Master's Thesis

# Development of Serious Games for Vocal Training in Speech Therapy

Edwina Dwi Sadika

Department of Industrial and Management Engineering

Pohang University of Science and Technology

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# 언어치료의 발성훈련 기능성 게임 개발

# Development of Serious Games for Vocal Training in Speech Therapy

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by

Edwina Dwi Sadika
Department of Industrial and Management Engineering
(Human Factors and Ergonomics Program)
Pohang University of Science and Technology

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Approved by
Heecheon You (Signature)
Academic Advisor

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Edwina Dwi Sadika

The undersigned have examined this thesis and hereby certify that it is worthy of acceptance for a master's degree from POSTECH

12/15/2016

Committee Chair Heecheon You (Seal)

Member Sooyoung Chang (Seal)

Member Myoung-Hwan Ko (Seal)

DIME Edwina Dwi Sadika

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## ABSTRACT

Serious games provide fun entertainment while supporting learning and skill development. Serious games have been used for supporting education, military training, and health treatment. Communication disorders including speech, language, and hearing disorders are considered high-incidence impairment, occurring in 10% of people. Particularly, 1.4% of children and 7.6% of adults have voice disorders, resulting in a significant need of speech therapy. Compared to traditional speech therapy, serious games can help to maintain patients' motivation and commitment. This study was intended to: (1) identify needs and game development strategies of vocal training games to support speech therapy for people with speech disorders by literature review, stakeholder needs survey, and benchmarking, (2) develop a motivating and effective program ("Smart Speech") consisting of various serious games for vocal training as a part of speech therapy by implementing the identified game development strategy, and (3) evaluate the proposed vocal training program ("Smart Speech")

by conducting absolute and relative assessments. The developed vocal training program consists of voice continuity, loudness, and pitch categories with five games each to keep patients' interest during training. Gamification factors such as difficulty level and score were used to challenge patients in the developed vocal training program. Therapists can determine customized values of variables such as duration, repetition, target loudness and pitch levels of a game according to patients' capabilities and disorder severity levels. The developed vocal training program was evaluated by 20 therapists. From the absolute assessment result, visual aesthetics (5.3 ± 1.0), usability (5.2 ± 1.1), personal gratification (5.2 ± 0.9), customization (5.2 ± 0.9), accuracy (5.1 ± 0.9) are the strenghts of *Smart Speech*, while play engrossment (4.5 ± 0.9), social connectivity (4.5 ± 1.1), and creative freedom (4.4 ± 1.0) are features to be improved. From the relative assessment result, *Smart Speech* is better than existing games in all scales, especially customization (5.5 ± 0.8), visual aesthetics (5.2 ± 1.1), narratives (5.2 ± 1.3), accuracy (5.2 ± 1.1), personal gratification (5.1 ± 1.2), and usability (5.1 ± 1.0). Therapists like the customization, various content (narratives), clarity of game rules (usability), and appealing graphics (visual aesthetics) of the games and considered the developed program is able to increase the interest of its users, especially children.

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# I. Introduction

## 1.1. Research Background

Voice disorder, a type of speech disorders, is characterized by an abnormal production and/or lack of vocal quality, pitch, loudness, and/or duration. Estimated 3 ~ 9% of the American population have voice disorder while only 0.98% of them seek treatment (American Speech-Language-Hearing Association, 2016). Among the treatment-seeking population, in term of gender the prevalence of voice disorder is higher in female adults than male adults (1.5:1.0) but higher in male children than female children. In term of age, the prevalence of voice disorder is higher in elderly adults (4.8 ~ 29.1%) than in children (1.4 ~ 6%). Voice disorder is considered a high-incidence impairment, resulting in a significant need of therapy.

Speech therapy can help patient with voice disorder to acquire self-confidence, independence, and social skills. According to Saz (2009), the conventional speech therapy is conducted in three steps including voice production, articulation, and fluency. Vocal training plays an important role as a fundamental basis of speech therapy where patient needs to practice to control their voice production. Skill of breathing, intensity, and voice tone control are essential for further steps of speech therapy and need to be conducted regularly. However, the conventional speech therapy has limitations in maintaining patients' motivation and attention during the training session.

Serious games can contribute to maintaining patients' motivation and attention during therapy by providing fun learning or teaching for skill development. Serious games have started to be applied in healthcare, including health monitoring, health detection, treatment & therapy, and rehabilitation (Wattanasoontorn et al., 2013). Therapists and patients provided positive responses to utilization of serious games in speech therapy (Grossinho et al., 2014; Navarro-Newball et al., 2014; Visci, 1995). Shtern et al. (2012) reported that immediate feedback and intuitive gaming scenarios led to higher levels of motivation and sustainment than conventional therapy.

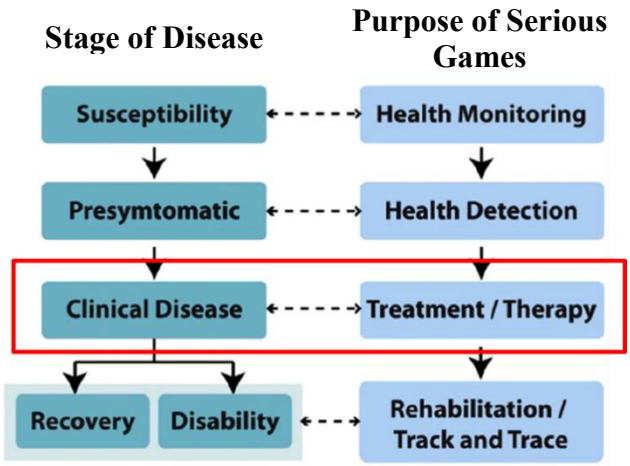



Figure I.1. Application of of serious games in different stages of a disease (Wattanasoontorn et al., 2013)

Currently several game programs are available for speech therapy including *Visi Pitch* by Kay Pentax, *Dr. Speech* by Tiger DRS, or *Vox Game* RS Care, which include vocal training program. However, further study is needed to identify whether the serious games are satisfactory to therapy stakeholders including therapists, patients, and parents. The

satisfaction level can be determined by various factors such as usability, narratives, play engrossment, enjoyment, creative freedom, audio aesthetic, personal gratification, social connectivity, and visual aesthetic (Phan et al., 2016).

## 1.2. Objectives of the Study

This study was intended to: (1) identify needs and game development strategies of vocal training games to support speech therapy for people with speech disorders, (2) develop a motivating and effective program ("Smart Speech") consisting of various serious games for vocal training as a part of speech therapy, and (3) evaluate the proposed vocal training program called *Smart Speech*. In system planning stage, game development strategies are established by literature review, survey of stakeholders' needs, and benchmarking of existing games. In system development stage, serious games are designed by complying the established game development strategies to provide features including explicit goal and reward, real-time feedback, adaptive play setting, and social interaction. The proposed serious game program *Smart Speech* consists of three categories: voice continuity, loudness, and pitch. Each category has five games, designed for Korean patients. In the system evaluation stage, *Smart Speech* program is evaluated by absolute and relative assessments.

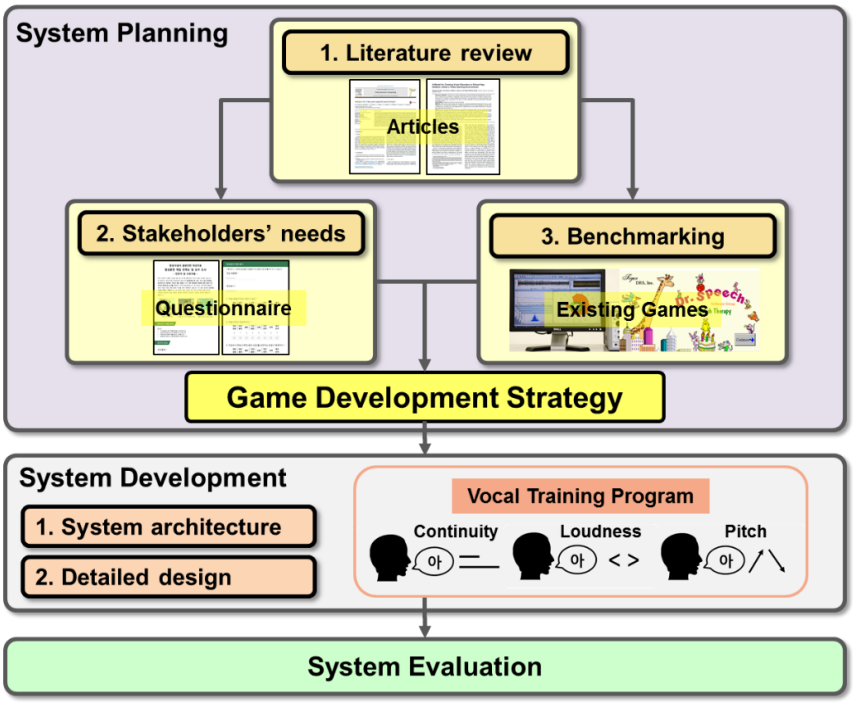



Figure I.2. System planning, development, and evaluation diagram of *Smart Speech*

## 1.3. Organization of the Thesis

This thesis is organized into six chapters and one appendix. Chapter 1 introduces research background and objective of this research. Chapter 2 explains definitions and types of speech disorders, speech therapies, and serious games. Chapter 3 explains system planning methods including literature review, stakeholder needs survey, and benchmarking of existing serious games for speech therapy. Chapter 4 describes development and evaluation of serious games for vocal training in speech therapy. Chapter 5 discusses main features, contributions, and evaluation of serious games. The last chapter concluded with contributions, limitation of this study, and further study.

# II. Literature Review

## 2.1. Speech Disorder

According to American Speech-Language-Hearing Association (1993), communication disorder consists of impairments in receiving, sending, and processing verbal or nonverbal systems such as hearing, language, and/or speech. Communication disorder can be classified into speech, language, hearing, and central auditory processing disorders as shown in Figure II.1. Disorder in each category can vary in term of severity levels and causes of disfunction. Single or combination of several disorders may occur.

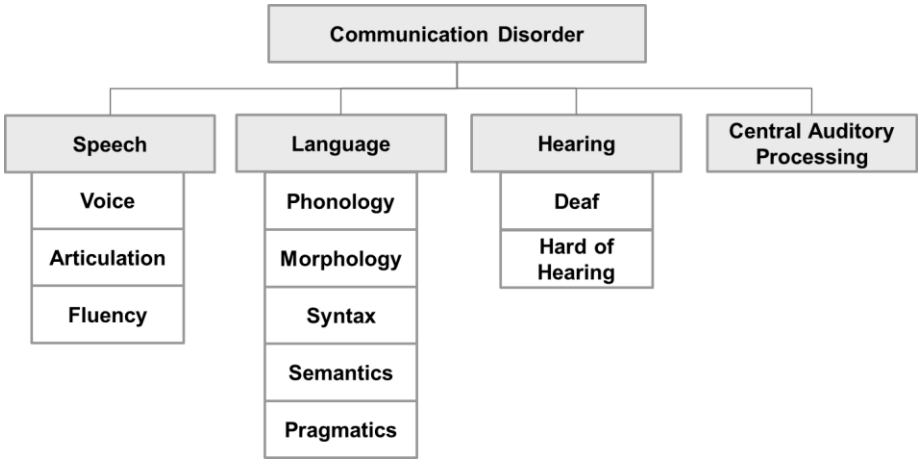



Figure II.1. Communication disorder classification

Speech is a means for verbal communicating, consisting of voice, articulation, and fluency (American Speech-Language-Hearing Association, 2016). Voice is the sound produced using the lungs and the vocal folds in the larynx. Articulation is the action of producing a series of vowel and consonant sounds by controlling the placement and

movement of lips, teeth, and tongue. Fluency involves the rhythm of speech. A person with speech disorders may have difficulties in managing their breath and vocal folds to produce sounds, producing vowel and consonant sounds, or controlling their speech rhythm.

