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Development of an AR-Based AI Education App for Non-Majors

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ABSTRACT The purpose of this study is to develop an AR-based app to teach non-engineering majors AI and analyze the educational effect. AIEduAR has developed a visual solution that displays the methods of teaching non-engineering majors how the machine learning on their own. Eighty-eight undergraduates who had not received any AI education were given lessons on AI learning principles and required to solve 10 problems using AIEduAR. Through AIEduAR, the students inputted data into augmented reality, set data attributes and learning rates, and entered new data to check out the accuracy of trained AI. Analysis of the technology acceptance model and Instructional Materials Motivation Survey questionnaire concluded that they are highly likely to accept and learn AR technology in AI education. Moreover, AIEduAR turned out to be effective in boosting their confidence in learning and instantaneous feedback. This study has successfully incorporated AR into AI education and developed learning steps required for AI education using AR.

INDEX TERMS AIEduAR, artificial intelligence, non-engineering majors, technology acceptance model.

I. INTRODUCTION

As Information Technology (IT) advances, the labor market demands that job seekers utilize IT technology. Recently, it is required to understand the technologies based on the 4th industrial revolution represented by Artificial Intelligence (AI) and Big Data. To adapt to these changes and set up a better career path and job, university students want to receive education related to IT technology, especially AI-related education regardless of their major [1]. To meet these needs, universities are providing education on AI to students who do not major in computer science or engineering [2].

The Korean government announced its National Strategy for Artificial Intelligence in 2019, presenting a direction to support the whole nation in utilizing AI [3]. In 2020, ''Education Policy Direction and Core Assignments in the Era of Artificial Intelligence'' were presented [4]. The key assignment presented by the report is that all adults, including university students, should have basic AI literacy. Additionally, the university not only nurtured professional labor but also tried to support all university students to receive AI-related education.

However, it is difficult for universities to provide AI education to students who do not major in computer science or engineering. This is because they do not have a chance to learn the knowledge related to AI in middle or high school before entering university. Furthermore, it is difficult for university students who prefer liberal arts to easily access AI concepts, since the learning contents related to AI include mathematical and abstract content [5]. Therefore, there is a need for an education method that can generate interest and motivation and that can be easily understood by non-engineering majors who are not familiar with AI.

Various studies have been conducted on AI education for non-engineering majors. They tried to elicit interest and motivation by providing hands-on activities using various teaching materials such as robots or by enabling audiovisual stimulation through computer simulation [2], [6]. Moreover, gamification was introduced so that students could naturally

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experience and utilize AI algorithms through competition and cooperative activities [7].

Augmented reality (AR) technology, which has recently been used in the field of education, is known to be sufficiently applicable to education because users can additionally receive virtual audiovisual stimulation based on the real world. In other words, it is highly valued as an educational material in that it improves learning engagement and outcome because of its high practicality and immersion in learning.

The purpose of this study is to utilize AR technology in AI education for non-engineering majors and to analyze the educational effectiveness. Therefore, for this study, an AR-based AI education app was developed and applied to university students who did not major in computer science and engineering. The AR-based AI education app, which was created for this study, has developed a visual solution that displays the process of automatically solving problems through simple manipulations so that non-engineering majors can easily understand the principles of machine learning (ML). The result of applying the AR-based AI education app to non-engineering majors indicates that the attitude and learning motivation to accept AR technology in AI education were high.

II. RELATED WORKS

A. AI EDUCATION FOR NON-ENGINEERING MAJORS

With the advent of AI, which is attracting attention as the core of future industries, the need for AI education has emerged. However, as the concept of AI is not only abstract and complex but also requires mathematical backgrounds, educational methods and tools different from the existing ones are required for AI education. In particular, to teach AI to non-engineering majors, it is necessary to consider the students' characteristics.

