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Design and Implementation of Scent-Supported Educational Content using Arduino

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Abstract

Due to the development of science and technology in the 4th Industrial Revolution, a variety of content is being developed and utilized through educational courses linked to digital textbooks. Students use smart devices to engage in realistic virtual learning experiences, interacting with the content in digital textbooks. However, while many realistic contents offer visual and auditory effects like 3D VR, AR, and holograms, olfactory content that evokes actual sensations has not yet been introduced. Therefore, in this paper, we designed and implemented 4D educational content by adding the sense of smell to existing content. This implemented content was tested in classrooms through a curriculum-based evaluation. Classes taught with olfactory-enhanced content showed a higher percentage of correct answers compared to those using traditional audio-visual materials, indicating improved understanding.

Keywords: *Olfactory support content, Realistic educational content, Arduino, Fragrance automatic spraying device*

1. Introduction

Due to the development of science and technology in the 4th Industrial Revolution, the use of digital textbooks is increasing in educational settings. Unlike paper textbooks, digital textbooks are textbooks provided through smartphones, tablets, laptops, etc. Through digital textbooks, learners can access learning materials anytime, anywhere, and learn more interestingly by utilizing a variety of content. In other words, using various multimedia materials can improve the learning experience and increase the efficiency and effectiveness of education.

A lot of realistic content is being developed that provides experiences similar to reality through the five human senses. Realistic content is content that provides realistic experiences and stimulates the five senses of humans by utilizing technologies such as virtual reality(VR), augmented reality(AR), and mixed reality(MR) [1]. It also increases user immersion by providing a realistic experience[2]. Sensory effects such as touch,

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smell, and taste are also utilized to increase immersion and realism in virtual reality content. Among them, the sense of smell also provides clues to invisible dangerous situations[3]. Fragrance is also used to relieve stress along with other factors[4]. Olfactory neurons are connected to both the amygdala, called the ′emotional brain', and the hippocampus, called the 'memory store,' so they improve memory and feel emotions through the sense of smell[5]. As odors are detected and transmitted to the brain, various odors can be identified, and they are also linked to memories and emotions. Therefore, realistic educational learning can increase understanding and concentration, and is effective in stimulating memory and mastering the learned content[6].

In this paper, we designed and implemented realistic educational content that automatically sprays scent through the corresponding flower card when a learned tag is detected using the tag function of an AI vision sensor. We designed content to teach 'the structure and function of flowers' among the science curriculum for 6th grade elementary school students. It is difficult to understand the complex structure, function, smell, and effects of flowers with existing image and text-oriented content. We created realistic educational content that supports the sense of smell to increase understanding and immersion in learning. The created realistic content was directly applied to classes. Classes were conducted with 56 6th grade elementary school students divided into two groups. 28 people in group A took classes with realistic content, and 28 people in group B took classes with existing audio-visual materials. After class, a test was conducted to understand the subject matter. As a result of the test analysis, the percentage of correct answers in group A, which took classes on realistic content supporting the sense of smell, increased by an average of 27.6%. It is understood that learners improved their understanding and memory by learning about the functions of flowers and the effects of fragrance while smelling the flowers.

The structure of this paper is as follows. Chapter 2 describes related research on realistic content and Arduino educational content. Chapter 3 explains the design process of educational content on 'Structure and Function of Flowers' that can increase educational effectiveness when spraying scent. Chapter 4 describes the implementation of a system that connects Husky Lens and Arduino to automatically spray scent according to flower type. In chapter 5, classes were conducted using realistic content and class effects were analyzed. Finally, we conclude in chapter 6.

2. Related studies

Previous research related to realistic content and Arduino educational content is as follows. In a study titled "A Design and Implementation of Tangible Educational Contents," realistic educational content was designed using a device that sprays odor into 2D animation content. It was suggested that the learning effect was improved by smelling the scent associated with 2D content[6].

The paper "The Effects of Science Classes on the Formation of Scientific Concepts for Elementary School Students Using Realistic Contents" analyzed the satisfaction of science classes and the structuring of scientific concepts using realistic content. It was shown that classes using realistic content had higher interest and immersion than the traditional class methods presented in science textbooks[7].