Voice disorder is characterized by the abnormal production and/or lack of vocal quality, pitch, loudness, resonance, and/or duration, inappropriate for an individual's age and/or gender. Voice disorder can be categorized into organic disorder due to physiological abnormality and functional disorder due to improper vocal mechanism (Figure II.2). Organic voice disorder can be divided into two types, structural and neurogenic disorders. Structural disorder is caused by physical changes in voice mechanism such as alteration or structural changes of vocal fold tissues due to aging. Neurogenic disorder occurs due to nervous system problem, affecting vocal mechanism functions. Functional voice disorders occur when the physical structure is normal but the vocal mechanism is impaired. Muscle tension dysphonia is one of the functional voice disorders, producing normal sound but causing discomfort to the people with muscle tension dysphonia. Estimated 3 ~ 9% of the American population have voice disorder while only 0.98% of them seek treatment (American Speech-Language-Hearing Association, 2016). Among the treatment-seeking population, in term of gender the prevalence of voice disorder is higher in female adults than male adults (1.5:1.0) but higher in male children than female children. In term of age, the prevalence of voice disorder is higher in elderly adults (4.8 ~ 29.1%) than in children (1.4 ~ 6%).

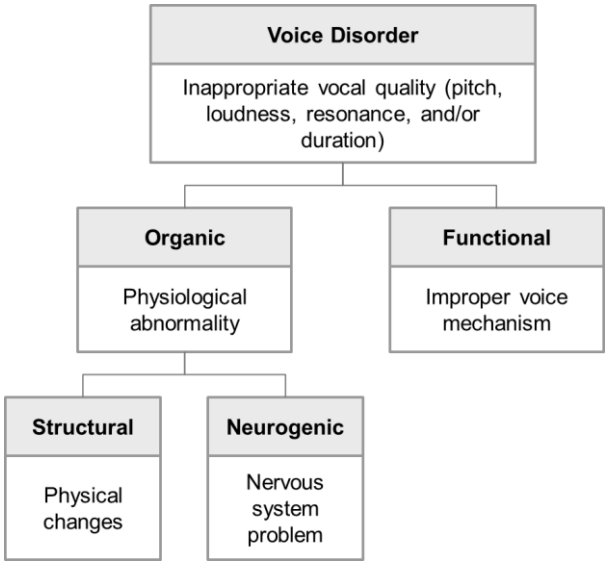



Figure II.2. Classification of voice disorders

People with articulation problems have difficulties in controlling tongue, jaw, teeth, lips, and palate to alter the air stream coming from the vocal folds to form sounds, syllables, and words. Fluency disorders are characterized by speaking flow interruption due to improper rate, rhythm, and repetition in sounds, syllables, words, and phrases. People with fluency disorder often repeat words/parts of the words or say “um” or “uh” in sentences. Treatment for this disorder is to teach them to control their breath and rate of speech.

Language disorder is a comprehensive impairment in symbol systems including speaking and writing. It is related to phonology (sound combination system), morphology (words structure and construction system), syntax (order and combination of words to form sentences and relationship between elements within sentences), semantics (meanings of words and sentences), and pragmatics (combination of language components in social

communication). Hearing disorder is impairment of auditory sensitivity in physiological auditory systems. It is classified into deaf and hard of hearing. Deaf limits communication performance, while hard of hearing affects communication ability permanently or fluctuatively. People with hearing disorder rely on auditory channel as the primary sensory input of communication. Central auditory processing disorder is characterized by limitations in processing information from audible signals, such as transmission, analysis, organization, tranformation, elaboration, storage, retrieval, and use of information (American Speech-Language-Hearing Association, 1993).

## 2.2. Speech Therapy

Speech therapy is a clinical program aimed at improving speech and language skills and oral motor abilities for children and adults with difficulties in communication. According to Saz (2009), the conventional speech therapy is conducted in three steps including voice production, articulation, and fluency. First, patients are trained to produce voice by controlling breath, tone, and intensity of voice. Second, they are trained how to say some words/phonemes. In this step, therapists will evaluate their pronunciation and teach them how to produce combined vowel and consonant sounds. Lastly, they are trained to understand and express the idea of speech. To help them to improve their abilities to communicate in their daily lives.

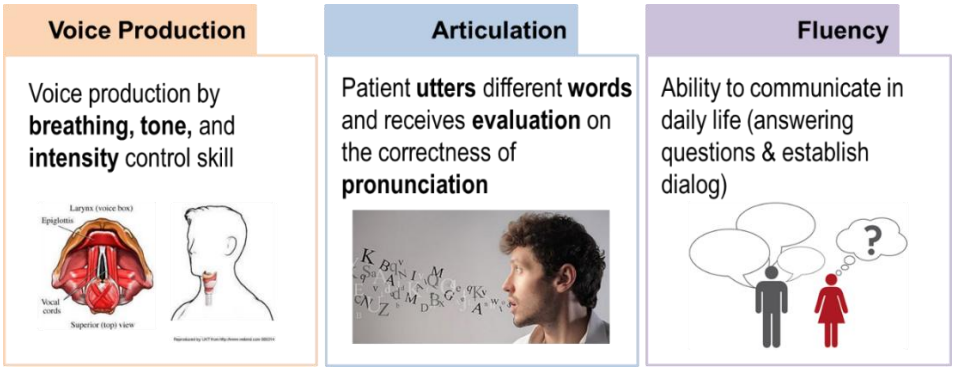



Figure II.3. Steps of general speech therapy

Speech therapy is conducted by speech and language therapists (SLTs) to improve communication abilities of patients with speech difficulties. The goal of speech therapy for patients with voice disorders is to maintain long-term voice quality and communication function with minimal recurrence. Most laryngologists consider the therapy essential for patients with voice disorders. Evidence suggests that preoperative voice therapy improves voice outcomes for more than 50% of patients with unilateral vocal fold paralysis so that surgery is unnecessary (Heuer et al., 1997). Speech therapy (specifically the Lee Silverman Voice Therapy method), has been demonstrated to be the most effective method for treatment of the lower volume, lower energy, and rapid rate of voice/speech for patients with Parkinson's disease (Dromey et al., 1995; Fox et al., 2006).

Direct meeting between SLTs and patients with speech difficulties is needed to perform assessment and conduct therapy program. In speech therapy, an SLT conducts a session with a patient one on one or patients in a small group to overcome speech difficulties related to a particular disorder. Therapy program is planned according to each individual's

needs consisting of various therapy duration and frequency. The duration and frequency of a session are determined based on the causes and severity of the disorders, and co-occurring medical therapy. For example, in hoarseness case, a therapy program generally consists of 1~2 therapy sessions each week for 4~8 weeks (Hapner et al., 2009). Additionally, an important factor for therapy success is patients' commitment to the practice and utilization of the new vocal behaviors outside the therapy session (Behrman, 2006). Outside the therapy session, speech-language professionals suggest that parental or family involvement is crucial to the success of speech or language therapy, especially when it applies to children (Nemours Foundation, 2015).

## 2.3. Serious Games

Serious game is a contest with explicit and implicit goals, according to a specific set of rules, challenges, and interactions. Serious game has special purposes to help learning or teaching process for skill development while providing fun entertainment. Serious games have started to be applied in healthcare and can be classified into four types according to their purposes: health monitoring, health detection, treatment & therapy, and rehabilitation. According to Wattanasoontorn et al. (2013), only 0.93% of serious games are for speech disorders, while 25.93% of serious games are for brain related diseases (Figure II.4).

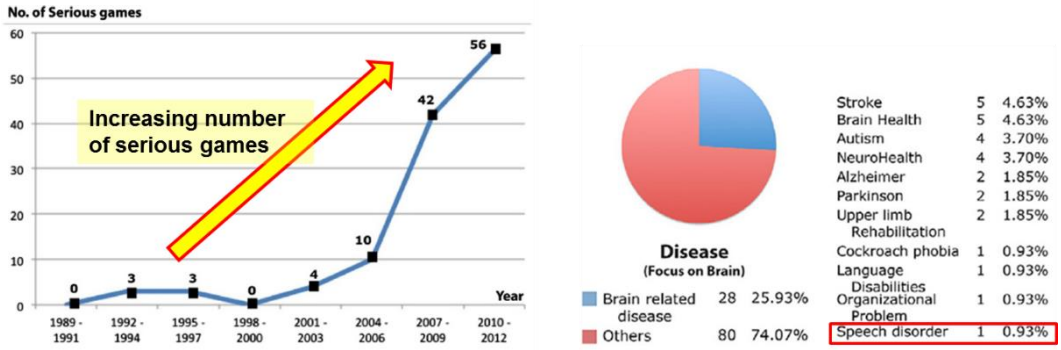



Figure II.4. Serious games for healthcare (Wattanasoontorn et al., 2013)

Development of serious games involves three core components in general: developer team, serious games/product, and the player/user (Wattanasoontorn et al., 2013). The developer team decide tools, content, and technology to utilize in the serious games, while the player will interact with the serious games by particular platform and special equipment. Tools consist of game engine, database, and design applications. Game engine controls how the system on the game operates, by providing graphic user interface (GUI), and defining a set of rules that determines the finish conditions. The database connects users' input and the feedback to be provided by the game engine as well as stores the data recorded regarding users' behavior within the game. Content of the game is provided by expert from the training field and converted into significant information according to the objective of the serious game. Technology deals with the use of technical means to simulate representative conditions to help users reach the goal of training.

Tools, content, and technology play important roles in the serious game system, and need to be properly determined by the developer team. In order to decide which tools, content,

and technology are proper to be applied, game objective and genre need to be identified. The objective of the serious game system can be more than one, focusing on education, training, treatment, and informing in an effective and incisive manner. Game categories are based on their gameplay, such as adventure, sport, strategy, and puzzle, and can be set to be single or multi-player mode.

In the game development process, identification of the target player specification is fundamental to develop the most satisfactory and effective game for target users in term of explicit (entertainment) and implicit (education/treatment/training) objectives of the game. Game players can be categorized by various criteria such as playing style (socializer, achiever, and explorer), playing skill (newbie, casual, and advance), and status (children, disabled, and elderly). Considering only the player status is not enough for repetitive play of the game when users skills are increased. Therefore, to encourage users on all levels, the challenge of the same needs to be properly determined using certain obstacles and rewards. Game platform, refering to a combination of computer hardware and software, also needs to be determined, for the serious game to be operated. In some cases, special equipments or interfaces such as hand tracking device, audio sensor, gyro sensor, and 3D vision google are also necessary to support the activities within the game.

