*Sensors and Materials*, Vol. 35, No. 4 (2023) 1363–1373
MYU Tokyo


S & M 3252

# Edutainment Content Production Platform Based on Activity Control Using Skeleton Tracking

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(Received November 30, 2022; accepted February 7, 2023)

***Keywords:*** activity control, edutainment, interactive content, motion recognition, skeleton tracking

During the COVID-19 pandemic, the activities required for child physical development were reduced because classes were conducted remotely. Thus, an interactive edutainment content that can assist the physical and cognitive development of children in indoor environments is required. In this study, we designed an edutainment content production platform (ECPP) that allows teachers to design and produce an educational content using students' movements. Teachers can develop an educational content by analyzing and modifying the children's response to the designed edutainment content. The skeleton tracking of the human body using a depth sensor was used for the user interface and activity analysis. The proposed platform allows teachers to set images and movements for educational icons, as well as visual and sound effects that occur when a child touches the icons. The ECPP includes an activity control function that allows teachers to analyze the amounts of activity and movement, and then adjust the movement level in the edutainment content. In addition, a content management module allows teachers to store and share an interactive content.

## 1. Introduction

Outdoor spaces where young children can play safely with their friends are decreasing owing to changes in the external environment with increased danger, such as from cars and motorcycles, on the streets. In addition, on days with high levels of fine dust, outdoor classes are being replaced with indoor classes, and owing to the impact of the COVID-19 pandemic, as students participate in classes online from home, the environments in which they can engage in activities with their friends and class are limited. Education involving physical activities is decreasing owing to various difficulties such as the difficulty in securing indoor spaces. Thus, there is a need for an educational content that provides both knowledge and physical activities to young children simultaneously in indoor environments.

Edutainment is a compound word that combines education and entertainment. Edutainment can produce educational effects in children while they perform fun activities. An edutainment

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https://doi.org/10.18494/SAM4267

content has been expanded to various forms by merging the latest technologies, including multimedia, human–computer interaction (HCI), virtual reality (VR), augmented reality (AR), and artificial intelligence (AI). Edutainment technologies enable education with no limitations in terms of time and space, and the paradigm of education is shifting from teacher-oriented methodologies to learner-oriented processes. Digital technologies can provide efficient study environments because they can be used to create and distribute curricula that are customized for individual learners.(1)

An interactive educational content must facilitate both physical and cognitive developments simultaneously, and a balance between play and education is required for young children.(2) Education that involves physical movements facilitates the physical development of children and allows them to form positive attitudes about movements, and it has positive effects on the development of cognitive abilities, for example, self-control and attention.(3,4) Using interactive edutainment technologies allows children to interact with the content while enabling cognitive education, including on society, nature, and art. Unlike education for adolescent education, early childhood education requires the help and management of teachers because young children cannot learn independently. An educational content in the form of games can be an effective alternative to induce physical activities for children while motivating interest.(5,6) A movement-based interactive content allows children to become immersed while observing images that change in real time according to their movements. Such a content can facilitate learning and memory developments while improving physical abilities.(7)

When combined with game theory, an interactive educational content has produced positive results in various educational fields by enabling self-directed learning while maintaining student participation.(8) In addition, an educational content that enhances immersion can be developed using VR and AR technologies, and such a content can enhance student engagement and comprehension, and it can expand their imagination and ideas because experience-, exploration-, and experiment-oriented contents can be developed for lessons that are difficult to experience in the real world.(9) In terms of educational content for young children, it would be more useful to provide an interface that can be controlled using their hands and by a simple motion than to use complex controller devices.

Human motion tracking technologies are divided into visual and nonvisual tracking methods.(10) Some motion tracking methods use IR markers attached to the user's body. The IR image reflected from the IR markers is acquired using an IR camera to capture human movements precisely. In addition, depth-sensor-based methods have been widely used because they can extract skeleton information in real time without attaching markers to the user's body.(11,12) Nonvisual tracking techniques include acoustic, mechanical, and magnetic systems. Inertial measurement unit sensors have become miniaturized and mitigate the drift issue in gyro sensors. However, when employing nonvisual tracking methods, special devices must be attached to the body or the user must hold a controller in their hand; thus, it is appropriate to use image vision technology and a Kinect sensor equipped with a depth sensor to facilitate a free body movement.(13–15)