AI education for non-engineering majors should promote their interest and motivation using various teaching materials and strategies. Lin (2021) examined the effect of Science, Technology, Engineering, and Mathematics (STEM)-based AI education on the AI literacy and awareness of AI ethical issues of non-engineering major university students [2]. Three hundred and twenty-eight non-engineering freshmen took a lecture on the concepts and utilization of AI. Afterward, they were asked to design an AI algorithm that can recognize moving directions and create a car-kit capable of autonomous driving in various circumstances. By comparing the pre-post test, students' understanding of AI was significantly improved and AI literacy was enhanced after the course. Moreover, in STEM education, it was determined that a hands-on activity is an important factor in promoting the learning efficiency and active learning of non-engineering majors. Rattadilok (2018) proposed a modified mobile game called Clash of Clans (CoC) as a teaching tool for ML to gamify the ML process and activate personalized learning [6]. In class Gamified Machine learning Environment (iGaME), a game bot that repeatedly applies the user's game strategy to CoC and records the outcomes of the game was used to teach the ML algorithm. The students selected the pixel color as a game strategy and the input for iGaME, and the game was repeated 3 times. The outcomes of games played using iGaME and the outcomes of playing games as a novice, intermediate, and expert in the mobile game, which are human players, were compared. Consequently, although the average of successful deployment for using pixel colors as an attack strategy was lower than that of a novice human player, some attacks of iGaME had better performances than the novice group. Furthermore, the students expressed their enjoyment of using iGaME than the traditional ML tool. In particular, it was concluded that gamification and visual attractiveness could reduce the cognitive load of non-engineering majors when learning technologically driven content. To attract students to advanced programming, Yoon (2015) offered the course on creating customized levels and an AI agent that can obtain the highest score in the Angry Birds game for 13 undergraduate students with a computer engineering major [7]. Students were divided into four teams and each team participated in three competitions, which became increasingly difficult. Consequently, students were satisfied and had positive responses for the game-based learning. Moreover, it was concluded that game-based learning could maintain learning motivation, lift students' spirits, and help students with learning program design.

AI education for non-engineering majors can improve students' understanding of AI by providing audio-visual information through simulation. Esteves (2019) presented a proposal to teach the basic mechanism of AI in school to achieve a widespread public understanding of AI [8]. To study the effect of computational experience with basic AI algorithms on the capability of AI, a workshop was conducted to teach the fundamentals and operations of K-means and Artificial Neural Network (ANN) to 37 high school students and asked them to perform Scratch tasks. Consequently, it was determined that the flexibility of visual programming, which is a characteristic of Scratch, helped the students to understand the meaning of codes and underlying mathematical concepts. Additionally, after the workshop, the students acquired a more realistic view of AI. Fretas (2021) suggested a curriculum for non-engineering majors to introduce general AI concepts and to design their AI agents [9]. One hundred and seventy-four freshmen taking the Introduction to Computing course (CS110) were selected as the study subjects. In the modified CS110 course and four additional AI lessons, core concepts of AI, implementation, limitations, and ethical considerations were covered. The final project was to program a rocket-landing simulator and design an AI agent to control the rocket's landing using a genetic algorithm. The students could modify their AI by watching a live stream of the simulation of the designed agent. Consequently, it was determined that students' understanding of AI and ML surpassed simple memorization, and they overwhelmingly preferred the AI version of CS110. Fernandes and Marcelo (2016) presented a proposal to apply Problem-Based

Learning (PBL) to the AI courses [10]. Sixty university students taking the Applied Artificial Intelligence course of the Computational Engineering program created AI enabling the collision-free movement of a terrestrial robot in an unknown environment and simulated it using IRobot Create platform. In doing so, they could visually monitor the collision-free route of the designed robot. They responded positively to the questionnaire on skill acquisition and proficiency through the PBL applied to the AI course, concluding that the designed proposal was well received.

AI education for non-engineering majors should emphasize learning contents on hands-on activities on AI rather than theory. The trend in ML education is the use of sophisticated tools for enabling students' hands-on experience [11]. For example, teaching ML using the modified mobile game CoC and the game bot iGaME increased students' interest and reduced the burden of technology learning for non-engineering majors [6]. Fretas (2021) also used two games to teach non-engineering major students how to implement intelligent agents and gave them the task of creating an AI agent [9]. The task was to design an agent that makes the rocket land safely. The student could check whether the designed agent works properly and modify one's AI, showing a significantly improved understanding of AI and ML. Utilizing tools not only in ML education but also in AI education can enhance students' interest and learning effectiveness. In an AI algorithm design experiment using a car kit for non-engineering majors, it was concluded that hands-on activities enhance learning efficiency [2]. Furthermore, in a workshop to teach AI basic mechanisms through Scratch for high school students, visual information helped the students understand the meaning of codes and mathematical concepts [8]. Such research findings indicate that tools that provide hands-on experiences or audio-visual information are the key to making AI accessible to non-engineering majors.

In summary, AI education for non-engineering majors or novices should satisfy the following conditions. First, audio-visual and tactile information should be provided to promote students' interest and motivation. Second, students should monitor one's programming results and get help in understanding concepts through visual information. Third, hand-on tools should be used rather than explanations of theory and principle. Therefore, it is necessary to consider providing AI education using AR, which is being used in education recently.

