K-12). AI4K12 (AI for K-12), an intelligence learning standard, presenting educational content and curriculum standards and promoting the development of educational programs. AAAI presented five major concepts for teaching artificial intelligence and the

content that should be covered by each grade in each idea [11]. The five big ideas for artificial intelligence education are AI recognition methods, AI expression and reasoning, AI learning, AI natural interaction, and AI social impact. Through the report 'AI in the UK?', the UK stated that all youngsters should have a basic awareness of artificial intelligence, as well as the ethical considerations involved in using this technology [12]. Finland has created a curriculum called 'Elements of AI' to develop a free online course for basic education in artificial intelligence and aims to strengthen the digital leadership of the European Union (EU) [13]. China is currently making intensive investments and efforts in computer education, focusing on artificial intelligence education. Accordingly, the next-generation artificial intelligence development plan was announced in 2017, suggesting the need for artificial intelligence education, and in 2018, a textbook called 'Basics of artificial intelligence' was developed and an artificial intelligence education pilot school was established for 40 high schools nationwide. It is in operation [13]. In Korea, information subjects were designated as mandatory subjects in the 2015 revised curriculum, and the content of artificial intelligence is being covered for middle school students. The Korea Foundation for the Advancement of Science and Creativity presented the goals and contents of artificial intelligence education in 'Development of a Next-Generation Software Education Standard Model' announced in 2019. The Ministry of Education announced a comprehensive plan for science-mathematics-information-convergence education in 2020 and presented the direction for artificial intelligence education in elementary, middle, and high schools. This comprehensive plan announced a plan to strengthen the information curriculum by adding artificial intelligence-related content to the school curriculum so that elementary to high school students can systematically develop information and AI capabilities [13].

2.3 Education using Artificial Intelligence

While artificial intelligence has continued to develop and stagnate since the 1950s, efforts to apply artificial intelligence to education include the Intelligent Tutoring System (ITS), Adaptive Learning (AL), and Computer-based Education. Education: CBE) and Learning Analysis (LA) have been studied in various forms [16]. However, until artificial intelligence received great attention under the wave of the Fourth Industrial Revolution, artificial intelligence convergence education research and its application were not very active. In their book 'Artificial Intelligence In Education', Holmes, Bialik & Fadel [3] refer to artificial intelligence in the field of education as 'AI in Education (AIED)' and refer to the long-standing trend of AIED as an Intelligent Tutoring System (ITS), Dialogue-Based Tutoring System (DBTS), and Exploratory Learning Environment (ELE). First, the use of the Intelligent Tutoring System (ITS). For subjects like mathematics or physics that have a clearly defined knowledge structure, ITS calculates the best step-by-step learning path. Second, the use of the Dialogue-Based Tutoring System (DBTS). A new iteration of ITS called

DBTS engages students in a dialogue about learning. DBTS utilizes advanced natural language processing and natural language generation technologies. Third, utilizing an exploratory learning framework (Exploratory Learning Environment: ELE). ELE adopts a constructive approach. Put another way, instead of adhering to a predetermined step-by-step sequence, students are urged to proactively generate knowledge on their own by investigating and manipulating parts of the learning environment.

3 DEVELOPMENT OF FRAMEWORK FOR AI CONVERGENCE OF TECHNOLOGY EDUCATION

3.1 Elements of Artificial Intelligence Convergence Education

As seen in the examples above, the artificial intelligence-enabled education system (AIED) is being studied so that it can be used in a variety of ways depending on the content and purpose of education. However, what AIED is and what it can do is still an ongoing question [3], so there are still many limitations in applying it smoothly to all areas of learning, and it needs to be continuously and actively researched in the future. It can be viewed as an area.