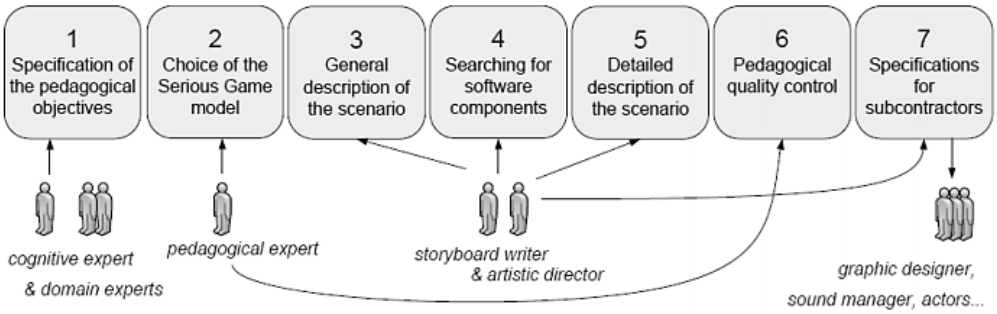



Figure II.5. Steps for designing serious games (Schottman et al., 2010)

Schottman et al. (2010) proposed a 7-step engineering process for designing serious games (Figure II.5), modified from Paquette's method (Paquette et al., 1999) for designing learning systems. First, the pedagogical objectives are specified to formulize the domain-specific knowledge to be learned by the users. Second, the expert or developer chooses a model for the serious game, such as board, puzzle, or adventure game to determine the required tools and modules related to the game scenario. Third, learning scenario and virtual environment are structured and combined to the fun game scenario by the writer and artistic directors. In this phase, a range of game components are determined, including the storyline, characters, and places where the story will be located. Fourth, reusable software components are searched to find if any of them can be used for efficiency. Fifth, detailed scenario is formulated and interactions between scenes are illustrated. Sixth, a pre-evaluation of the serious game is performed before it is actually produced to minimize the testing phases. Lastly, the director needs to recheck the specifications for each subcontractor (graphic designer, sound manager, and programmer) to have a clear and precise component for each specialist.

# III. Smart Speech System Planning

## 3.1. Vocal Training Game Features Identification

Game User Experience Satisfaction Scale (GUESS) is a comprehensive gaming scale for game evaluation (Phan et al, 2016). GUESS includes nine subscales, including usability, narratives, play engrossment, enjoyment, creative freedom, audio aesthetics, personal gratification, social connectivity, and visual aesthetics, as described in Table III.1.

Table III.1. Game evaluation scales description*

| No. | Scale | Description |
|---|---|---|
| **1** | Usability | The ease in which the game can be played with clear goals/objectives in mind and with minimal cognitive interferences or obstructions from the user interfaces and controls |
| **2** | Narratives | The story aspects of the game (e.g., events and characters) and their abilities to capture the player's interest and shape the player's emotions |
| **3** | Play Engrossment | The degree to which the game can hold the player's attention and interest |
| **4** | Enjoyment | The amount of pleasure and delight that was perceived by the player as a result of playing the game |
| **5** | Creative Freedom | The extent to which the game is able to foster the player's creativity and curiosity and allows the player to freely express his or her individuality while playing the game |
| **6** | Audio Aesthetics | The different auditory aspects of the game (e.g., sound effects) and how much they enrich the gaming experience |
| **7** | Personal Gratification | The motivational aspects of the game (e.g., challenge) that promote the player's sense of accomplishment and the desire to succeed and continue playing the game |
| **8** | Social Connectivity | The degree to which the game facilitates social connection between players through its tools and features |
| **9** | Visual Aesthetics | The graphics of the game and how attractive they appeared to the player |
| **10** | Accuracy | The accurate interoperation of the input device with the game contents |

| No. | Scale | Description |
|---|---|---|
| **11** | Customization | The degree to which game parameters are customizable to the player |
| **12** | Game Analytics | The extent to which game results are managed and analyzed for effective training |
| **13** | Therapy Continuity | The extent to which treatment activities in a treatment facility to practices at home |

* adapted from GUESS: Game User Experience Satisfaction Scale

Usability of serious games determines the ease of understanding how the game works and the objective of the game. Navarro-Newball et al. (2014) developed a video game for speech therapy named *Talking to Teo* for Colombian Spanish. *Talking to Teo* provides satisfying usability since children can easily understand the game mechanics (cause-effect relationship) and the goal of the game. Faria et al. (2014) developed a game to be simple and executable by family members or caregivers to provide good usability. Visci (1995) developed an interactive feedback system for handicapped person to illustrate speech organ position for sound production. Visci tested the system with 8 handicapped children and found that the children can use the system easily and see whether they pronounced sounds correclty or not.

Game scenario is important to capture users by the story in each step. *Talking to Teo* provides a game story line which needs to be completed by users step by step. However, in the beginning of the game, users need to hear a long story about Teo (bear) searching other bears in the zoo and practice mini games on their way to completing the zoo map.

Play engrossment is realized when users immerse themselves to the game and want to play the game repetitively without feeling tired. King et al. (2012) developed an

entertainment video game for voice therapy, requiring players to compete against the leading character through vocal tasks. They tested the game using patients with vocal disorders and found that the game was too difficult and made participants feel frustrated and tired.

Maintaining patients' enthusiam while conducting therapy can be achieved by providing fun and motivating games for therapy. Navarro-Newball et al. (2014) tested their game *Talking to Teo* using children with speech disorders and got positive responses from the children and therapists as it can maintain their attention and enthusiasm.

In the creative freedom aspect, a game should inspired users curiosity and imagination. The speech therapy game in Turkish language developed by Cagatay et al. (2012) requires patients to describe objects and activities in certain environment to encourage and support conversation between therapists and patients. Various environment, objects, and stories are provided to inspire user imagination about how the objects effects in certain environment.

To achieve better game experience, sound effects can provide better mood and description of the game events. However, sound effects in speech therapy games should not interupt users voice production. As mentioned by Wattanasoontorn (2013), game event feedback can be provided in various forms such as visual, audio, and physical feedback. For example, sound effects can be added when user succeed in reaching certain score.

Personal gratification in a game can be achieved by providing obstacle & reward, and feedback and players' independent performance. Wattanasoontorn (2013) suggested that reward should be provided for good actions as well as obstacle to avoid players to reach the

game goal easily. To increase challenge of the game, interactive scenario, requiring players' problem solving strategies and self-control can be applied (Kostoulas et al., 2012). Adequate feedback helps users to understand the effect of their actions and control their actions. The system developed by Vicsi (1995) provides mouth and tongue positions to produce a sound (e.g. /s/), represented by a snake picture as shown in Figure III.2. Grossinho et al. (2012) developed a system to provide a visual biofeedback to track orofacial motion and evalute patients' speech productions. For example, /rr/ sounds are represented by a lion image while /buuh/ sounds are represented by a ghost image. Therapists' and patients' roles in therapy should be balanced so that patients can achieve good performance independently. In the game developed by Cagatay et al. (2012), a therapist should actively ask questions to patients and initiate the description of the environment and objects provided. In this game, patient cannot achieve proper independent performance due to high dependence on therapists' role.

Mayer (2012) mentioned social connectivity aspect in serious games evaluation, which for facilitating interaction between players or player and facilitator. In speech therapy, patients usually are involved in therapy activities individually under the facilitators' guidance instead of group activities. Therefore, social connectivity aspect can be considered in speech therapy games as connections between player and facilitators such as therapist, family, and caretaker.

Visual aesthetics represent the mood of game environment and facilitate game enjoyment. King et al. (2012) used modern graphics for the visual interfaces and reported that they were appealing to children. Contrast color of graphics and interfaces is able to catch

users' attention (Faria et al., 2014).

Four more scales of game features are developed to complement the 9 GUESS scales. Accuracy in vocal training game represents how accurately the signals from the input device are processed to control the game contents. Vocal training games require the input device to acquire users' voice characteristics, a microphone will be used as the main input device, to capture loudness and pitch signals from users' voice for game control. For accurate performance assessment, a less-interference system is preferred. Shtern et al. (2012) developed a speech assistive technology for tongue control training in a 3D game environment. The issue of the game is some special tool has to be attached to the tongue of the user resulting in users' inconvenience. Moreover, some people may have difficulty in perception of 3D environment, which affects users' behavior not related to speech capability in playing the game.

Serious games for patients with disorders should consider their capability and needs by providing customized game parameter values. Kostoulas et al. (2012) developed serious games for supporting therapy of mental disorders using speech and emotion recognition techniques to detect a patient's behavior. Game environment and difficulty are adaptable according to a user's preferences, game tasks, and a player's behavior (e.g. if a user's anger is detected, the game becomes more difficult). Shtern et al. (2012) and Cagatay et al. (2012) mentioned that allowing therapist to tailor the game for specific patients is an important factor to be applied in therapy game.

Game results including users' data, exercises' completed, and performance should

be saved and managed systematically to allow therapists to analyze patients' performance. Information needed by therapists depends on therapy requirement. Grossinho et al. (2014) and Cagatay et al. (2012) developed a logging system to record patients' visual and audio data (video clips) for therapists' later evaluation scores (rewards) or any data which provide objective measurement of patients' behavior can also be stored into database.

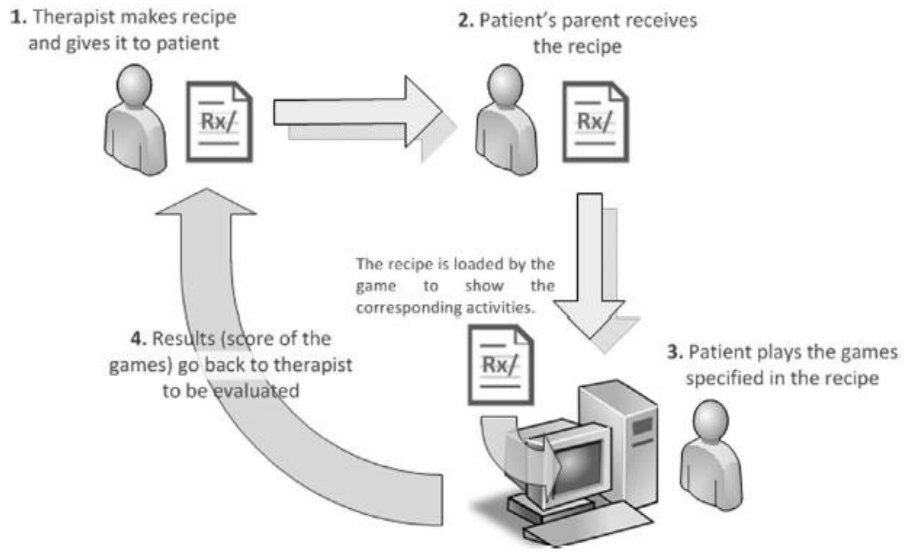



Figure III.1. Therapy activity workflow of *Talking to Teo* (Navarro-Newball et al., 2014)

Game-like contents, integrated to a therapy system can support home-based practice for therapy continuity. King et al. (2012) mentioned that the success of therapy relies on patients' initiative and motivation to keep practicing not only in clinic but also at home. In an integrated therapy system, a therapist or parents should be able to control the therapy contents and evaluate the patient's performance with or without a direct meeting. After the therapist decides the therapy content beforehand, the patient can play speech games at their

home independently. The therapist can evaluate the patients' performance from the database system. Navarro-Newball et al. (2014) proposed a therapy activity workflow as shown in Figure III.1. Therapists can make therapy contents as recipe for specific patients. Patients play the games according to the recipe. For children, parents may accompany them to make sure they play the games specified in the recipe. Therapists can evaluate the results and give another recipe according to patients' performance.