B. EFFECT OF AR IN EDUCATION

Users can additionally receive virtual visual and auditory stimuli in the real world using AR technology. AR technology, which provides additional information in augmented reality, plays a positive role in education. Moreover, AR is on the rise as the latest educational medium to improve students' learning engagement and outcomes.

Ibanez (2014) examined the effect of AR on learning effectiveness and level of enjoyment [12]. Sixty high school students aged 17–19 were distributed among the experimental or control groups that learned the basic principle of electromagnetism based on AI or the web. As a result of the comparison, the experimental group reported a relatively high concentration on the task, sense of control, and distorted sense of time. Furthermore, the experimental group had clearer, direct feedback, and a higher level of autotelic experience than the control group. In other words, the AR approach led the student to reach a relatively high level of the overall state of flow. Therefore, AR enables students to achieve better learning outcomes and increases self-motivation by promoting a higher flow experience.

Teng (2018) presented and evaluated an AR-enhanced learning system to examine the applicability and effectiveness of AR in programming language education [13]. Thirty-four first-year university students were divided into two groups, where one group used the AR-enhanced version and subsequently the ordinary version and the other group used the versions in reverse order. When evaluating the influences of the AR-based learning system, regarding four dimensions of system usefulness, learning efficiency, flow experience, and usage perception, students perceived the AR-enhanced version as more efficient, useful, and easy to use. In particular, the AR-enhanced version led students to better engagement and a more enjoyable experience through quick and immediate feedback.

Conley (2018) investigated the effect of the AR learning environment on the learning gains and perception of collaboration and engagement [14]. Two hundred and fifty-two participants, consisting of undergraduate and graduate students, were divided into six groups with different AR learning environments given the levels of AR experience and collaboration. The levels of AR experience were classified into a high AR, a low AR, and non-AR, and the levels of collaboration were divided into pairs and no pairs. By comparing the six groups, the collaboration did not have a significant effect on learning gains, and students with low prior knowledge benefited most from a high AR regarding learning outcomes. Additionally, students who completed the learning activity with AR reported a relatively high perception of engagement. Therefore, the educational application of AR helps students to motivate themselves, increases their interest in learning, gets feedback immediately, and in particular engages in the learning experience.

Soltani (2020) analyzed 52 articles on sports education using AR to characterize the benefits of AR in sports education [15]. AR in sports education and training stimulates practices and helps users to improve sports skills and receive additional information and feedback on one's performance. Furthermore, AR, which provides visual, auditory, and haptic feedback, is especially useful for a novice player to learn abstract concepts and improve experiences, skills, enjoyment, and immersion. AR also enhances player performance by enabling personalized content and increasing challenges and the diversity of movements.

Boonbrahm (2019) developed and evaluated an AR flowchart that provides visual outcomes of control structure

constructed by students to learn the concept of programming [16]. Twenty university students who pursue a study program related to programming language were asked to program a flowchart to deliver a parcel to the destination using AR markers. Consequently, the AR flowchart helps students to understand and utilize the concept of control structure by visualizing the final output of the command execution. In other words, AR improves learning outcomes by providing immediate feedback and visualized information.

In summary, AR provides the following educational effects. First, AR leads students to engage in learning by enhancing concentration and fostering a flow experience. Second, AR enhances the understanding of abstract concepts and increases academic achievement by providing visual information. Third, AR promotes students' positive emotional experience and improves the enjoyment of learning. Finally, AR helps to correct errors by providing immediate personalized feedback. Therefore, AR has great potentials in the educational field.

III. DEVELOPMENT OF AR APP (AIEDUAR) FOR AI EDUCATION

A. AUGMENTED REALITY BASED ARTIFICIAL INTELLIGENCE EDUCATION

AI education for non-engineering majors should visualize the process of automatically solving problems through simple manipulation so that the student can understand the principle of self-learning of the machine. AR is an effective method for AI education since it enables practical hands-on experiences with markers and the outcome is visually provided with a simple operation on the screen of the smart device.

The processes of AR-based AI education for non-engineering majors are as follows. First, the student inputs data into AR and selects the most appropriate data attribute to solve the problem by manipulating them. Second, the student builds a model by learning AI based on the input data and selected attributes. The process of setting the attribute, initial value, and learning rate, and AI learning is visualized so that the student understands the concept of learning in AI. Third, the student enters new data into the trained AI and tests it to check the accuracy. Lastly, the student compares different AI that can solve the same problem to understand the differences in data attributes used in learning.