Today's artificial intelligence convergence education includes not simply using artificial intelligence functionally in the education system, but also educating artificial intelligence itself so that humans can understand and use it directly. Accordingly, Lim [1] reviewed the literature related to artificial intelligence convergence education and presented artificial intelligence convergence education (AIED) by dividing it into 'education about artificial intelligence' and 'education using artificial intelligence.' At this time, education on artificial intelligence can be expressed as 'AI in Educational Contents (AIEC)', and the target and topic of education is artificial intelligence, or artificial intelligence is used in the learning process to help learners understand and handle artificial intelligence. It is 'artificial intelligence education' aimed at cultivating the ability to Education using artificial intelligence can be expressed as 'AI in Educational Technology (AIET)', and 'Use of Artificial Intelligence' is the application of integrating artificial intelligence into the teaching and learning process in education and tool that allows instructors to improve the effectiveness of education. AIEC shows a trend of development relatively recently when artificial intelligence has received public attention. AI4ALL (AI for ALL), a US-based non-profit organization, was established in 2015 and provides artificial intelligence education programs, and has been providing artificial intelligence education programs to computer science teachers in the US. The Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA) have proposed five major themes for artificial intelligence teaching, the EU's artificial intelligence education elements, China's main artificial intelligence education contents, The results of deriving detailed elements by synthesizing the main contents of Korea's artificial intelligence education are shown in Fig. 2, and the AIEC education elements of the education model were derived using the categorized results considering each detailed education element.

USA	EU	China	Korea	Synthesis
AI recognition method	What is AI	AI concept	AI concept	AI concept
AI expression and reasoning	AI problem solving	AI problem solving	Knowledge expression and reasoning	Learning in AI
Natural interaction of AI	Real-world AI	Use of AI AI interaction		AI problem solving
Learning in AI	Machine learning Neural network	Machine learning Neural network	Machine learning Artificial neural network	Use of AI
Social Impact of AI	Social influence	The future of AI	.	Social Impact of AI

Figure 2 Derivation of AIEC education elements

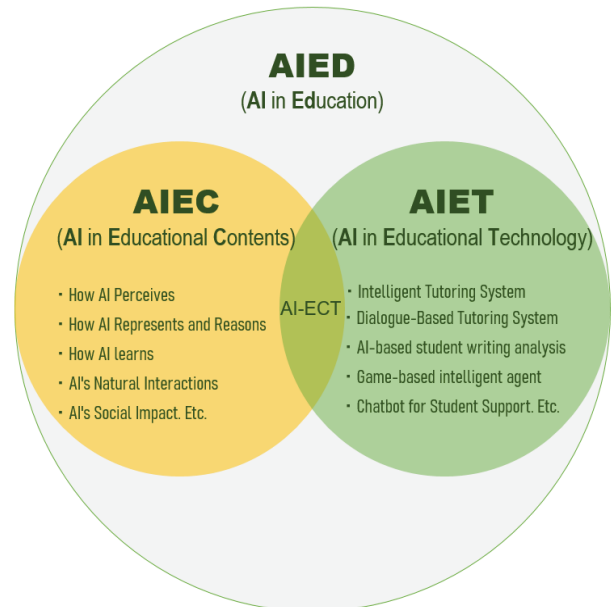


Figure 3 Educational elements of AIED

Regarding AIET, the representative topic of research using artificial intelligence in education is ITS. ITS aims to develop more intelligent and adaptable educational software by introducing artificial intelligence techniques to existing CBE. ITS chooses the best incremental learning route for areas with a well-defined knowledge structure, such as mathematics or physics. ITS has been studied by many scholars studying artificial intelligence since the 1980s and evaluations in schools have been reported [15], but it has not achieved as much success as expected. The reason for this is that it was difficult to clearly extract the learner's intellectual activities or responses. Recently, as interest in artificial intelligence has rapidly increased and related technologies have developed, various forms of AIET research other than ITS have been conducted, began to become lively. Holmes, Bialik & Fadel [3] show that the education system using artificial intelligence includes step-by-step customized education based on artificial intelligence, artificial intelligence-supported inquiry learning starting from a conversation system, analysis of student writing, intelligent agent in a game-based environment, and chatbot for student support. It was said to include etc. The above AIEC education elements and AIET education areas are graphically depicted in Fig. 3.

3.2 Framework of Technological Problem Solving

Lim & Kim [14] created a model for technological problem solving. According to the process and results of model development, the types of technological problems were defined as troubleshooting, design, development, and invention as shown in Tab. 1, and the technical problem solving model was defined according to the technical problem solving stage as shown in Tab. 1. It can be divided into problem understanding, conception, realization, and evaluation.

Table 1 Types of technological problems

X-AXIS	X1	X2	X3	X4
Types of Technological Problems	Troubleshooting	Design	Development	Invention

Table 2 Steps in solving technological problem

Y-AXIS	Y1	Y2	Y3	Y4
Steps in solving technological problem	Understanding the problem	Conception	Realization	Evaluation

Framework of technological problem solving derived by considering Tab. 1 and Tab. 2 is shown in Fig. 4.