### 3.2. Stakeholders' Needs Survey

Stakeholders' needs should be considered in developing serious games for a user-friendly speech therapy system. Lee et al. (2015) reported that parents and experts required smart contents (such as simulation and game-type contents) to support self-diagnosis and provide various stimuli for speech therapy. To identify stakeholders' needs, questionnaire adapted from GUESS and other literature was used including 13 scales and 36 statements to evaluate existing games by a 7-point Likert scale. The questionnaire consists of (Figure III.2) (1) introduction and general information, (2) serious game use experiences, (3) main assessment, and (4) likes & dislikes & suggestion to improve existing games.

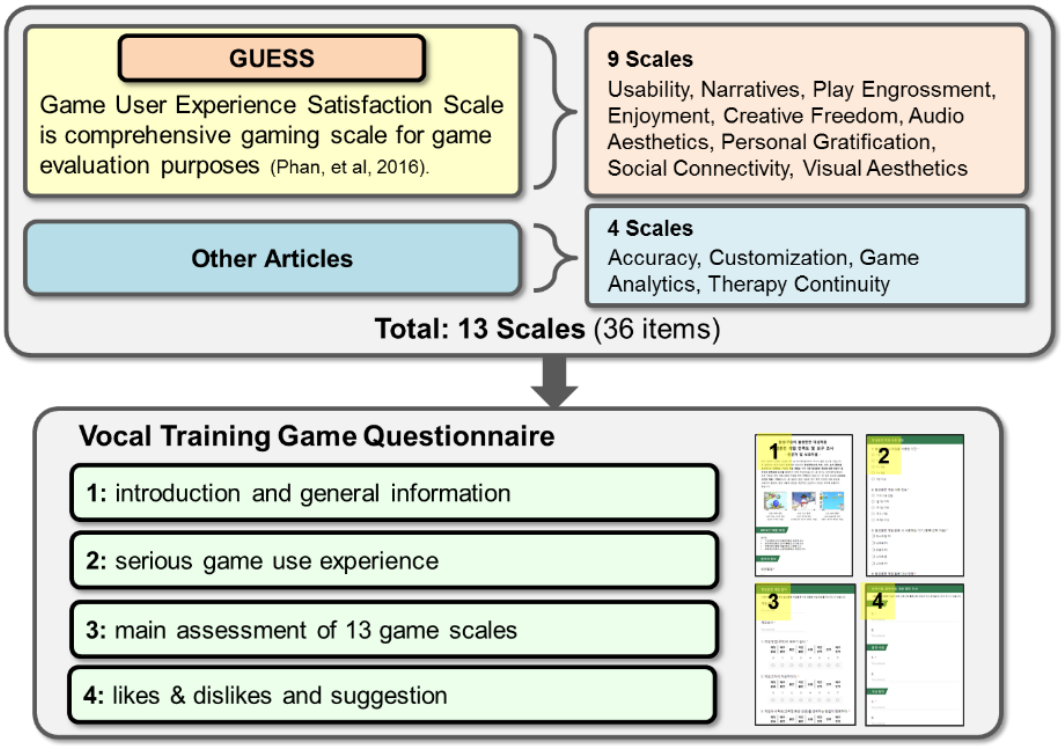



Figure III.2. Vocal training game questionnaire

Eighteen (Male: 6; Female: 12) speech therapists with 3~23 years experiences evaluated serious games for speech therapy. For game usage experiences, 33.3% of therapists utilize serious games for more than 5 years. 38.9% of them use the serious games in speech therapy activity 2~4 times a week. The devices they usually use are desktop (43.5%) and notebook (26.1%). Patients with speech disorders mostly are preschool-aged children (38.9%) or school-aged children (38.9%), while adult are only 16.7%. There are three games mainly used for speech therapy, *Visi Pitch* by Kay Pentax (33.3%), *Vox Game* by RS Care System (22.2%), and *Dr. Speech* by Tiger DRS (16.7%).

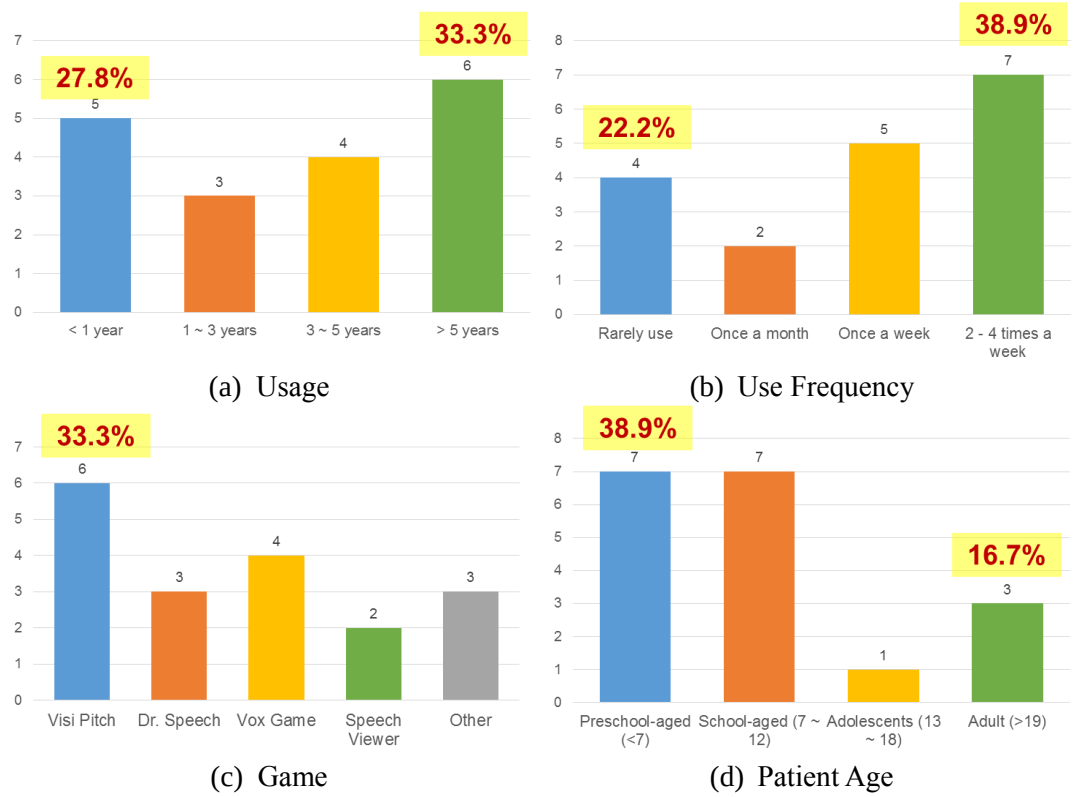



Figure III.3. Serious games for speech therapy experiences

Among three mainly used games, *Visi Pitch* has lowest satisfaction score (3.3 ± 1.3), while *Vox Game* has highest satisfaction score (5.0 ± 1.1) and *Dr. Speech* is in the middle (4.3 ± 0.9). *Visi Pitch* is lacking in therapy continuity (1.7 ± 0.8), social connectivity (2.4 ± 0.6), creative freedom (2.5 ± 0.8), customization (2.5 ± 1.0), and game analytics (2.5 ± 1.1), while has good review in usability (4.1 ± 1.2), audio aesthetics (4.2 ± 1.6), and personal gratification (4.0 ± 1.0). However, there are some suggestions from therapist in term of usability such as real-time feedback, compatibility, and ease of use. In term of enjoyment, they expect to have various games for not only children but also adult. They also mentioned

that it is better if the graphics are more modern and captivating for user. *Vox Game* is lacking in therapy continuity (4.3 ± 1.2), creative freedom (4.3 ± 1.5), social connectivity (4.4 ± 1.3), while has good satisfaction in term of usability (5.4 ± 0.9), personal gratification (5.3 ± 0.8), visual aesthetics (4.2 ± 1.5), and game analytics (5.2 ± 1.3). There are suggestions to improve their variation of game or customization because if the game is too simple, user will get tired or bored quickly. *Dr. Speech* is better in game analytics (5.2 ± 1.3), personal gratification (4.7 ± 0.8), and therapy continuity (4.7 ± 1.1), while lacking in social connectivity (3.3 ± 0.5), creative freedom (3.8 ± 0.6), and audio aesthetics (3.8 ± 0.4). Therapist also provides suggestion to add difficulty level so that user's motivation is not decreasing easily.

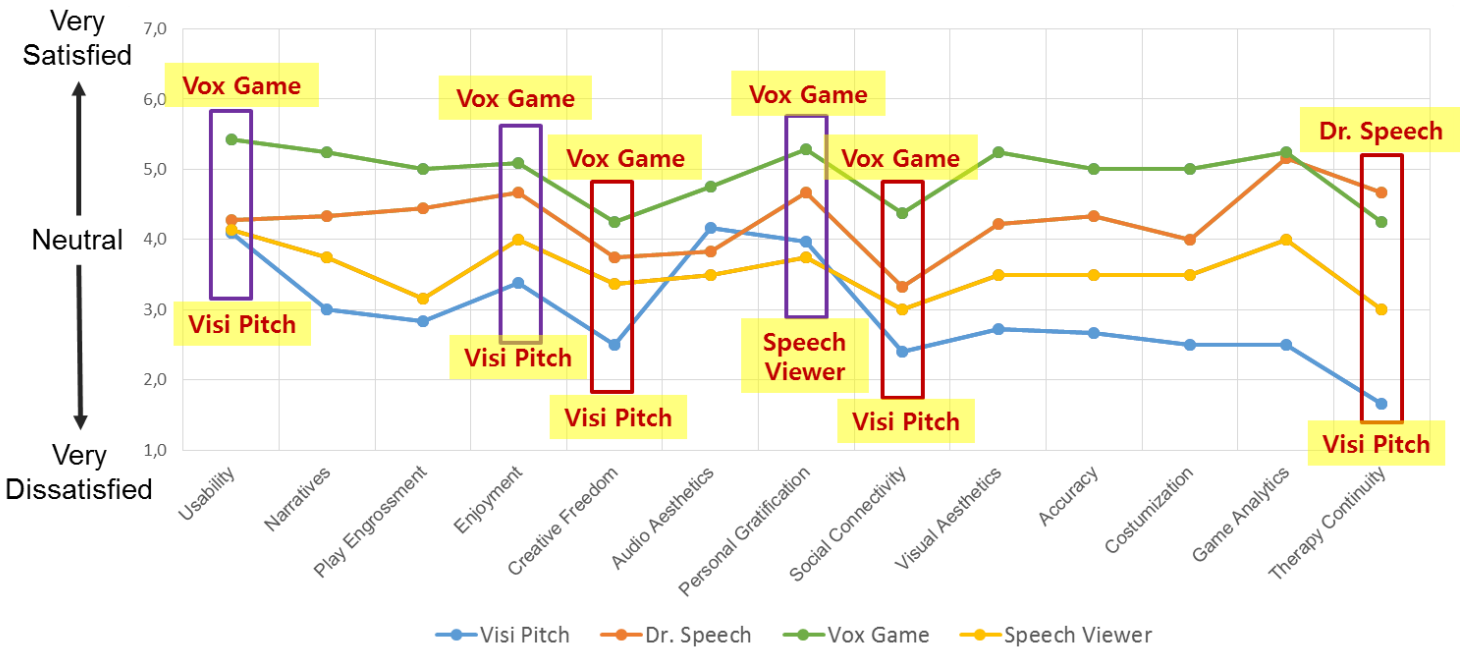
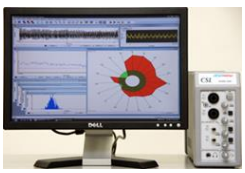
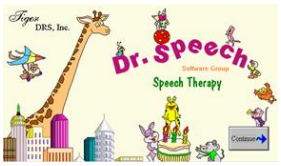



Figure III.4. Comparison of existing vocal training games satisfaction

## 3.3. Benchmarking of Existing Vocal Training Games

Speech therapy games such as Visi-Pitch by Kay Pentax, *Dr. Speech* by Tiger DRS, and *Vox Game* by RS Care System include continuity, loudness, and pitch training. These speech therapy games can be used as therapy tasks which difficulty level can be adjusted according to the user's needs. *Visi Pitch* has one continuity game and 7 games of loudness or pitch training, *Dr. Speech* has 4 games for each categories, while *Vox Game* has 5 games for each categories.