B. IMPLEMENTATION OF AN AR-BASED AI EDUCATION APP

Considering the advantages of education using AR, an AI education mobile app is developed using Unity and AR Foundation. 'AIEduAR' creates AI that analyzes the input data and automatically classifies the gender so that students can solve the problem of classifying the gender of the input human data. Through the process of FIGURE 1 to 6, AI that can distinguish gender is created. Data are entered in the form of a Quick Response (QR) code, and all data have attributes and values of height, weight, waist circumference, and head circumference. As the QR code is scanned by the camera, the augmented human object is visualized by reflecting the data attributes (height, weight, waist circumference, and head circumference), so that the student can easily explore the data. Moreover, a large amount of data can be easily grasped since numerous input data are visualized as a two-dimensional graph that can check attributes and gender. The student can train AI by selecting the most appropriate attribute to classify gender, and setting the initial value and learning rate. Additionally, since the learning process of the AI model according to the set learning rate and accuracy can be monitored, the student can immediately check whether the AI is learning correctly. The trained AI that can automatically classify gender is evaluated by additionally entering new test data other than the training data previously used for learning.

The characteristics of 'AIEduAR' are that, first, it is possible to set many questions of diverse difficulty levels since data used in the question of classifying gender can be presented in various ways. Second, even non-engineering majors can easily explore the data because the size and color (male-blue/female-pink) of the augmented human object reflects the data attributes (height, weight, waist circumference, and head circumference). Third, the process of changing the accuracy of data as the AI model learns according to the learning rate is provided visually, so that the concept of learning can be easily understood. Finally, learning activities can be conducted like a game using help and instructional materials in a general classroom environment, not a computer laboratory.

IV. METHOD

A. PARTICIPANTS

This study was conducted on a sample of 88 students that did not major in engineering science and had not received AI education in the past. Participant's gender and grade information is shown in TABLE 1.

B. PROCEDURE

To analyze the usability and educational value of 'AIEduAR', this study required students to solve 10 problems in 2 hours. Before solving the problem, the students learned about the basic concept and principles of AI learning for about 10 minutes, and then installed the application and learned how to use it for about 15 minutes. By self-directed solving 10 problems, students utilized and applied the principles of AI. FIGURE 7 shows the student participating in the experiment and solving the problems. After completing the learning activities, the Instructional Materials Motivation Survey (IMMS) questionnaire, which is a questionnaire based on the interest and importance of AI education, and the technology acceptance model (TAM), were conducted.

C. RESEARCH TOOL

1) ATTITUDE TOWARD AI

After non-engineering majors used the AR-based AI education app, students completed the survey that assessed their attitude toward AI. The components of the attitude toward AI

are interest and importance, and the reliability of the survey is illustrated in TABLE 2.

2) TAM

TAM was proposed to explain and predict the behavior of users who accept or reject new information technologies [17]. TAM consists of perceived usefulness (PU), perceived ease of use (PEU), perceived enjoyment (PE), attitude toward use (ATU), and interest to use (IU). In this study, the questionnaire tool of the previous study that applied the TAM model to AR-based educational tools was modified and used, and the reliability is presented in TABLE 3 [18].

3) IMMS

The IMMS tool based on Keller's Attention, Relevance, Confidence, and Satisfaction (ARCS) model was modified and used for evaluating the students' learning motivation for AR-based AI instructional material [19], [20]. The IMMS questionnaire tool was evaluated with a 5-point Likert scale, and ARCS were measured as components. The reliability of the questionnaire is shown in TABLE 4.

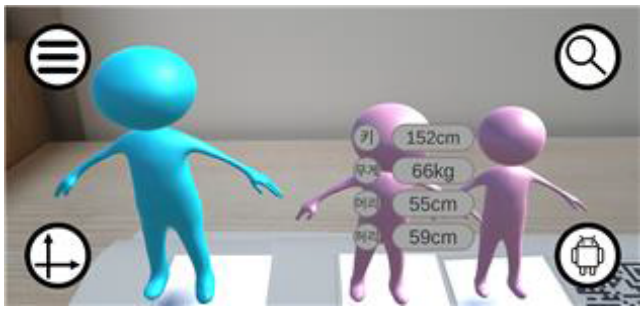

FIGURE 1. Input the training data.