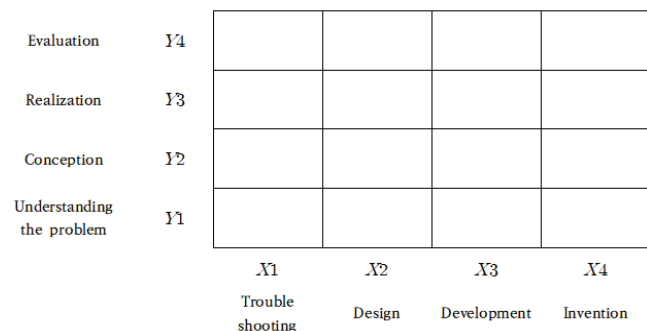


Figure 4 Framework for technological problem solving of technology education

Framework of technological problem solving in Fig. 4 represents 16 technological problem areas. One problem type is divided into four problem solving steps. For example, Troubleshooting (X1) goes through the stages of problem understanding (Y1), conception (Y2), realization (Y3), and evaluation (Y4). If a problem is in the realization stage of the Troubleshooting type, it becomes a problem in area X1Y3.

3.3 Framework for Integration of AI in Technology Education

Based on the above discussion, this study designed a framework for AI convergence technology education as shown in Fig. 5. Based on the framework in Fig. 4 previously designed, a framework was created by dividing the types of artificial intelligence-based education that can be used in each area into ITS, DBTS, and ELE.

In Fig. 5, one technical problem can utilize three types of AI convergence education. For example, the invention realization stage (X4Y3) can utilize the types of ITS (Z1), DBTS (Z2), and ELE (Z3). If the learner is currently in area X4Y3Z3 in the framework of Fig. 5, the learner is realizing

an invention problem and solving a technological problem using ELE's AI convergence education.

Table 3 Types of education using artificial intelligence

Z-AXIS	Z1	Z2	Z3
Types of education using artificial intelligence	Intelligent Tutoring System: ITS	Dialogue-Based Tutoring System: DBTS	Exploratory Learning Environment: ELE

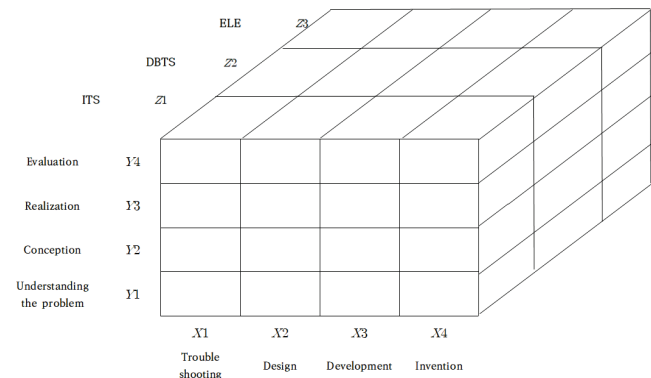


Figure 5 Framework for integration of AI in technology education

4 CONCLUSION

The aim of this research was to develop a foundation for AI convergence education in technology education. The framework of this study is based on the most important problem-solving learning process in technology education. The developed framework structures the problem-solving steps of such types of problems into problem solving, design, development, and evaluation. Each technological problem and problem-solving step area can be implemented using the ITS, DBTS, and ELE systems of AI convergence education. Technology education helps students develop Technological knowledge and develop critical and creative thinking in the process of solving real-life technological problems. Since the process of solving technological problems is complex in itself, it was necessary to categorize technological problems in real life and organize the procedure for resolving issues with technology into a series for formal education in schools. In this process of technological problem-solving learning, explicit knowledge may be necessary, and interpretive or procedural knowledge may be necessary. Methods of utilizing AI convergence education vary depending on the target knowledge. Therefore, structuring and presenting a plan to apply various AI convergence educations to the process of solving highly complex technological problems is meaningful in that it suggests the basis for method of AI convergence education. Based on the framework developed in this study, expected that AI convergence education methods appropriate for each problem-solving process of various technological problems will be systematically researched and implemented in the future.

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