In the paper on "Using the Arduino for 6th grade science 'Seasonal change unit' program development and application effect", we used Arduino to learn about seasonal changes, scientific inquiry skills, and attitudes related to science. The experimental group showed higher improvement than the control group in the seasonal change concept test and scientific inquiry ability test, and also showed effective scientific attitude[8].

According to a study on "Study on educational utilization of physical computing using Arduino", students

who are new to programming learned basic scientific concepts using the easy-to-use Arduino. Applying it to various topics helped improve educational learning[9].

In the paper "Development of Teaching and Learning Materials for Robot Topic of Practical Arts Subject by Using of Arduino-sensor Kit," an invention education program was designed using Arduino on the topic of understanding robots using technology. The class was conducted to devise inventions by applying creative thinking techniques using the robot's sensors. The invention program using Arduino sensors helped with creative thinking and various inventions. They also expressed confidence in understanding and using the robot using the developed program [10]. It can be confirmed that realistic content and educational content using Arduino are positive for learning effects. However, there is not much realistic content for education that supports scent, and research on content combined with Arduino is insufficient. Therefore, in this paper, scent-supporting realistic educational content on the structure and function of flowers, a subject related to scent, was developed using Arduino.

3. Realistic content design using Arduino

In this paper, realistic educational content was created with the content of 'What are the structure and function of flowers?' in unit 3 of 'Structure and function of plants' in the 6th grade elementary school science curriculum. When learning the structure and function of flowers, the scent of actual flowers is sprayed to increase the learning effect. By examining the structure and function of flowers, we designed and produced realistic educational content that supports the sense of smell to increase understanding and immersion. Figure 1 shows the scent-supported educational content development process.

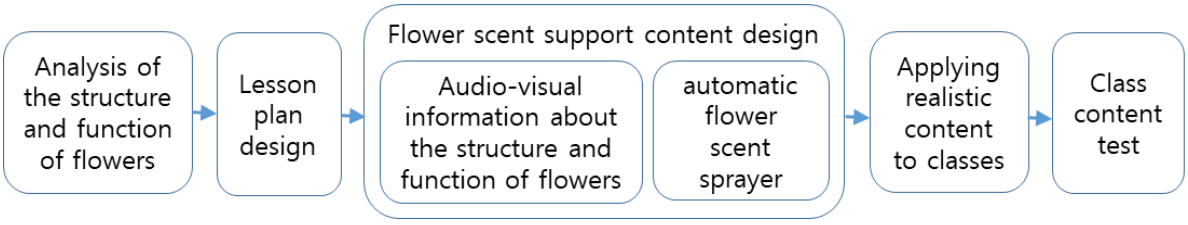


Figure 1. Olfactory support education content development process

Analyze elements to be learned in the structure and function of flowers and design a lesson plan. The class consists of two sessions, and through the class, you can understand the structure and function of flowers and learn about the scent and efficacy of flowers. To spray scent for each flower, we build an automatic scent spraying module using Arduino. We connect the AI vision sensor and Arduino board, and write code to recognize six types of flowers and spray scent. After applying it to an actual class, the effect was determined. Figure 2 shows the structure of the scent spraying system.

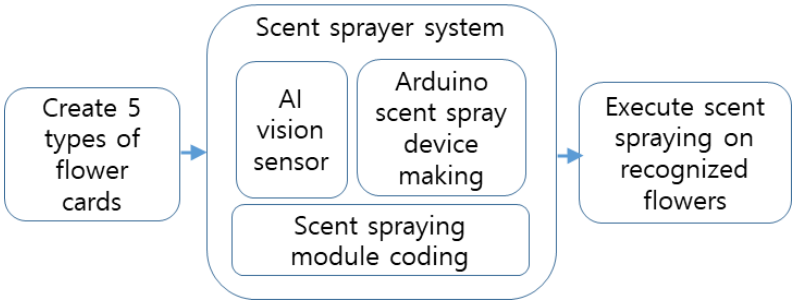


Figure 2. Scent spray system structure

In class, learn about the structure, function, scent, and effects of five types of flowers. The five flowers are peach blossom, tulip, geranium, ylang-ylang, and orange. When the AI vision sensor recognizes the flower card, the scent corresponding to each flower is sprayed. Arduino's water spray module was used to spray the scent. The hardware was built by connecting the AI vision sensor, Arduino board, and water spray module. We code and test so that the scent can be sprayed according to each flower.