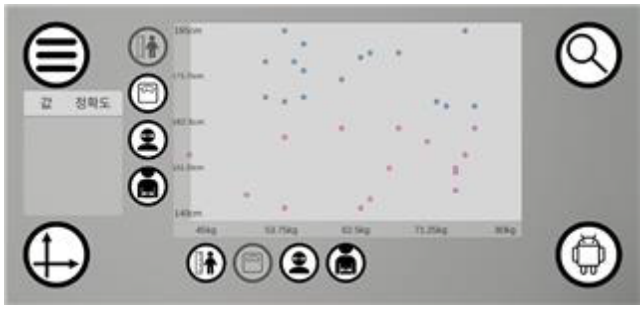

FIGURE 2. Visualization of the training data.

FIGURE 3. Setting initial value for AI to train.

FIGURE 4. Setting learning rate.

FIGURE 5. Result of trained AI.

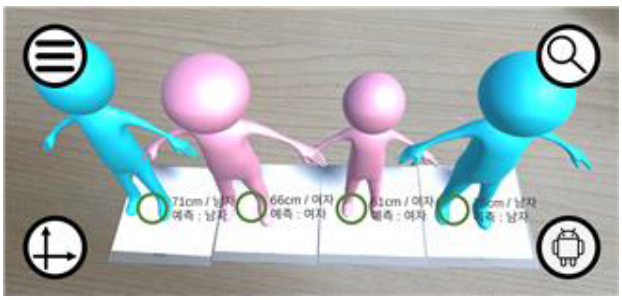

FIGURE 6. Evaluating new test data with AI.

V. RESULTS

A. ATTITUDE TOWARD AI

The result of the attitude toward AI is presented in TABLE 5. Interest perceived by non-engineering majors was analyzed with 3.98 and importance with 4.38, which are high figures. Furthermore, as shown in TABLE 6, there was no statistically significant difference between grade and gender.

B. TAM

The results of TAM are presented in TABLE 7. By analyzing the perception of non-engineering majors, PU was 3.84, PEU 3.27, PE 3.50, ATU 3.99, and IU 3.91. Moreover, as shown in TABLE 8, there was no statistically significant difference between grade and gender.

C. IMMS

TABLE 9 and 10 present learning motivation for 'AIEduAR', which is an AR-based AI instructional material. By analyzing attention, relevance, and confidence, which are the components of learning motivation, the scores were 3.73, 3.69, and 3.64, respectively. Additionally, although there was no statistically significant difference between males and females,

TABLE 1. Participants.

Gender	1st Grade	2nd Grade	3rd Grade	4th Grade	TOTAL
MALE	4	10	9	10	33
FEMALE	12	18	6	19	55
TOTAL	16	28	15	29	88

FIGURE 7. Participant receiving AI education with AIEduAR.

TABLE 2. Reliability of attitude toward AI.

Attitude	Interest	Importance
Cronbach's alpha	0.870	0.740

TABLE 3. Reliability of TAM.

TAM	PU	PEU	PE	ATU	IU
Cronbach's alpha	0.863	0.870	0.908	0.677	0.832

TABLE 4. Reliability of IMMS.

IMMS	Attention	Relevance	Confidence	Satisfaction
Cronbach's alpha	0.886	0.846	0.886	0.927

TABLE 5. Result of attitude for AI by grade.

Attitude	1st Grade	2nd Grade	3rd Grade	4th Grade	TOTAL
Interest	4.06 (0.84)	3.82 (1.01)	4.02 (0.99)	4.08 (0.66)	3.98 (0.86)
Importance	4.35 (0.56)	4.39 (0.57)	4.38 (0.59)	4.38 (0.62)	4.38 (0.58)

TABLE 6. Result of attitude for AI by gender.

Attitude	Male	Female	Total
Interest	4.18 (0.92)	3.87 (0.82)	3.98 (0.86)
Importance	4.52 (0.53)	4.30 (0.59)	4.38 (0.58)

there was a difference between grades only in attention ($f = 4.684$, $p = 0.04$).

D. ACHIEVEMENT

Ten problems were presented to non-engineering majors, and the AI education app developed in this study was used to solve problems with AI. Partial scores were included and if all the questions were answered correctly, 100 was scored.

TABLE 7. Result of TAM by grade.

TAM	1st Grade	2nd Grade	3rd Grade	4th Grade	TOTAL
PU	3.88 (0.73)	3.88 (0.94)	3.60 (0.73)	3.91 (0.87)	3.84 (0.84)
PEU	3.84 (0.91)	2.98 (1.21)	2.97 (1.19)	3.40 (0.97)	3.27 (1.11)
PE	4.13 (0.87)	3.16 (1.19)	3.30 (1.24)	3.59 (1.16)	3.50 (1.17)
ATU	3.94 (0.64)	4.07 (0.57)	3.71 (0.94)	4.09 (0.73)	3.99 (0.71)
IU	4.09 (0.82)	3.88 (0.80)	3.57 (0.88)	4.02 (0.87)	3.91 (0.85)

TABLE 8. Result of TAM by gender.