Kinect sensors can recognize the user's body movements without requiring wearable devices at a relatively low cost. They convert shape data into skeleton data, which is convenient for downstream analysis or applications that involve human movements. With the release of sports and gymnastics games that recognize motion using Kinect sensors, health-related games have attracted increasing attention, and related research has been conducted.(16) Studies on applications that can enhance therapy while analyzing body movements using Kinect sensors are also being conducted in physical therapy and rehabilitation fields, where the constant monitoring of patients and the accurate performance of exercises by patients are required.(17) Analyzing skeleton data allows us to predict activity levels and energy expenditure, which facilitates the control of the exercise intensity in an interactive content.(18) In addition, combining Kinect sensors and a visual content can promote the development of hand-eye coordination in early childhood.(19) Positive results have been demonstrated in various fields by applying game theory to an interactive content for young children.(20)

Typically, an interactive edutainment content cannot be developed by teachers; thus, ready-made products are generally used. However, commercial interactive edutainment systems will inevitably be limited because teachers' ideas for new educational conditions cannot be applied to such systems. In this study, to address this issue, we designed an edutainment content production platform (ECPP) to allow teachers to produce an appropriate edutainment content for young children easily. In addition, we designed and developed an edutainment system to enable the design of an edutainment content by interconnecting physical and cognitive activities to facilitate simultaneous physical and cognitive education.

## 2. Edutainment Production Platform

### 2.1 Edutainment content production system

The proposed ECPP, which was developed on the basis of the Unity game engine, offers functionality to design an interactive edutainment content based on movements. With the content supported by this platform, as shown in Fig. 1, children can interact with on-screen objects by touching them with their hands or other parts of their body. Note that this method is

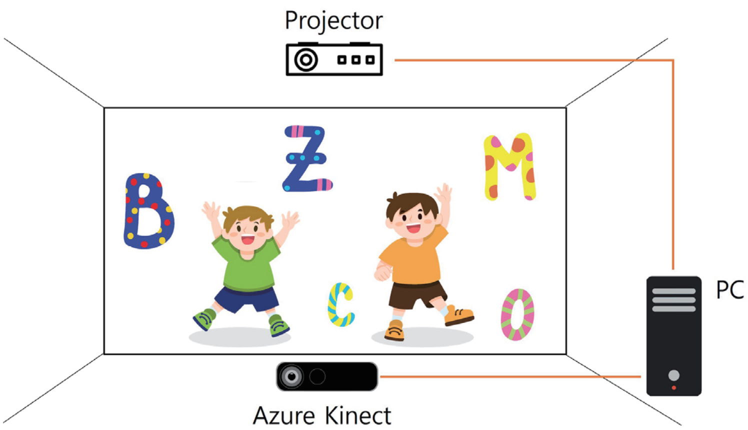


Fig. 1. (Color online) Edutainment content system environment.

widely used in exhibition halls, theme parks, and kid cafes. Kinect sensors installed in front of the screen recognize the child's movements, and the content can interact with the child and measure their activities by analyzing the skeleton.

The proposed ECPP was designed to allow teachers to develop and design various curricula and produce an interactive content for children. The functions required for content production were analyzed, as shown in Fig. 2. Here, we considered background images and music to represent the themes presented by the edutainment content. Elements that react with a child's body were defined as game objects, which are generated and moved according to the teacher's settings. Game objects are categorized as image, size, movement, and creation. The interaction module includes visual effects and sound functions. When a student touches a moving game object with their hands or feet, corresponding visual and sound effects are generated. The activity management system includes a motion recognition function that tracks the user's skeleton using the Azure Kinect sensor. The activity analysis function measures the amount of movement performed by the user, and the activity management system generates a collision event in the interaction module by setting the interaction area on hands and feet, and it is used to generate the positions where the game objects are created using the results of motion analysis.

The proposed ECPP has functions to execute an edutainment content, produce an edutainment content, and manage both the produced edutainment content and students. In addition, the edutainment content and resources can be stored as files for reuse. When a new edutainment content is created, a new folder is created; the content theme is used for the folder name. A game object's setting file is created when a new game object is added to the folder with the theme name, and the image file path, sound file path, animation index, and animation run time are saved. In addition, other resources, such as image, sound, and animation files, are stored separately. Thus, teachers can save and load the developed edutainment content as files, and these files can be shared with other teachers.