Table III.2. *Visi Pitch*, *Dr. Speech*, and *Vox Game* main information

| | ***Visi Pitch*** | ***Dr. Speech*** | ***Vox Game*** |
|---|---|---|---|
| Developer | Kay Pentax | Tiger DRS, Inc. | RS Care System |
| Website | pentaxmedical.com | drspeech.com | rscaresystem.blog.me |
| Game Category | • Phonation (continuity, voicing onset, timing)<br>• Amplitude (loudness)<br>• Frequency (pitch) | • Phonation (continuity)<br>• Loudness<br>• Pitch<br>• Voicing<br>• Voicing onset<br>• Speech articulation<br>• Sound awareness | • Phonation (continuity)<br>• Loudness<br>• Pitch<br>• Voicing |
| Number of games | 3 phonation games<br>7 frequency/amplitude games | 4 games each category | 5 games each category |
| |  |  |  |

*Visi Pitch*'s applicable key features are providing loudness or pitch mode for each game and showing loudness or pitch indicator as feedback to make the user aware of their

voice level and allow correction. *Visi Pitch*'s continuity game called *Croaker* requires user to make a continuous voice so that a frog will expand their neck and make "croaking" sound. User needs to repeat the continuous voice production until they collect a certain number of frogs. *Visi Pitch* also provides seven games, including dinosaur slide, dragon blast, flower, penguin, crystal, fishing, and plane, which can be switched into loudness or pitch mode. One of the games is the fishing game showing a fishhook which height depends on user's voice loudness or pitch. Fishes in various height will come near to the fishhook. User can get the fish if they make a right loudness/pitch in the right timing. Therapist can determine the frequency or loudness target, difficulty level, and number of trial. Instead of providing score or target, *Visi Pitch* games provide current playing time in second. User performance can be assessed from how long they can finish the game, while difficulty level is controlled by the length of stimulus.

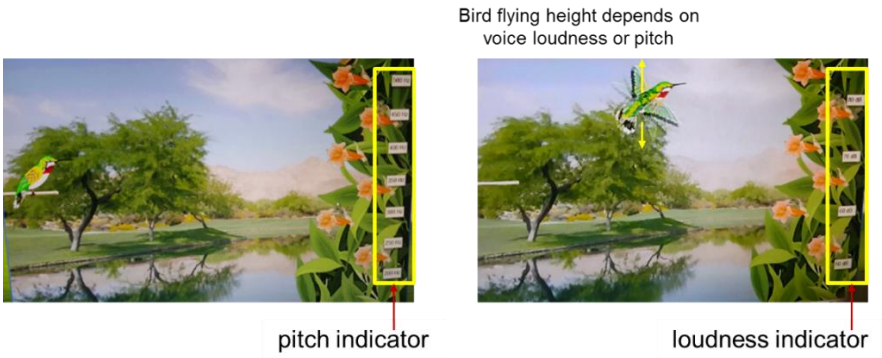
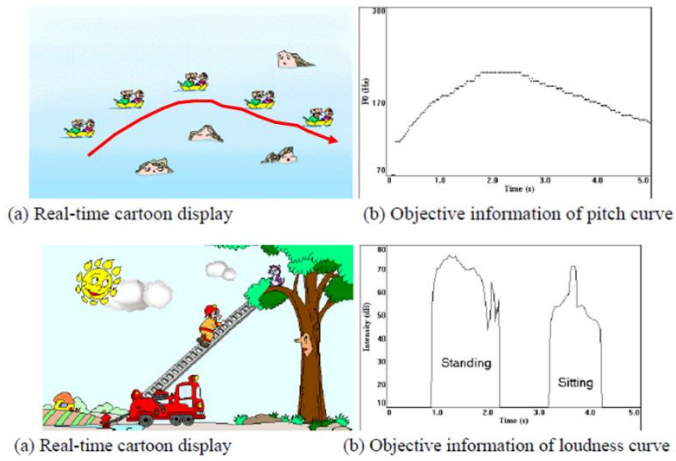



Figure III.5. Pitch and loudness mode in *Visi Pitch*

The recording function of users' pitch/loudness plotting graph in *Dr. Speech* can be applied to our games for analyzing patients' performance. *Dr. Speech*'s continuity games are

astronaut, strawberry, insect, and sunflower. In *Dr. Speech*'s continuity games, user needs to make continuous voice to move game object from one place to another. For example, in the astronaut game, when user makes voice continously, a rocket will fly from the moon to land at the earth. *Dr. Speech*'s loudness games such as cloud, fire truck, moon, and giraffe, require user to make voice in a certain range of loudness to make the game character moves and reaches a certain target. *Dr. Speech*'s pitch games are boat, desert, fun sea, and tree. In the boat game, user needs to make a boat to avoid some rock obstacles by changing voice pitch. *Dr. Speech* games provide current playing time but not score. Similar with *Visi Pitch*, they assess user performance from the game play time. Therapist can set the loudness and pitch target according their needs, however *Dr. Speech* do not consider duration and repetition aspect in their loudness and pitch games. They also do not provide current loudness or pitch indicator in the game scene.




(a) Real-time cartoon display (b) Objective information of pitch curve

(a) Real-time cartoon display (b) Objective information of loudness curve

Figure III.6. Pitch and loudness graph information in *Dr. Speech*

*Vox Game* provides vocal training games, which user interface was designed using Korean language. Since most of the patients who use vocal training games are children, it will be more comfortable for them to play the game using their language. Providing language options is important if the games will be used in some countries. In term of costumization, *Vox Game* provides pitch or loudness range setting to determine the minimum and maximum value of pitch/loudness according to the training needs. In term of motivation and enjoyment, *Vox Game* applies the concept of timing in making voice. The user should make voice and stop making voice according to the game environment. For example, one continuity game requires user to control the character to cross the street where there are many cars passing by. User should make voice in order to make the character walks accross the street and stop making voice when there is car passing by. In Vox's loudness game, the character should shoot arrows to some balloons by making voice loudness within range in the right time. Similar to loudness game, in Vox's pitch game called *heart*, user should make voice within a pitch range and control the character flying height to get some hearts.

Figure III.7 Continuity, loudness, and pitch games in *Vox Game*

### 3.4. Smart Speech Development Strategy

According to stakeholders' needs, literature review, and speech games benchmarking, serious games should satisfy 13 scales, which are usability, narratives, play engrossment, enjoyment, creative freedom, audio aesthetics, personal gratification, social connectivty, visual aesthetics, accuracy, customization, game analytics, and therapy continuity. From questionnaire survey result, scales that are not commonly applied or high urgency of improvement are social connectivity (3.6 ± 1.4), creative freedom (3.5 ± 1.4), therapy continuity (3.6 ± 1.7), and customization (3.9 ± 1.5). However, overall satisfaction of each scale is not more than 5 (3.5 ~ 4.5), which means each scale needs improvement. Also from 13 scale, there are many suggestions to improve usability (4.5 ± 1.2), enjoyment (4.3 ± 1.3), and visual aesthetics (4.1 ± 1.4). The game development strategy of each scales are summarized in Table III.4.

Table III.3. *Smart Speech* development strategy

| No | Scales | Application |
|---|---|---|
| 1 | Usability | Ease of use |
| | | Game mechanics (cause-effect relation) and objectives understanding |
| 2 | Narratives | Game story or message should be clear and simple |
| | | Various games |
| 3 | Play Engrossment | Tired-less |
| 4 | Enjoyment | Fun and bring enthusiasm |
| 5 | Creative Freedom | Several type of environment or object or story |
| 6 | Audio Aesthetics | Sound effects as a feedback |
| 7 | Personal Gratification | Reward and obstacle |
| | | Difficulty level |
| | | Problem-solving strategies & self-control, skill development |

| No | Scales | Application |
|---|---|---|
| | | Real-time feedback to make user adjust their speech, Independence performance |
| 8 | Social Connectivity | Interaction with other player or facilitator (therapist, caretaker) |
| 9 | Visual Aesthetics | Appealing graphics (animation) and user interface, adequate information |
| | | Up-to-date graphics |
| 10 | Accuracy | The accurate interoperation of the input with the game contents (microphone accuracy, less-interference) |
| 11 | Customization | Depend on user's capability (voice characteristic target (loudness/pitch), duration and repetition) |
| 12 | Game Analytics | Record user data, game played, performance, sound recording |
| 13 | Therapy Continuity | Integration of therapist's (clinic) and patient's system (home) |

Clarity of game objectives, real-time feedback, and ease of use need to be considered in game development for better usability. Providing clear direction is important to lead user to reach the goal. Interactive feedback shows users the effects of their action so that users are fully aware what they have to do. For example, loudness and pitch indicator is one of important feedbacks in vocal training. Score can provide explicit goals for game user and objective performance evaluation. In narratives aspect, game character and object should be designed and positioned to describe clearly the game story. How to make user be captivated by the game is important to provide enjoyable therapy. Some therapist gave suggestion to increase game variation not only for children but also for adult patient. To allow user be imaginative and creative, game should provide several type of environment, objects, and stories. Audio and visual aesthetics, which fit the mood of the game will also enhance game experience.

Serious games can contribute to maintain patients' motivation and attention during

therapy by providing fun training for skill development. However, we have to adjust the difficulty level in the right amount so that it will not make user feel exhausted and demotivated. To actualize personal gratification aspect, difficulty level, reward, and obstacle can be applied as motivation factors. User will take problem-solving or self-control strategies, which train user's skill. Customization function provides adjustable difficulty factors for different level of disorder severity. For vocal training, therapist should be able to set several voice characteristic target such as loudness/pitch target, duration, and repetition. Therapist will be able to assign appropriate game material to each patient. Patients' improvement can be assessed by analyzing information such as user data, customized parameter value, score, and objective measurement, which are stored in game data storage. To support therapy continuity, therapy activity is supposed to be repetitively conducted in order to support patients' improvement.