TAM	Male	Female	Total
PU	3.86 (0.83)	3.83 (0.85)	3.84 (0.84)
PEU	3.21 (1.17)	3.31 (1.08)	3.27 (1.11)
PE	3.36 (1.26)	3.58 (1.12)	3.50 (1.17)
ATU	3.95 (0.79)	4.02 (0.67)	3.99 (0.71)
IU	3.89 (0.82)	3.92 (0.87)	3.91 (0.85)

TABLE 9. Result of IMMS by grade.

IMMS	1st Grade	2nd Grade	3rd Grade	4th Grade	TOTAL
Attention	4.16 (0.63)	3.61 (0.67)	3.27 (0.77)	3.83 (0.73)	3.73 (0.74)
Relevance	4.01 (0.69)	3.70 (0.72)	3.49 (0.73)	3.61 (0.94)	3.69 (0.80)
Confidence	4.13 (0.76)	3.77 (0.77)	3.59 (1.10)	3.87 (0.76)	3.84 (0.83)
Satisfaction	3.94 (0.79)	3.55 (0.91)	3.36 (1.12)	3.70 (0.94)	3.64 (0.94)

TABLE 10. Result of IMMS by gender.

TAM	Male	Female	Total
Attention	3.61 (0.75)	3.80 (0.74)	3.73 (0.74)
Relevance	3.62 (0.81)	3.73 (0.80)	3.69 (0.80)
Confidence	3.68 (0.97)	3.93 (0.73)	3.84 (0.83)
Satisfaction	3.65 (0.94)	3.63 (0.95)	3.64 (0.94)

TABLE 11. Achievement by grade.

Grade	1st Grade	2nd Grade	3rd Grade	4th Grade	TOTAL
Achievement	65.70 (24.95)	60.03 (33.92)	76.43 (25.86)	69.63 (25.65)	67.02 (28.59)

TABLE 12. Achievement by grade.

Gender	Male	Female	TOTAL
Achievement	65.49 (30.70)	67.94 (27.49)	67.02 (28.59)

The results of analyzing the achievement are presented in the TABLE 11 and 12. There was no statistically significant difference between grade and gender.

VI. DISCUSSION AND CONCLUSION

The purpose of this study was to develop an app applied with AR technology to provide AI education for non-engineering majors and analyze its educational effect. The stages of AR-based AI education proposed in this study are as follows. First, after inputting data in AR, the student selects the most appropriate data attribute for problem-solving. Second, the student trains AI based on the input data and selected attributes and creates a model. During this stage, the process of setting data attribute, initial value, and learning rate of AI model, and the learning process of AI are provided visually, which helps to understand the concept of training AI. Third, the accuracy can be checked by entering new test data into the trained AI and testing it. Finally, the student can understand the differences in the data attributes used for learning by comparing different AI capable of solving the same problem.

The implications of this study are as follows. First, the results indicate that AR-based AI education proposed in this study can sufficiently recognize the interest in AI and the importance of AI to non-engineering majors who have never learned about AI. In other words, this study indicated that AR-based hands-on activities provide enough immersion and audiovisual stimulation so that even non-engineering majors can perform meaningful learning activities [8], [14]. Second, by analyzing the acceptance of AR technology used in AI education for non-engineering majors, the scores of ATU and IU were high, which implies that the attitude and intention to actively use AR-based AI education apps are high. Therefore, to automatically solve problems, the activity of building an AI model by setting data attributes, initial value, and learning rate in augmented reality is helpful for non-engineering majors in learning [16], [17].

Third, confidence (3.84), attention (3.73), relevance (3.69), and satisfaction (3.64) were answered in the order on the survey according to the ARCS theory, which indicates that the AR-based AI education app increases the confidence of learning for non-engineering majors and the feedback through the app is effective. Moreover, it was determined that AR, which catalyzes immersion and practical experience, is effective in making students concentrate. However, AIEduAR was evaluated as not providing enough satisfaction to the student, implying that a reward system such as a star rating is required depending on the degree of solving the problem. Considering that the results of measuring IMMS were attention (3.86), confidence (3.96), relevance (3.98), and satisfaction (3.88) in a study that applied AR object to education using educational technology for students who major in pedagogy, the app developed in this study is sufficiently and educationally effective [18], [20].

