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SHORT PAPER

Open-ended Simulation 3D Game as a Tool for Speech Therapy Intervention

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ABSTRACT

Speech and communication disorders are widespread among preschool children. Various studies indicate that approximately 8% of children aged 317 years have some form of communication disorder. This paper presents a three-dimensional serious game, open-ended in nature, intended as a tool for speech therapy intervention to address these disorders. The software is suitable for supporting speech, language, and communication in preschool children and is primarily intended for speech therapists, but also for parents and educators involved in language development programs for children. The game simulates the toys and objects used by speech therapists during sessions with children and creates an engaging virtual environment. By promoting active listening, imitation, prompted speech and spontaneous language production, the game enhances children's communication skills. The software is compatible with devices running on Windows, Mac, Android, and iOS and is also available as a web application, ensuring maximum accessibility for users.

KEYWORDS

speech therapy, technological application, simulation game, intervention, serious games

1 INTRODUCTION

Communication disorders in preschool children have a significant impact on their developmental skills. They impact speech, language, social, and academic skills, cognitive and emotional development, and functioning in everyday life [1], [2], [3]. Children with speech disorders, such as childhood apraxia of speech (CAS) or developmental language disorder, often face difficulties in learning to read and write [4]. Speech, language, and communication disorders are also likely to affect a child's emotional development, causing anxiety and frustration [4], [5]. Difficulty in communication can affect the children's ability to fully participate in daily activities and to independently care for themselves [6]. The importance of early therapeutic intervention is undeniably crucial, as experts emphasize the need for an early diagnosis and treatment to avoid long-term impacts on the child's social, cognitive,

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and emotional development. Early intervention is critical for the development of communication skills [7], [8], reduces the severity of phonological disorders, and improves phonological awareness [9].

One of the significant obstacles faced within conventional therapeutic interventions is the necessity for ongoing oversight by trained specialists, coupled with the inherent rigidity and limited adaptability of the employed therapeutic techniques [10], [11], [12]. The materials used in traditional speech therapy methods include board games, books, printed materials, and various objects that help in acquiring and practicing speech and language skills. However, traditional methods can become tiring and unattractive for children when the materials used in the interventions are not frequently changed [13], [14], [15].

Technological solutions offer an effective way to address such challenges. Digital technologies increase the flexibility of therapies while at the same time allowing for the development of personalized therapeutic programs [11], in accordance with the principles of speech therapy. The digitization of therapeutic tools and the use of digital media can enhance the attractiveness of sessions for children [19].

Regarding input devices and digital interfaces for preschool children, the studies by Lu and Frye [16], Nacher et al. [17], and Grünzweil and Haller [18] substantially contribute to understanding children's interaction with these technologies and their specific needs. In particular, Lu and Frye [16] conducted one of the first comparative studies on the use of a mouse and a touch screen by preschool children and showed that the touch screen offers advantages in terms of accuracy and speed of selecting objects compared to the mouse. Nacher et al. [17] confirmed those findings and extended the study to examine the use of multi-touch screens by two–three-year-old children, documenting their ability to perform both basic and more complex gestures, as well as the difficulties they face in more intricate movements. Lastly, the work of Grünzweil and Haller [18] highlighted the considerable increase in the use of digital technologies by preschool children and the need for developing software tailored to the unique skills and needs of this age group.

However, from the literature review, no open-ended rehabilitation software was found that is versatile and suitable for targeting a wide range of speech, language, and communication disorders in therapy. Furthermore, a review of the literature indicates that the use of the touch screen in this software is most suitable for this particular age group [16], [17], [18].

In the present study, we present a serious game for speech/language therapy intervention, which was designed and developed for preschool children with speech, language, and communication disorders. The software is three-dimensional and simulates the objects and games used by speech-language therapists during interventions. The aim of creating the software is, on one hand, to provide a supportive tool for interventions that covers as many functions of speech, language, and communication as possible, making it suitable for the treatment of various disorders, and on the other, to offer speech therapists a wide range of three-dimensional objects and games to enrich stimuli choices and create diverse intervention scenarios. Additionally, the software was designed with tactile interactivity to ensure that it is accessible and user-friendly for preschool-age children [16], [17], [18].