Using game development strategy, vocal training game is developed to provide explicit goal and reward, real-time feedback, adaptive play setting, and social interaction. Explicit goal & reward can be achieved by providing scoring system, counter, and obvious object as target, which play important role as gamification factors. Real-time feedback is can be provided by loudness or pitch indicator, which shows current status of user's voice. Adaptive play setting by providing customized loudness/pitch target, duration, and repetition can support learning objective so that user can be trained certain loudness or pitch in exact duration and repeat the trial several time. Additionally, social interaction between therapist and patient can be improved by providing multi-player mode.

# IV. Smart Speech System Development

## 4.1. System Architecture of Smart Speech

Three categories of vocal training games are provided according to voice characteristic, including continuity, loudness, and pitch. Various game scenarios are designed for each training category in order to avoid boredom of playing one scenario all the time. Different scenario ideas were developed, including sports as well as modern-theme inspired games. We provide five different scenarios for each game category. Patients can select a proper therapy session under therapists' guidance.

Serious game development was conducted in three steps, scenario development, interface design, and program building. Game scenario describes the goal of the game and how voice parameters control game elements. Following the game scenario development, we proceeded to interface design step. Interface design covers the development of user interface of game element includes characters and objects needed in every game. Program building was conducted using Unity3D game development engine and C# programming language.

The therapy can be done by following certain steps of using (Figure IV.1). First, user log in with particular user name as an identity. Then, user can select which module will be conducted. When user enters vocal training modules, user needs to select what categories (continuity, loudness, pitch) and which game they want to play. Then, setting function provides loudness/pitch game target setting and duration & repetition setting. Therapists can

determine variables of the games according to patients' capabilities and disorder level. Main game will be played according to setting value. Finally, score will be shown after the game ends. The system has a function to record the result of each playing session and store it into designated database. Therapists can access database to assess patients' performance.

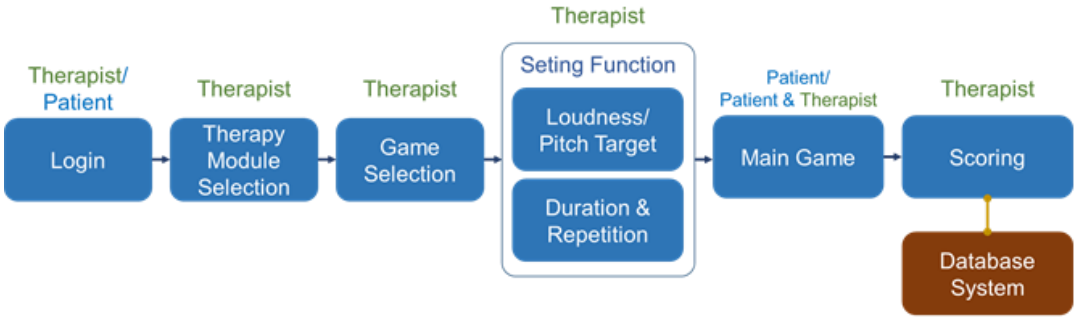



Figure IV.1. Use flow of *Smart Speech*

## 4.2. Detailed Design of Smart Speech

For voice continuity training, games are designed for players to make voice continuously to play the games. Continuity training can help improvement of controlling how long they need to make voice. There are 5 continuity games provided, candle, nail art, balloon, curling, and jumping games. Prior to playing the game, the system will show two setting functions, which include loudness target setting, duration and repetition setting (Figure IV.2). First, therapists can adjust minimum loudness target according to therapy requirement. Second, therapists can adjust duration (how long patient needs to make voice continuously) and repetition (how many times games will be played). Those customized values will affect to the game play.

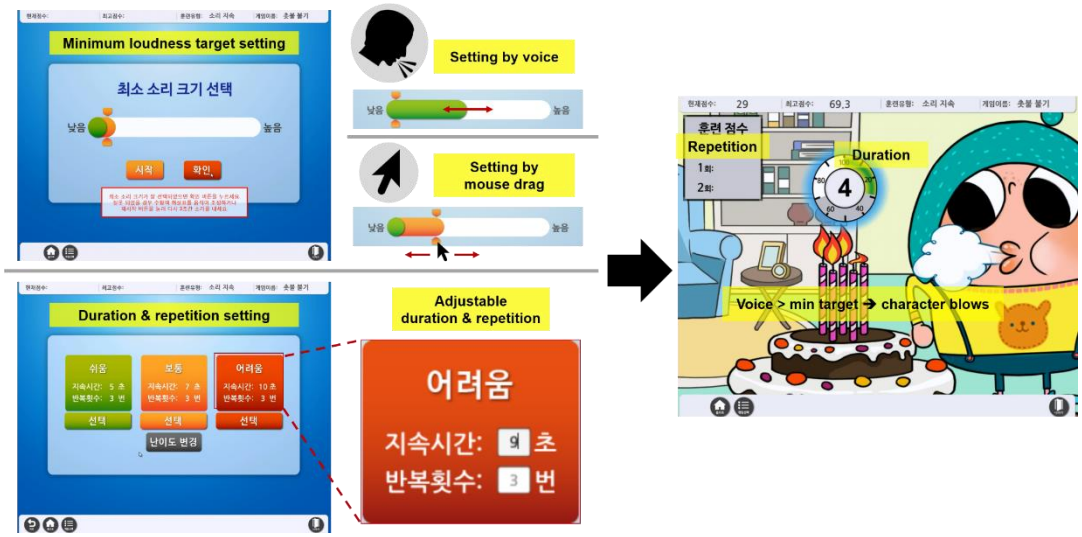



Figure IV.2. Setting Function of *Smart Speech*

In candle game, a character needs to blow up a number of candles on cake. The number of candles is determined according to duration (e.g. 5 candles is shown for 5 seconds duration). When user's voice loudness is higher than minimum loudness target, candle will be blown up (one candle per second), score will be calculated, and loudness indicator will be activated. When there is no time left (game timer equal to zero), game will be proceeded to the next trial. After user play the game for several trials (according to repetition number chosen in setting function), scoring function will calculate average score from several trial scores.

In nail art game, user needs to make voice continuously to color the nail. One nail will be colored within duration time, while number of nail to be colored is repetition number. In balloon game, there is a bird, which will peck the balloon and make it explode. However,

user needs to make the balloon expand by making voice continuously until the bird able to reach the balloon. In curling game, curling player will throw the stone and the stone movement will depend on user's voice. User needs to make the stone reach the target by making continous voice. In jumping game, a monkey will jump from one place to another to avoid crocodile in the river. The time needed for jumping from one place to another will depend on duration and user should make continuous voice during that time to make monkey jump. If user failed to make voice continuously within that time, monkey will fall to the river.

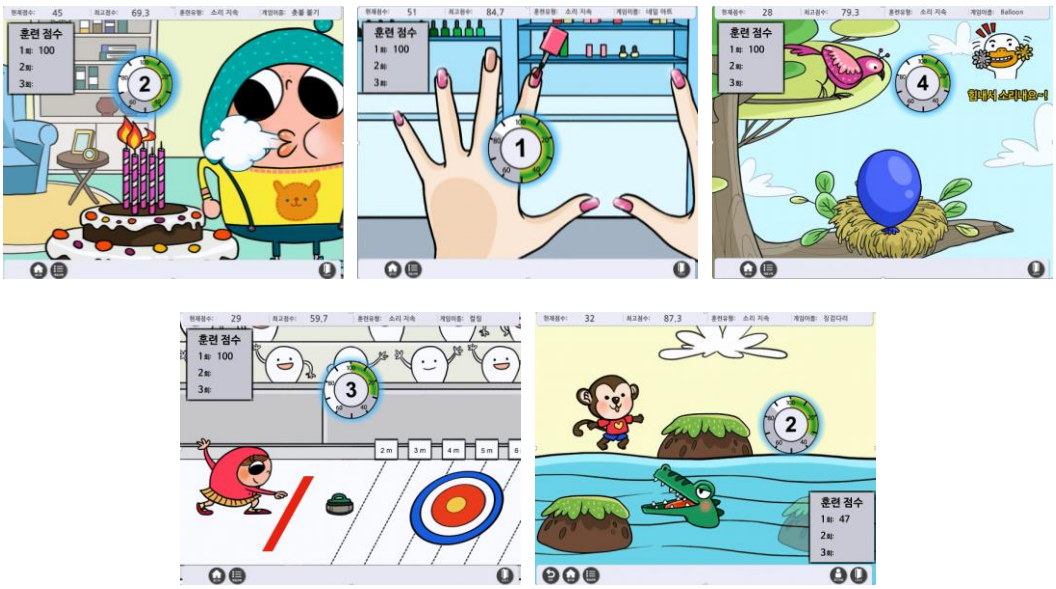



Figure IV.3. Continuity games of *Smart Speech*

For voice loudness training, games are designed to train players to produce voice with a certain level of intensity. In each loudness game, target loudness range can be determined by therapists. Besides, therapists can customize the duration value, which

determines how long a patient needs to make certain voice loudness. Five loudness games provided are snowman, tube, box, cat, and board jumper. In snowman game, user's loudness level will determine hat's size of snowman. If user's voice is louder than the maximum value of the target loudness range, the hat will get bigger and it will cover snowman's head. If user's voice is lower than minimum value of the target loudness range, the hat will get smaller and it will not fit to snowman's head. If user's voice is within loudness range target, the hat will perfectly fit to snowman's head. In the same manner, this concept will apply to tube and box game. In cat game, cat wants to go out from cage. User's voice within loudness range target will open the cage. In board jumper game, one/two player mode is provided. The characters will jump alternately to the board and make the other character fly. If they can make their voice within loudness range target continuously, they will get better score.