### 2.2 Edutainment content design

We produced an edutainment content for young children using the proposed ECPP. In the ECPP's setting mode, the list of contents stored in the platform can be viewed, and the content to

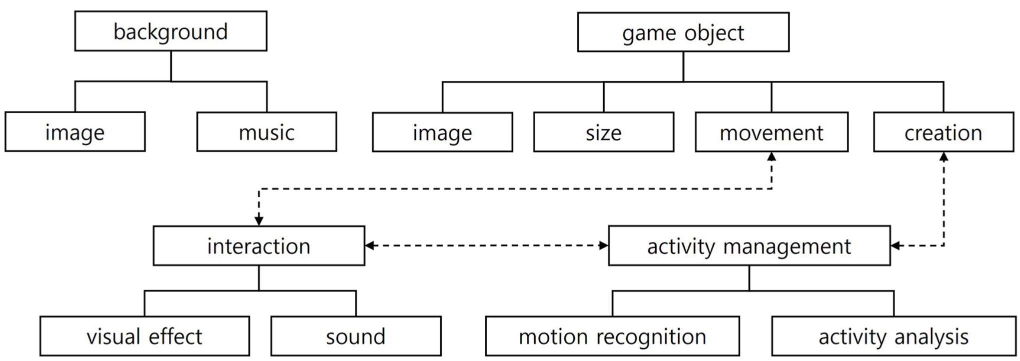


Fig. 2. Structure of interactive edutainment content system.

use can be selected in the play mode. The proposed ECPP includes functions to create, modify, and delete the content. To create a new content, the “New” button is pressed to create a content theme. In this study, we created an edutainment content that teaches the alphabet to children (Fig. 3) using the proposed ECPP. The teacher determines the image and sound files to use as the game objects of the content.

When a teacher selects a content and clicks the “Setting” button, the content settings page is displayed. Here, the content title, background settings, and game object settings can be edited. For the background settings, an image file to use as the background image can be selected by clicking the “Image” box, and a background sound can be selected by clicking the “Sound” box, as shown in Fig. 4.

Figure 5 shows examples of the icons used in the alphabet theme content. Here, clicking the “Property” button for the game object displays the game object’s settings page, where the game object image, image size, animation effect, collision sound effect, and other settings can be selected. Using the image setting box, the user can set the image of the game object used in the play mode and the size of the image. If the teacher sets a random image size, the icon can be displayed with different sizes between predetermined maximum and minimum size values. Various game object movements and speeds can be set in the animation setting box, as shown in Fig. 6. When the speed of a game object is set randomly, the game object’s animation speed is varied between the minimum and maximum values. In addition, the animation movement can be


Fig. 3. (Color online) Alphabet images.

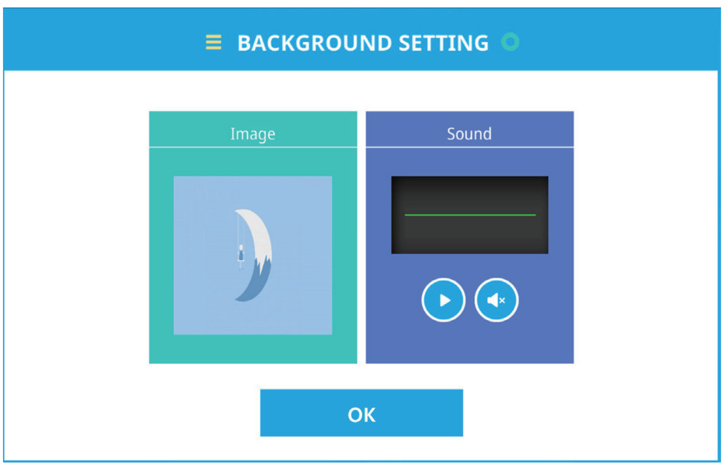


Fig. 4. (Color online) Background settings.


Fig. 5. (Color online) Game objects for alphabet content.