2 METHOD

The software is open-ended, meaning there is no specific scenario or predetermined goals set by the software. What the software offers is a three-dimensional space where the client and therapist can use 3D objects in a playful manner to support the speech therapy intervention process. Children and speech therapists interact with the software using their fingers, making it user-friendly and enjoyable to use. The main area of the software environment consists of a large green surface that serves as a stage where the game takes place. This corresponds to the concept of a table, which is an essential structure for conducting traditional in-person therapy.

In the bottom left corner of the screen, an emoticon depicting a smiling face is displayed (see Figure 1).

Fig. 1. Main game area

If the user touches this face, a horizontal scroll bar with 12 different icons appears. These icons represent categories that include the 120 different 3D objects that can be used during the game (see Figure 2).

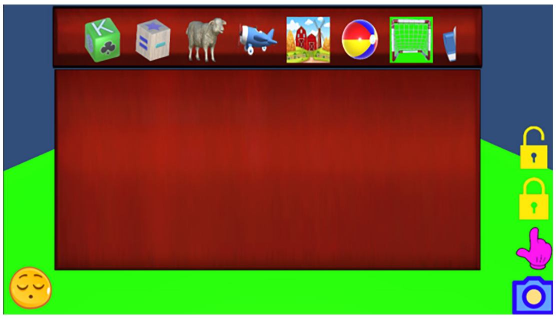

Fig. 2. Horizontal scroll bar with all the prop categories

If the user taps on one of the 12 icons, the items/contents of each category appear in the area below the horizontal scroll bar. For example, if the user taps the "farm" icon with their finger, the corresponding items for that category will appear, as shown in Figure 3.

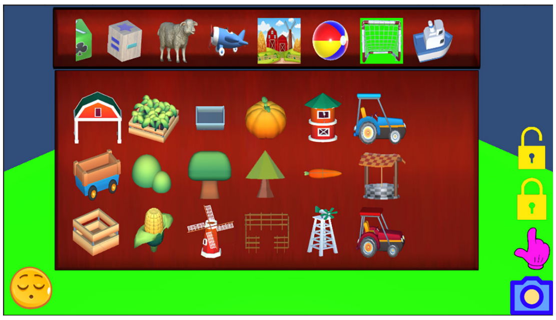

Fig. 3. Menu

Next, the user is prompted to select the objects they wish to use. The selection of each object is done as follows: the user first taps the icon corresponding to the object of their choice. Then, to place it within the game environment, they must close the object selection menu. To close the selection menu, the user needs to tap the emoticon again at the bottom left corner of the screen. Finally, to make the object appear within the game environment, the user must tap their finger anywhere on the green surface (see Figure 4).

When the user places any 3D object on the stage, they can then manage it using the features provided by the software. To use these features, the user must first tap on the purple "hand" located on the right side of the screen and then on the object of their choice that is already on the stage. After that, a series of different icons/tools appears at the bottom of the screen, which, when tapped by the user, perform various functions (see Figure 4).

Fig. 4. Prop on stage

Starting from the right, the first icon that appears is the "recycling bin," which, when tapped by the user, deletes the selected object. The next two icons are "fish" in two different sizes, allowing the user to adjust the size of the selected objects. If the user taps on the "small fish," the selected object on the stage shrinks by 5% in all three dimensions. Similarly, if the user taps on the "large fish," the selected 3D object on the stage increases in size by 5%. The fourth icon in the sequence is a "ghost," which, when tapped, makes the selected object on the stage transparent, allowing the user to see any objects placed behind it. This feature is particularly useful when a large 3D object is placed in the environment and smaller 3D objects behind it are not visible.

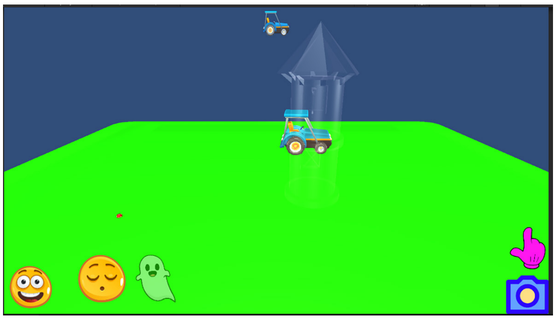

Fig. 5. Tower in ghost mode

When the large object becomes transparent and the user can see through it, they can then manipulate the objects behind it using touch. In this way, the user has access to all the 3D objects, regardless of where they are in the space, whether they are visible or not. To return the object to its original solid form, the user needs to tap the "ghost" icon again.