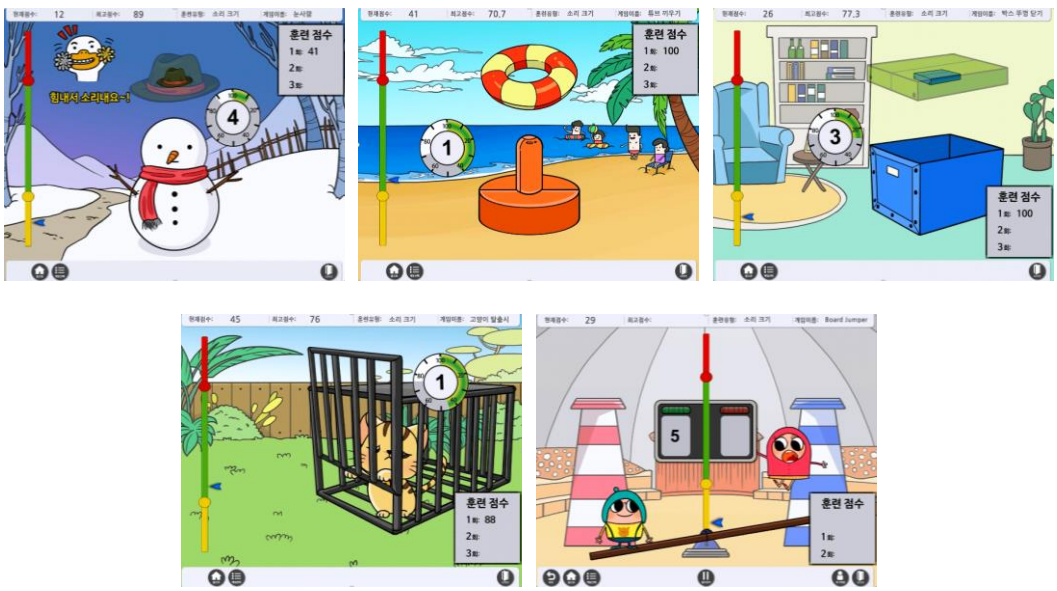



Figure IV.4. Loudness games of *Smart Speech*

For voice pitch training, games are designed to help patients to increase their ability to accurately produce a particular level of pitch. Producing and controlling the voice pitch is important for intonation in speech. Need to be considered that the therapy patients may vary in age and gender, which means, each user may have different pitch range. In pitch game, therapists can choose a pitch range, which patient needs to train. Five pitch games provided are firefighter, plane, bird, clay shooter, and stairs. In firefighter game, there are fires in certain floor of an apartment. The firefighter wants to extinguish fire and user's voice pitch will determine if the water can reach fire. If user's pitch can reach pitch target for certain duration, fire will be extinguished completely. In plane game, user can control plane altitude using their pitch. While controlling pitch, user should make the plane get coins to get more score. In bird game, user should control bird altitude to avoid cloud and trees. For plane and bird game, target pitch will be a range of pitch value and coins and obstacle position will be determined randomly to provide pitch variation. In clay shooter game, therapist can set three clays height as pitch target. User will be able to shoot the clay with making voice in pitch target. In stairs game, male character should going up or down the stairs to meet girl character. If the pitch target is high pitch, character will going up. If the pitch target is low pitch, character will going down.

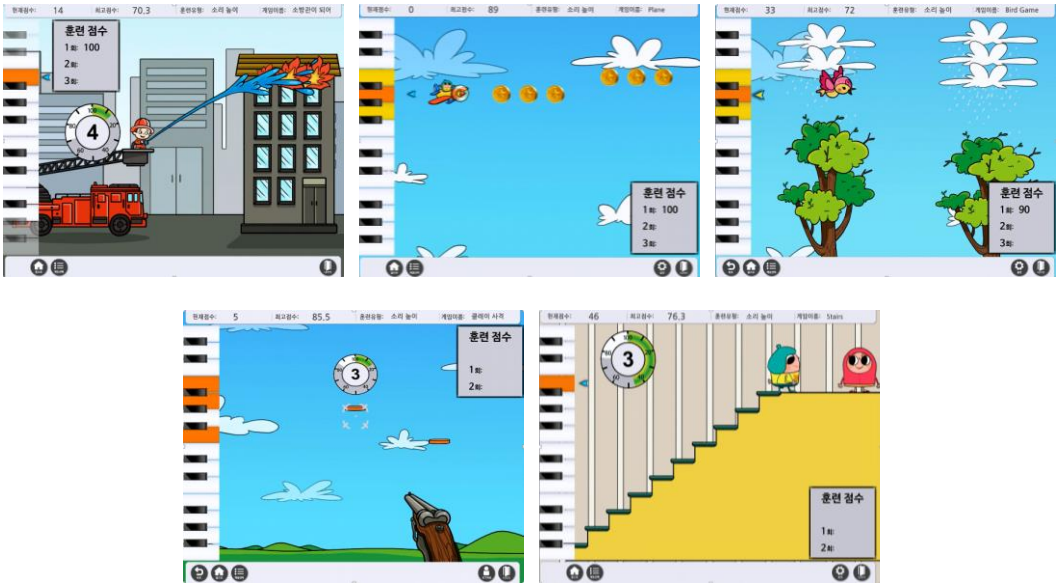



Figure IV.5. Pitch games of *Smart Speech*

## 4.3. Smart Speech System Evaluation

To evaluate the effectiveness of the developed vocal training games, absolute and relative assessments was conducted using questionnaire, which measure 11 scales includes 35 statements to be evaluated in 7-point Likert scale. Game analytics and therapy continuity were removed because the proposed vocal training games do not include the two features completely. Two questions were added to accomodate features suggested by therapists related to game content variation (narratives) and up-to-date graphics (visual aesthetics). Absolute assessment is needed to identify game's satisfaction score in general. While relative assessment is required to compare developed and existing games. Assessment questionnaire is organized into 5 parts, introduction and general information, serious game use experience, absolute assessment (35 likert-scale questions), relative assessment (35 likert-scale

questions), and likes & dislikes and suggestions to improve the game. By providing video demos of our proposed games and executable game files, therapists can explore the game features, evaluate, and suggest improvement needed for further development.

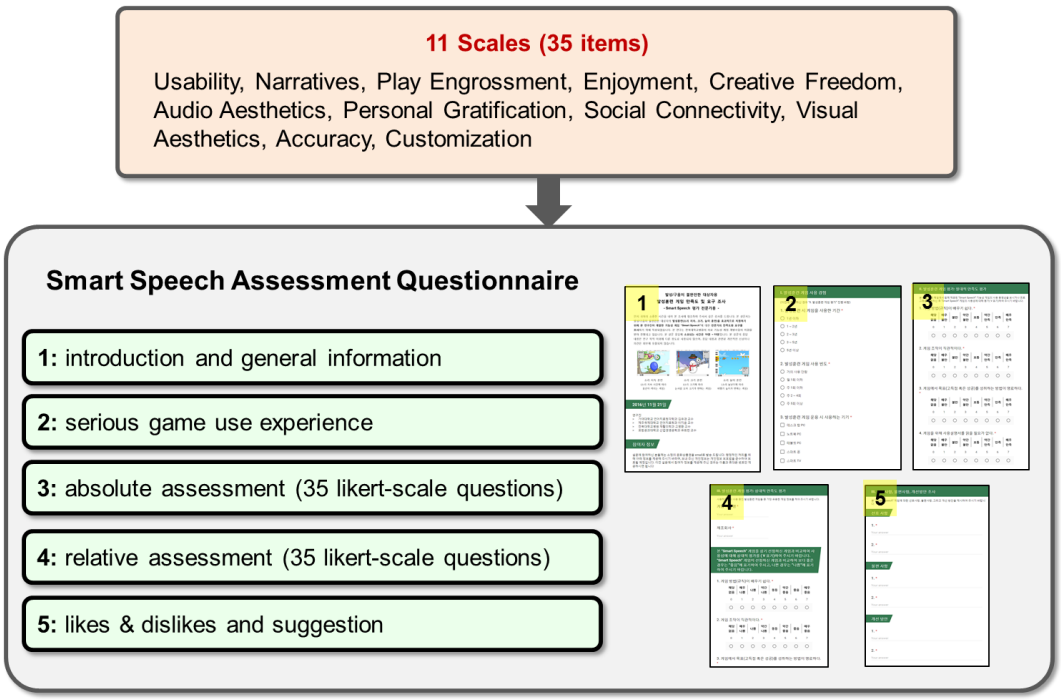



Figure IV.6. *Smart Speech* assessment questionnaire

Twenty (Male: 5; Female: 15) speech therapists with 2~22 years experiences evaluated the effectiveness of *Smart Speech*. From the absolute assessment result, visual aesthetics (5.3 ± 1.0), usability (5.2 ± 1.1), personal gratification (5.2 ± 0.9), customization (5.2 ± 0.9), accuracy (5.1 ± 0.9) are the strenghts of *Smart Speech*.. The best score was given to the question number 3 “I always know how to achieve goals in the game” (5.6 ± 0.9) in usability scale. Besides, question number 28 “I feel the game encourage the trainee” in

personal gratification scale scored 5.5 ± 0.9. Play engrossment (4.5 ± 0.9), social connectivity (4.5 ± 1.1), and creative freedom (4.4 ± 1.0) are features to be improved for better vocal training games.

From the relative assessment result, *Smart Speech* is better than existing games in all scales. Customization (5.5 ± 0.8), visual aesthetics (5.2 ± 1.1), narratives (5.2 ± 1.3), accuracy (5.2 ± 1.1), personal gratification (5.1 ± 1.2), and usability (5.1 ± 1.0) are the strengths of *Smart Speech* compared to other games. In visual aesthetics scale, the graphics fit the mood of the games (5.3 ± 1.0). Understanding the game story (5.3 ± 1.3) and various content (5.3 ± 1.2) is the main strengths of the game in narratives scale. In term of personal gratification, motivation to accomplish further level (5.3 ± 1.2) and skill improvement (5.4 ± 1.2) are the main strengths.

From the subjective evaluation, therapists mostly like the customization, various content (narratives), clarity of game rules (usability), and appealing graphics (visual aesthetics). Therapists gave positive responses and considered the developed program is able to increase the interest of its users, especially children. However, they suggested the program to provide other games or graphics, targeting adult patient in the future development. In term of personal gratification, therapists demand better feedback, for example more encouraging message. For game analytics, therapist suggested to provide graph and voice recording function, supporting patients' performance assessment.

# V. Discussion

In this study, system planning is conducted by literature review, stakeholder needs survey, and benchmarking to form game development strategies. Through literature review, important features should be considered in developing vocal training games to achieve 13 scales established in this study, including usability, narratives, play engrossment, enjoyment, creative freedom, audio aesthetics, personal gratification, social connectivity, visual aesthetics, accuracy, customization, game analytics, and therapy continuity. Nine scales were adapted from GUESS (Game User Experience Satisfaction Scale) developed by Phan, et al. (2016). GUESS itself can be applied to compare different games of the same genre or purpose (Phan et al., 2016). While other 4 scales were identified from other articles for comprehensive evaluation of vocal training game.

Based on the 13 scales, survey of stakeholders' needs and benchmarking of existing games are conducted to identify strengths and weaknesses of existing games. A questionnaire for evaluating vocal training game satisfaction was developed based on the 13 scales. Questionnaire was designed to evaluate existing serious game from therapist or parents point of view since most of speech disorder patient are children. However, parents' questionnaire result are not included in analysis since they are lack of experience and therefore their result tend to be biased and not critical. If we compare parents' and therapists' questionnare score, parents' tend to have better score than therapists' even if they evaluate the same game. Three vocal training games frequently used in speech therapy are *Visi Pitch* by Kay Pentax, *Dr. Speech* by Tiger DRS Inc, and *Vox Game* by RS Care System. *Vox Game* satisfaction score

are the highest, followed by *Dr. Speech* and *Visi Pitch*. The most satisfying scales are usability, personal gratification, and enjoyment. While social connectivity, therapy continuity, and creative freedom should be improved. Therapist specifically points out that some games has old-designed graphics. They also want the story and graphics to fit the player at a particular age group. Therapist mentioned that patient can get bored easily, which means the game require variation of game contents.

Gamification is not only applying surface elements such as challenge and reward but also require understanding of user style, expertise level and engagement level in the task (Marache-Francisco, 2016). Analysis of literature review, survey of stakeholders' needs, and benchmarking of existing games helped us form vocal training game development strategy which consider compulsory elements, stakeholder needs, and existing system requirement. There are 19 main applicable features to implement 13 scales in vocal training game.