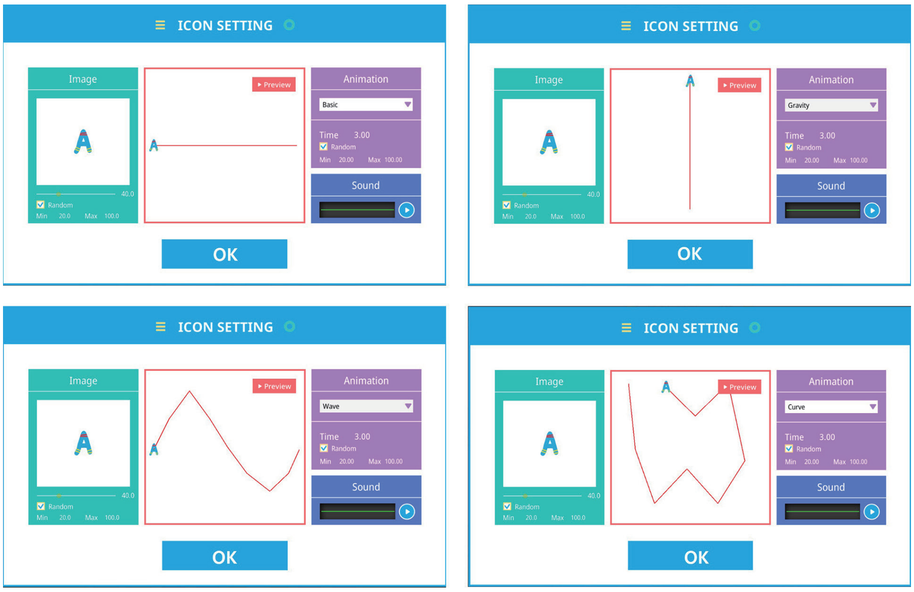


Fig. 6. (Color online) Game object settings.

viewed by clicking the "Preview" button. In the "Sound" setting box, the sound effect file for the corresponding game object can be selected, and the sound can be heard by clicking the "Play" button.

The proposed ECPP allows a teacher to set the images and sounds for each game object. Game objects interact with children's movements. In addition, using the proposed ECPP, game objects can be created and moved automatically, selected by the child's movement, and changed after being selected.

Figure 7 shows the process of producing an educational content with the alphabet theme. When the teacher sets the background and game objects and then selects the ECPP play mode, the main screen appears, and the game objects are created and moved according to their settings. For example, the alphabet edutainment content can be set such that when the child selects a letter

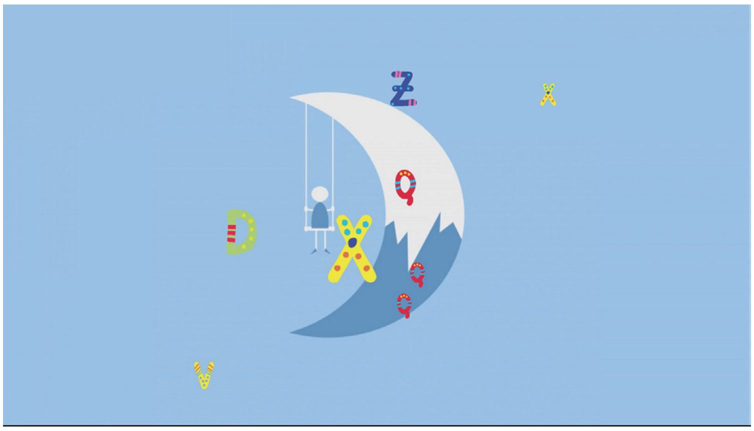

Fig. 7. (Color online) Edutainment content play mode.

of the alphabet using their body, the image disappears and the pronunciation of the letter is played.

### 2.3 Activity management

The activity management module includes motion recognition and activity analysis modules. The motion recognition module uses the Azure Kinect sensor to recognize the user's movement. An Azure Kinect sensor has a color camera resolution of 3840 × 2160 px @ 30 fps and a depth camera resolution of 640 × 576 @ 30 fps. It has a standard deviation of ≤17 mm and a distance error of <11 mm + 0.1% of distance.[21] It can obtain data from 32 skeleton joints as shown in Fig. 8.[22]

The motion recognition module performs interactions by installing a sphere collider on each of the HAND_RIGHT, HAND_LEFT, FOOT_RIGHT, and FOOT_LEFT joints (Fig. 8). Here, by setting a box collider on a moving game object, an interaction occurs when the game object collides with the child's hands or feet on the screen. When the collider at the hands or feet collides with the game object collider, a destruction animation is activated using a sprite, and then the game object is eliminated to visualize the collision interaction and the sound registered for the game object is played. Here, game objects that do not collide until the final animation are eliminated when the animation is completed.