To make the icons for the recycling bin, the fish, and the ghost disappear from the screen, the user must tap the emoticon with closed eyes, which is located to the right of the ghost icon (see Figure 4).

Another feature that the software offers is the ability to lock objects that have been placed on the stage so that the user cannot move them. To lock an object's position, the user must first select it. This selection is made by tapping on the purple "hand" icon and then on the object. Then, the user taps on the "closed lock" icon located on the right side of the screen (see Figure 3).

The above actions result in the object being locked in a specific position, making it impossible for it to be moved either by the user or by another object that might collide with it. When the user wants to unlock the object, they select it again and then tap on the "open lock" icon (see Figure 3).

Users have the ability to move the props in various ways. Briefly, the movement options are as follows:

With one finger: The object moves on the green surface in any direction.

With two fingers: The object can move up, down, right, or left.

With three fingers: The object can move up, down, forward, or backward.

With four fingers: The object rotates.

These movement options allow the user to place the props next to each other or on top of one another.

More specifically, to move an object on the green surface, the user must touch the object with one finger and then drag their finger in any desired direction on the green surface. As the user moves their finger on the green surface, the object follows this path at a speed proportional to that of their finger. If the object collides with another object during its movement, a "physics simulation engine" simulates the outcome of the collision, taking into account the speed and masses of the objects.

The software also offers the user the ability to move the object up, down, right, and left. To achieve this movement, the user must touch the object with two fingers. When the software detects two fingers, the movement of the object follows the motion of the fingers along the x and y axes. The software also provides the option to move the object up, down, forward, and backward. To perform this movement along the x and z axes, the user must touch the object with three fingers.

Finally, the user has the ability to rotate the object around the y-axis. This feature is activated using four fingers. Once the software detects them, the object is fixed at a point, and by moving one finger left and right on the screen, the user can rotate the object as desired.

These four options for moving objects were all chosen to be tactile commands, so that children can execute them using their fingers. Additionally, the software allows up to ten users to simultaneously move ten different objects on the stage, making the game highly interactive and engaging.

The development platform used was Unity 3D, and the programming language was C#.

3 DISCUSSION

This study introduces an original three-dimensional open-ended game as a tool for speech therapy intervention, focused on speech and communication disorders in preschool children. The use of digital tools in speech therapy is not new; however, this particular approach offers innovative solutions such as the tactile manipulation of three-dimensional objects that simulate the toys used in traditional interventions and their natural, physical properties they have in space. It also provides limitless combinations for creating simple or complex imaginary play scenarios, in line with the developmental motor and cognitive maturity and interests of each child.

One of the main challenges that speech therapists face is maintaining the attention and active participation of children during therapeutic sessions. The game presented here is highly versatile, as it offers a virtual, interactive space where children can engage in various alternative activities that enhance their language skills through play. The open-ended nature of the game allows therapists to tailor activities to the needs of each child, which is particularly practical given the variety of speech and language disorders. It also enables the therapist to adapt materials to the child's interests and sustain their motivation.

A distinct feature of the software is its capability for multiple interactions, as it allows up to 10 users to participate simultaneously. This not only makes the tool flexible for use in group sessions (e.g., sessions with the presence of parents, siblings, or other children with disorders) but also encourages social interaction among children as well as team play, which are crucial for the development of their communication and social behavior skills.

However, it is necessary to acknowledge the limitations of this study. Despite the software's technical strengths, of the software, its actual effectiveness depends on its proper integration into the therapeutic process and its adaptation to the needs of each child. Further research is needed to evaluate the use of the software by speech-language therapists, as well as its long-term impact on the development of children's language skills.

4 CONCLUSION

The three-dimensional open-ended game presented in this study represents a powerful innovation in the field of speech or language therapy, particularly for children with speech, language and communication disorders. By integrating technological solutions into a virtual environment, and especially through the tactile management of the screen by the child, this game offers a customizable tool that can increase children participation and improve their language skills through a variety of interactive and engaging activities. At the same time, it allows speech-language therapists to adapt sessions according to each child's needs, which is crucial for successfully remediating these disorders. However, the success of this tool depends on its proper integration into daily practice and the continuous evaluation of its effectiveness. Further research is necessary to fully assess its long-term impact on speech therapy intervention.

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