Figure 3 below shows the main Arduino components used in the scent spraying system[11]. The first AI vision sensor is an artificial intelligence camera equipped with machine learning that collects and analyzes data information. Arduino Uno is the most commonly used for secondary coding, and is easy to use for beginners and intermediate users. Lastly, the water spray module is a device that connects to Arduino to spray and control water.

Figure 3. Main components of a scent dispensing system

Figure 4 below is a diagram of the scent spray system that automatically sprays the corresponding scent when the AI vision sensor detects a learned tag. The configuration diagram in Figure 4 was created on the fritzing site[12].

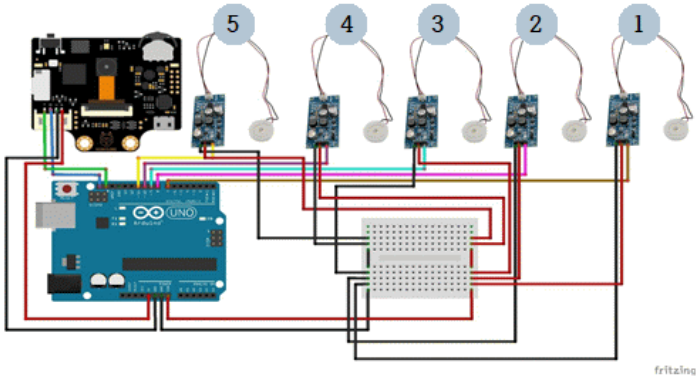


Figure 4. Arduino hardware configuration diagram for scent spray system

When you connect Arduino Uno and the spray module through the AI vision sensor, scent spray is generated

according to the learned tag. When a picture of a peach flower is recognized, peach scent is sprayed from spray module 1, and when a picture of a tulip flower is recognized, tulip scent is sprayed from spray module 2. When a photo of a geranium flower is recognized, geranium scent is sprayed from spray module 3. Spray module number 4 is designed to spray ylang-ylang scent, and spray module number 5 is designed to spray orange scent. Through this learning content, you can understand the structure and function of flowers and increase your understanding of the scent and efficacy of flowers.

4. Implementation of scent spray system

Figure 5 below shows the spray module connected through the AI vision sensor and Arduino. After coding using C language, upload it to Arduino and check the execution result. The spray module was connected to Arduino digital pins 7, 8, 9, 10, and 11. When tag number 1 is recognized by the AI vision sensor, spray module number 1 is sprayed, when tag number 2 is recognized, spray module number 2. Spray modules 3, 4, and 5 were also coded to run automatically based on tag numbers 3, 4, and 5, respectively.

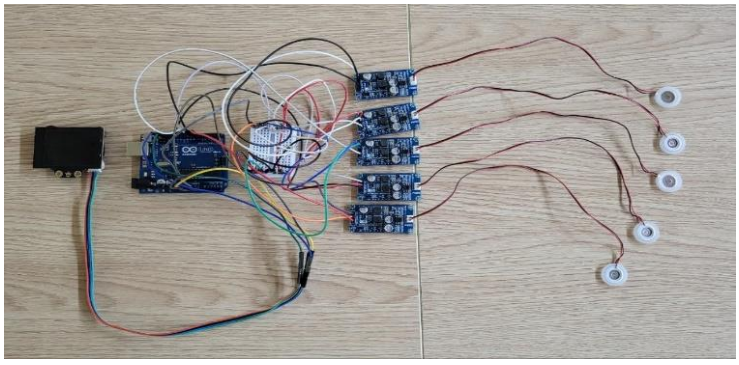


Figure 5. Connecting AI vision sensor and Arduino

When a picture of a flower is projected onto the AI vision sensor, the scent for that flower is sprayed. Figure 6 shows the execution result in which the Husky lens detects a flower and the corresponding flower scent is actually sprayed. The photo on the left in Figure 6 shows the ylang-ylang flower tag being recognized and the ylang-ylang scent being sprayed. The photo on the right of Figure 6 shows an orange being recognized and orange scent being sprayed.