Lastly, there was no statistically significant difference between males and females in the interest, importance, the survey according to the TAM model, and the survey according to the ARCS theory. Therefore, education through AR can be applied to anyone regardless of gender and grade. In particular, regarding achievement, since there was no statistical difference according to the characteristics of gender and grade, it can be concluded that AI education using AR can be generally applied to any non-engineering major.

This study developed an environment where adult learners can learn easily with interest so that they can continuously adapt to changing technology and society. The educational environment designed considering the level of adults helped learners to independently experience and learn AI, and improve AI literacy skills [2]. Furthermore, it contributes to helping adult learners have careers and related to AI.

The limitations of this study and considerations for future work are as follows. First, as the study is designed in a single group, it is necessary to conduct future studies with a true experimental design. Second, to draw generalized results as students who participated in the study, many students are needed. Lastly, it is necessary to analyze the educational effect by designing a more sophisticated AR-based AI education model.

APPENDIX

QUESTIONNAIRE

PART I. INTEREST AND ATTITUDE TOWARDS AI

1. I am interested in AI
2. I would like to learn more about AI.
3. I think it would be interesting to try AI.
4. I think AI is helpful in my life.
5. I think universities should provide education on AI
6. Learning AI will be helpful no matter what I do in the future

PART II. INTEREST AND ATTITUDE TOWARDS AIEDUAR

7. I think AR improves learning achievement.
8. I think AR in class makes certain concepts, such as AI, easier to understand.
9. I think AR is useful for learning.
10. I think operation of AIEduAR is simple.
11. I think the usage of AIEduAR is clear and understandable.
12. I enjoyed using AI with AIEduAR.
13. I think using AIEduAR made the process of learning AI more interesting.
14. I think it will be more interesting if additional AR technology other than AIEduAR is used for learning.
15. I think using AR technology would make the class boring.
16. I think it is a good idea to use AR technology in existing classes to help learning.
17. Given that I had access to AR, I predict that I would use it.
18. I want to use AIEduAR to learn more about AI.

PART III. AFTER PARTICIPATING IN THE EXPERIMENT, THOUGHTS ON AIEDUAR AND EXPLANATORY MATERIALS

19. The text and images of AIEduAR and explanatory materials (pdf/video) got my attention.

20. The way the information is arranged on AIEduAR and explanatory materials helped keep my attention.
21. Various contents, examples, images, and questions in AIEduAR and explanatory materials drew my attention.
22. AIEduAR and explanatory materials was interesting enough to get my attention.
23. AIEduAR and explanatory materials stimulated my curiosity.
24. AIEduAR and explanatory materials were relevant to things I already know.
25. AIEduAR and explanatory materials were useful to improve my knowledge and experience.
26. AIEduAR and explanatory materials made me realize the importance of experiencing AI.
27. It was meaningful to solve problems using AIEduAR and explanatory materials.
28. AIEduAR and explanatory materials were relevant to my learning.
29. With the assistance of AIEduAR and explanatory materials, I think I can learn and experience AI.
30. As I used AIEduAR and explanatory materials, I was confident that I could easily learn AI.
31. AIEduAR and explanatory materials improved my knowledge of AI.
32. The explanatory materials made it easier for me to complete of the learning activities.
33. As I used AIEduAR and explanatory materials, I was confident that I could fully experience AI.
34. AIEduAR and explanatory materials are sufficient, which made me want to keep using AI.
35. It was a pleasure to use AIEduAR and explanatory materials.
36. Completing the exercises with AIEduAR gave me a satisfying feeling of accomplishment.
37. I felt good to successfully complete the exercises.
38. I enjoyed this lesson so much that I would like to study more about AI with AIEduAR.