The activity analysis module measures the amount of movement activity of the child. This module measures the relative amount of activity using changes in the position data for the 32 joints shown in Fig. 8. Here, the positions of the 32 joints are tracked, and the distances between the previous and current positions are calculated every second. The change in the position of each joint is classified into the whole, upper, and lower body movements according to the location of the joint, allowing the teacher to evaluate the amount of exercise. Note that the activity data are classified into 10 movement levels, and the teacher can set the desired activity level, giving an appropriate amount of exercise for each child in the edutainment content. After setting the desired activity level, the distance between randomly generated game objects is adjusted such that the children must move more to the left or right.

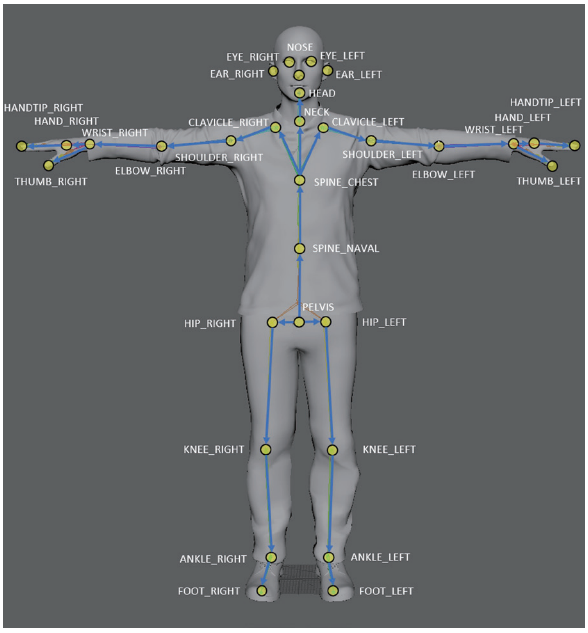


Fig. 8. (Color online) Skeleton structure tracked by Azure Kinect sensor.

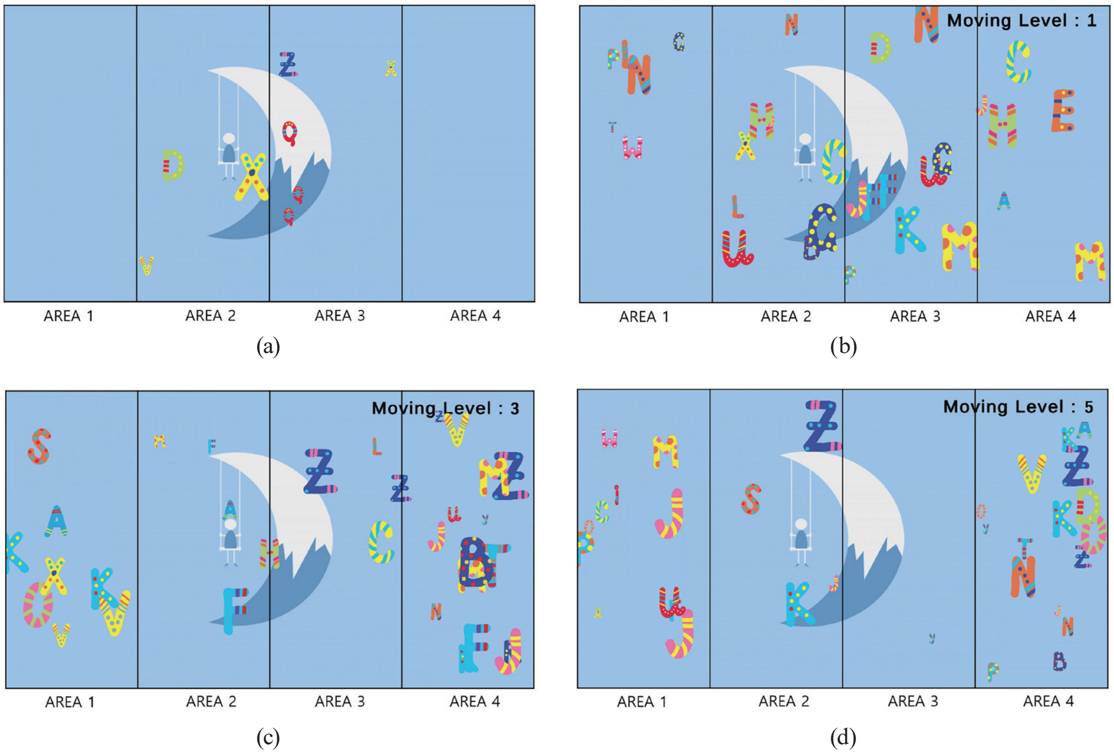


Fig. 9. (Color online) (a) Screen space partitioning, (b) activity level 1, (c) activity level 3, and (d) activity level 5.