Figure 6. Arduino scent spray execution

5. Application to classes and analysis of effectiveness

In this study, classes using realistic educational content were conducted to improve children's learning effectiveness. To confirm the learning effect of realistic educational content, understanding of subject matter was evaluated after class. Classes were conducted for 56 sixth graders attending S Elementary School in Andong-si, Gyeongsangbuk-do, and a curriculum content test was conducted. The participating students were divided into Group A with 28 students and Group B with 28 students. Group A took classes using realistic educational content, and Group B took classes without applying realistic educational content. Table 1 shows the curriculum content test questions. The course content is mainly about the shape and function of flowers, scent, effect, Arduino, etc.

Table 1. Test questions regarding understanding of class content

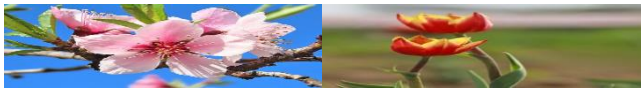
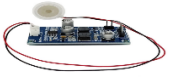
1. Look at the picture below and write the name of the flower. 
2. What is the name of the flower that fits the following description? It has a refreshing citrus scent. It is effective in promoting digestion and relieving constipation. Helps with skin regeneration
3. What flower name fits the following description? Sweet and elegant, it has a rose-like scent. Helps relieve anxiety and depression. It improves blood circulation and is effective in removing waste.
4. Which Arduino part is related to the photo below? 
5. Which of the following Arduino UNO board components corresponds to the underlined part? 

Table 2 below shows the percentage of correct answers for the subject comprehension test conducted in classes that applied and did not apply realistic educational content.

Table 2. Correct answer rate

	Question 1	Question 2	Question 3	Question 4	Question 5	Average
Apply scent support content (28 people)	95%	71%	63%	52%	39%	64.0%
Apply existing audio-visual content (28 people)	100%	95%	93%	88%	82%	91.6%

In classes where realistic educational content was not applied, the correct answer rate for the content test was 95% for question 1, 71% for question 2, 63% for question 3, 52% for question 4, and 39% for question 5.

The overall average correct response rate is 64%. Looking at the percentage of correct answers in the curriculum test using the realistic educational content application method, question 1 was 100%, question 2 was 95%, question 3 was 93%, question 4 was 88%, and question 5 was 82%. The overall average correct response rate was 91.6%. Therefore, looking at the subject test results, it was confirmed that the percentage of correct answers increased by 27.6%p compared to when the class was conducted without applying realistic educational content.

6. Conclusion

In the educational field, students can feel interest and immersion by experiencing realistic virtual learning content using smart devices through realistic content contained in digital textbooks. However, among realistic content, there are many content with audiovisual effects such as 3D virtual reality, augmented reality, and holograms, but olfactory content that allows users to feel actual sensations has not yet been introduced. Accordingly, in this paper, we designed and implemented 4D realistic educational content by adding the sense of smell among the five senses to existing realistic content. We designed a scent spray function that automatically sprays scent by connecting to Arduino through the tag recognition function of the AI vision sensor, and manufactured it so that you can actually smell the scent through an automatic sprayer. The created scent-spreading support content was applied to actual classes. Fifty-six sixth-grade elementary school students were divided into two groups. Group A conducted classes using realistic educational content, and group B conducted classes using existing audio-visual materials. After class, there was a test to understand the topic. Looking at the average of the subject content tests for each group, it was confirmed that the average correct answer rate of group A, which took a realistic educational content class incorporating the sense of smell, increased by 27.6 percentage points compared to the general subject class. In fact, learning comprehension and concentration improved by smelling and remembering smells through the sense of smell. In the future, it is expected that the quality of education will be improved by using realistic educational content classes in various subjects.

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