REFERENCES

[1] A. Goel, "Editorial: AI education for the world," *AI Mag.*, vol. 38, no. 2, pp. 3–4, Jul. 2017, doi: 10.1609/aimag.v38i2.2740.
[2] C.-H. Lin, C.-C. Yu, P.-K. Shih, and L.-Y. Wu, "STEM-based artificial intelligence learning in general education for non-engineering undergraduate students," *Educ. Technol. Soc.*, vol. 24, no. 3, Jul., pp. 224–237, 2021.
[3] *National Strategy for Artificial Intelligence*, Republic Korea Government, Ministry Sci. ICT, South Korea, Dec. 2019.
[4] *Education Policy Direction and Core Tasks in the Age of Artificial Intelligence*, Republic Korea Government, Ministry Sci. ICT, South Korea, Nov. 2020.
[5] M. Hearst, "Improving instruction of introductory artificial intelligence," in *Proc. AAAI Fall Symp.* New Orleans, LA, USA: AAAI Press, Aug. 1995, pp. 1–4.
[6] P. Rattadilok, C. Roadknight, and L. Li, "Teaching students about machine learning through a gamified approach," in *Proc. IEEE Int. Conf. Teaching, Assessment, Learn. Eng. (TALE)*, Wollongong, NSW, Australia, Dec. 2018, pp. 1011–1015.
[7] D.-M. Yoon and K.-J. Kim, "Challenges and opportunities in game artificial intelligence education using angry birds," *IEEE Access*, vol. 3, pp. 793–804, 2015, doi: 10.1109/ACCESS.2015.2442680.
[8] J. Estevez, G. Garate, and M. Grana, "Gentle introduction to artificial intelligence for high-school students using scratch," *IEEE Access*, vol. 7, pp. 179027–179036, 2019, doi: 10.1109/ACCESS.2019.2956136.
[9] A. A. de Freitas and T. B. Weingart, "I'm going to learn what?!?: Teaching artificial intelligence to freshmen in an introductory computer science course," in *Proc. 52nd ACM Tech. Symp. Comput. Sci. Educ.*, Colorado Springs, CO, USA, Mar. 2021, pp. 198–204.
[10] M. A. C. Fernandes, "Problem-based learning applied to the artificial intelligence course," *Comput. Appl. Eng. Educ.*, vol. 24, no. 3, pp. 388–399, May 2016, doi: 10.1002/cae.21717.
[11] M. Tedre, T. Toivonen, J. Kahila, H. Vartiainen, T. Valtonen, I. Jormanainen, and A. Pears, "Teaching machine learning in K–12 classroom: Pedagogical and technological trajectories for artificial intelligence education," *IEEE Access*, vol. 9, pp. 110558–110572, 2021, doi: 10.1109/ACCESS.2021.3097962.
[12] M. B. Ibáñez, Á. Di Serio, D. Villarán, and C. D. Kloos, "Experimenting with electromagnetism using augmented reality: Impact on flow Student experience and educational effectiveness," *Comput. Educ.*, vol. 71, pp. 1–13, Feb. 2014, doi: 10.1016/j.compedu.2013.09.004.
[13] C.-H. Teng, J.-Y. Chen, and Z.-H. Chen, "Impact of augmented reality on programming language learning: Efficiency and perception," *J. Educ. Comput. Res.*, vol. 56, no. 2, pp. 254–271, Apr. 2018, doi: 10.1177/0735633117706109.
[14] Q. Conley, R. K. Atkinson, F. Nguyen, and B. C. Nelson, "MantarayAR: Leveraging augmented reality to teach probability and sampling," *Comput. Educ.*, vol. 153, Aug. 2020, Art. no. 103895, doi: 10.1016/j.compedu.2020.103895.
[15] P. Soltani and A. H. P. Morice, "Augmented reality tools for sports education and training," *Comput. Educ.*, vol. 155, Oct. 2020, Art. no. 103923, doi: 10.1016/j.compedu.2020.103923.
[16] S. Boonbrahm, P. Boonbrahm, C. Kaewrat, P. Pengkaew, and P. Khachorncharoenkul, "Teaching fundamental programming using augmented reality," *Int. J. Interact. Mob. Technol.*, vol. 13, no. 7, pp. 31–43, Jul. 2019, doi: 10.3991/ijim.v13i07.10738.
[17] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS Quart.*, vol. 13, no. 3, pp. 319–340, Sep. 1989, doi: 10.2307/249008.
[18] J. Cabero-Almenara, J. Barroso-Osuna, C. Llorente-Cejudo, and M. D. M. F. Martínez, "Educational uses of augmented reality (AR): Experiences in educational science," *Sustainability*, vol. 11, no. 18, p. 4990, Sep. 2019, doi: 10.3390/su11184990.
[19] M. B. Ibáñez, A. U. Portillo, R. Z. Cabada, and M. L. Barrón, "Impact of augmented reality technology on academic achievement and motivation of students from public and private Mexican schools. A case study in a middle-school geometry course," *Comput. Educ.*, vol. 145, Feb. 2020, Art. no. 103734, doi: 10.1016/j.compedu.2019.103734.
[20] N. Loorbach, O. Peters, J. Karreman, and M. Steehouder, "Validation of the instructional materials motivation survey (IMMS) in a self-directed instructional setting aimed at working with technology," *Brit. J. Educ. Technol.*, vol. 46, no. 1, pp. 204–218, Jan. 2015, doi: 10.1111/bjet.12138.

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