The proposed ECPP generates game objects randomly by dividing the screen space into four regions, as shown in Fig. 9(a). Here, the activity level comprises five levels, and the probability

Table 1
Game object creation probability according to activity level.

| Activity level | Level 1 (%) | Level 2 (%) | Level 3 (%) | Level 4 (%) | Level 5 (%) |
|---|---|---|---|---|---|
| Area 1 | 20 | 25 | 30 | 35 | 40 |
| Area 2 | 30 | 25 | 20 | 15 | 10 |
| Area 3 | 30 | 25 | 20 | 15 | 10 |
| Area 4 | 20 | 25 | 30 | 35 | 40 |

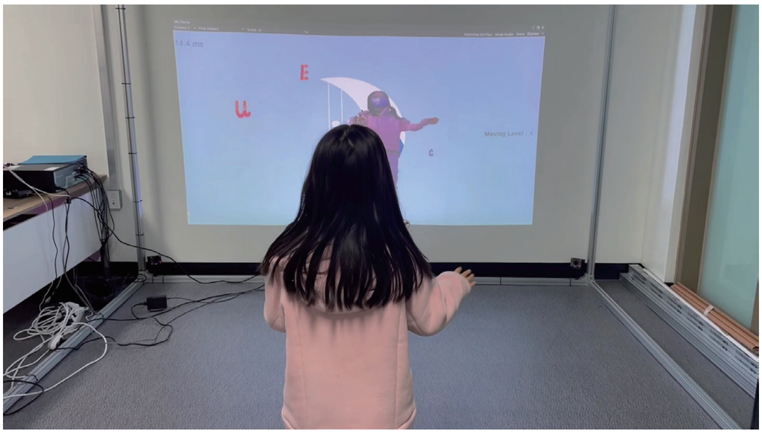

Fig. 10. (Color online) Edutainment content test.

of game object creation in each area is determined according to the activity level, as shown in Table 1. When the activity level increases, many game objects are created in both edge areas (areas 1 and 4), which induces more movements. Figure 9 illustrates the game object creation probability according to the activity level.

In this study, an edutainment content that teaches the alphabet was developed and tested for five 7–9-year-old children, as shown in Fig. 10. Here, the children touched falling alphabet objects with their hands, and they enjoyed the corresponding visual and sound effects. The amount of movement was calculated using the Azure Kinect sensor. When the activity level was increased, a larger number of game objects were assigned to the left and right edge areas, and we confirmed that the amount of movement increased. Teachers can analyze each child's reactions to the designed educational content and further develop an interactive content by modifying the content iteratively. The proposed platform also includes content management features so that teachers can store and share their interactive content with other teachers.

## 3. Conclusion

The edutainment field is advanced by merging various interactive technologies, and studies are currently investigating edutainment contents for adults using various VR, AR, and AI devices. In this study, we examined an interactive edutainment content for young children based on the Kinect device that uses body movements as an interface rather than complex input interfaces. In schools for young children, the capacity to add a new educational content is limited even when interactive education systems are utilized. Thus, we designed and developed an ECPP that enables the design and production of a new educational content based on the teacher's ideas. The proposed platform allows teachers to set the images and movements of icons that can react to a child's movements and visual and sound effects that appear when children touch the icons.

We designed an interactive content that can facilitate both physical activities and the creative development of children by letting the children perform body movements and cognitive activities simultaneously. The proposed platform can be used by teachers to analyze the number of activities based on a child's movements, and the content can be set to increase the number of physical activities.

In addition, interviews were conducted with five HCI professionals. We found that HCI-related professors appreciated the ability to create an edutainment content easily using images and sound files found on the Internet. Teachers can draw their own images or use existing images. In addition, teachers can record their own voices to create content. The game mechanics are simple; thus, it would be better if game elements were added to motivate interest. Using the amount of movement of students as an interface can be effective; however, we found that a functional development that recognizes multiple users and analyzes their movement is required in cases where a large number of students participate simultaneously.

In the future, the effect of the edutainment content through user experience must be analyzed statistically. In addition, we plan to diversify the types of supported interactive content and develop a platform that allows multiple educational institutions to use the same content simultaneously over a network infrastructure.

## Acknowledgments

This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2020R1I1A3051739).

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