This study developed a serious game for speech therapy, which provides the features needed for both patients and therapists to conduct an effective therapy session. We focused on implementation of the game development strategy for vocal training game development for speech therapy. The proposed serious games provide explicit goal & reward, real-time feedback, adaptive play setting, and social interaction. Explicit goal & reward can be achieved by providing scoring system, counter, and obvious object as target, which play important role as gamification factors. Real-time feedback is represented by loudness or pitch indicator, which shows current status of user's voice. Adaptive play setting by providing duration and repetition aspect can support learning objective so that user can train

certain loudness or pitch in exact duration and repeat the trial several time. Since the type of disorder and level of severity varies among patients, designing serious game for speech therapy should consider the difficulty level and appropriate material. Additionally, social interaction between therapist and patient can be improved by playing the serious games together.

Using serious game in speech therapy will help maintaining patients' motivation. Various gamification factors such as game type, scenario, level, score, and cheering message will keep patients' interest to conduct the therapy. Patients not only conduct therapy in hospital together under therapists' guidance but also they can use the system in their home under their parent guidance. Therapists can still assess patients' improvement since the therapy result will be store in database. Patients' improvement can be objectively evaluated by therapists since the system provides objective scoring system from the game played.

Therapists and patients give positive responses to serious games utilization in speech therapy (Grossinho et al., 2014; Navarro-Newball et al., 2014; Visci, 1995). Shtern et al (2012) discussed that immediate feedback and the intuitiveness of the gaming scenarios will lead to higher levels of motivation that are sustained longer than traditional modes of therapy. Chen, et al (2016) reviewed 20 papers about virtual speech therapists (VSTs) for speech disorders, while VST is an interactive computer program that targets a specific speech deficit. Hearing impairment was the disorder most frequently addressed by the VSTs reviewed. The VSTs system reviewed has been developed to deliver the part of therapy instead of whole cycle of therapy. All the studies agreed on the effectiveness of computer

program implementation in speech therapy.

Therapists, who evaluated serious games proposed, gave positive responses to customization, visual aerthetics, accuracy, usability, narratives, and personal gratification. Adjustable game difficulty level, including target loudness/pitch level, duration, and repetition, is helpful to meet training needs. Therapists found the graphics to be appealing, clear, and various. In term of accuracy, the voice input can control the game element really well. However, microphone (hardware) quality can affect to the sensitivity of capturing voice characteristic (loudness/pitch). In their opinion, it is easy to explain the game story to patients and the game is user-friendly. Users can know how to achieve goals in the game easily since the controls of the game is straightforward and the information provided is clear. Understanding the game story and various contents are the main strengths of the game in narratives scale. Even if the game contents are more diverse than existing games, therapists suggested *Smart Speech* to provide more games for adults. Three main strengths of personal gratification scale are encouragement, motivation to accomplish further level, and skill improvement. For better personal gratification aspect, therapists demand more feedback, such as encouraging messages or sound effects.

# VI. Conclusion

This study was intended to achieve three objectives of vocal training program development. First goal was identification of needs and game development strategies of vocal training games to support speech therapy for people with speech disorders by literature review, stakeholder needs survey, and benchmarking. Second goal was development a motivating and effective program ("Smart Speech") consisting of various serious games for vocal training as a part of speech therapy by implementing the identified game development strategy. Lastly, this study was aiming to evaluate the proposed vocal training program ("Smart Speech") by conducting absolute and relative assessments.

By complying literature review, features to be consider in identifying needs of vocal training games was found. There are 13 scales to be consider, which are usability, narratives, play engrossment, enjoyment, creative freedom, audio aesthetics, personal gratification, social connectivity, visual aesthetics, accuracy, customization, game analytics, and therapy continuity. Stakeholder needs survey is conducted by using questionnaire evaluating the 13 scales. Benchmarking of existing vocal training game is conducted to find applicable key features are required in vocal training games. Game development strategy is organized from result of literature review, stakeholder needs survey, and benchmarking.

Serious games for vocal training were developed by implementing game development strategies to provide features including explicit goal & reward, real-time feedback, adaptive play setting, and social interaction to facilitate speech therapy.

Vocal training game proposed was evaluated using absolute and relative assessment. Absolute assessment was needed to identify game's satisfaction score in general. While relative assessment was required to compare developed and existing games. By providing video demos of our proposed games and executable game files, therapists explored the game, evaluated the game features, and suggested things to be improved in further development. The evaluation result showed positive responses to customization, visual aesthetics, usability, narratives, accuracy, and personal gratification of the developed serious games.

More therapists are needed to get better understanding of therapists' needs of vocal training game in speech therapy system. In the analysis process, parents' data are excluded since the result are not significant to explore advantages and disadvantages of existing vocal training games. To support therapy continuity, which may require patients' activity at home, more responses from parents are needed to explore their needs.

This study did not include clinical testing of effectiveness of serious games in speech therapy. For future works, comprehensive clinical testing is needed to measure serious games effectiveness in supporting therapy activity. Clinical testing can be conducted by comparing performance improvement of speech disorder patient using serious game and without serious game. Clinical testing to compare patients' improvement between existing serious games also can be interesting issue.

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# APPENDICES

Appendix A. Vocal Training Games Needs Questionnaire

| No | Subscale | Statement No | Description |
|---|---|---|---|
| 1 | Usability | 1 ~ 7 | The ease in which the game can be played with clear goals/objectives in mind and with minimal cognitive interferences or obstructions from the user interfaces and controls. |
| 2 | Narratives | 8 ~ 9 | The story aspects of the game (e.g., events and characters) and their abilities to capture the player's interest and shape the player's emotions. |
| 3 | Play Engrossment | 10 ~ 12 | The degree to which the game can hold the player's attention and interest. |
| 4 | Enjoyment | 13 ~ 15 | The amount of pleasure and delight that was perceived by the player as a result of playing the game. |
| 5 | Creative Freedom | 16 ~ 19 | The extent to which the game is able to foster the player's creativity and curiosity and allows the player to freely express his or her individuality while playing the game. |
| 6 | Audio Aesthetics | 20 ~ 21 | The different auditory aspects of the game (e.g., sound effects) and how much they enrich the gaming experience. |
| 7 | Personal Gratification | 22 ~ 26, 31 | The motivational aspects of the game (e.g., challenge) that promote the player's sense of accomplishment and the desire to succeed and continue playing the game |
| 8 | Social Connectivity | 27 ~ 28 | The degree to which the game facilitates social connection between the player, trainer, and/or parents through its tools and features. |
| 9 | Visual Aesthetics | 29 ~ 30 | The graphics of the game and how attractive they appeared to the player. |
| 10 | Accuracy | 32 | The accurate interoperation of the input device with the game contents. |
| 11 | Customization | 33 | The degree to which game parameters are customizable to the player. |
| 12 | Game Analytics | 34 ~ 35 | The extent to which game results are managed and analyzed for effective training. |
| 13 | Therapy Continuity | 36 | The extent to which treatment activities in a treatment facility to practices at home. |

# 발성/구음이 불완전한 대상자용
# 발성훈련 게임 만족도 및 요구 조사
## - 전문가 및 보호자용 -

먼저 귀하의 소중한 시간을 내어 본 조사에 협조하여 주셔서 깊은 감사를 드립니다.
본 설문지는 발성/구음이 불완전한 대상자의 **발성훈련(소리 지속, 크기, 높이 훈련)을 효과적으로 지원하는 기능성 게임 개발**을 위해 **기존 발성훈련 게임에 대한 전문가 및 부모의 만족도와 요구를 조사**하기 위해 작성되었습니다. 본 연구는 전북대학교병원의 의료 기능성 게임 개발사업의 지원을 받아 진행되고 있습니다. 본 설문 응답에 **소요되는 시간은 10분 ~ 15분**입니다. 본 설문의 응답 내용은 연구 목적 이외에 다른 용도로 사용되지 않으며, 응답 내용과 관련된 개인적인 신상이나 의견은 외부에 유출되지 않습니다.

소리 지속 훈련
(소리 지속 시간에 따라
풍선이 커지는 게임)

소리 크기 훈련
(소리 크기에 따라
눈사람 모자 크기가 변하는 게임)

소리 높이 훈련
(소리 높낮이에 따라
비행기 높이가 변하는 게임)

**2016년 10월**


**연구진**

- 가야대학교 언어치료청각학과 김유경 교수
- 제주국제대학교 언어치료학과 이지윤 교수
- 전북대학교병원 재활의학과 고명환 교수
- 포항공과대학교 산업경영공학과 유희천 교수


**참여자 정보**

생년월일: _____년 _____ 월　　성별: ❑ 남성 ❑ 여성

(전문가 경우) 언어치료 경력: _____년　　직무유형: _____

설문에 참여하신 분들께는 **소정의 문화상품권을 email로 발송** 드립니다. 행정적인 처리를 위해 아래 정보를 제공해 주시기 바랍니다. 보내 주신 개인정보는 개인정보 보호법을 준수하여 보호될 예정입니다.

성　　명: _____　　휴대폰번호: _____

Email 주소: _____

## I. 발성훈련 게임 사용 경험

1. 발성훈련 시 게임을 사용한 기간

❑ 1년 이하 ❑ 1 ~ 2년 ❑ 2 ~ 3년 ❑ 3 ~ 5년 ❑ 5년 이상

2. 발성훈련 게임 사용 빈도

❑ 거의 사용 안함 ❑ 월 1회 이하 ❑ 주 1회 이하 ❑ 주 2 ~ 4회 ❑ 주 5회 이상

3. 발성훈련 게임 운용 시 사용하는 기기

❑ 데스크 탑 PC ❑ 노트북 PC ❑ 태블릿 PC ❑ 스마트 폰 ❑ 스마트 TV

4. 발성훈련 게임 활용 대상 연령

❑ 학령기 이전 (0~7세) ❑ 학령기 (8~18세) ❑ 청년기 (19~29세) ❑ 장년기 (30 ~ 59세) ❑ 노년기 (60세 이상)

## II. 발성훈련 게임 평가

사용하였거나 사용 중인 발성훈련 게임들 중 가장 유용한 게임 정보를 적어 주시기 바랍니다.

게임 제품명 _____ 제조회사 _____

사용하는 발성훈련 **게임에 사용성에 대해 평가**(√ 표기)하여 주시기 바랍니다.

| No | 세부요소 | 해당 없음 | 매우 불만 | 불만 | 약간 불만 | 보통 | 약간 만족 | 만족 | 매우 만족 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 게임 방법(규칙)이 배우기 쉽다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 2 | 게임 조작이 직관적이다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 3 | 게임에서 목표(고득점 혹은 성공)를 성취하는 방법이 명료하다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 4 | 게임을 위해 긴 사용설명서를 읽을 필요가 없다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 5 | 게임 메뉴를 사용자가 쉽게 이해하고 사용할 수 있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 6 | 게임 플레이를 위해 필요한 정보를 적절하게 제공한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 7 | 게임 플레이 중 화면이나 도움말에서 제공되는 정보가 명료하다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 8 | 게임 시나리오(스토리)가 흥미롭다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 9 | 게임 시나리오(스토리)가 명료하게 이해된다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 10 | 게임에 몰입하게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |

| No | 세부요소 | 해당 없음 | 매우 불만 | 불만 | 약간 불만 | 보통 | 약간 만족 | 만족 | 매우 만족 |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 게임을 마치면 다음에 또 게임하는게 기다려진다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 12 | 게임하느라 시간 가는 줄 모른다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 13 | 게임이 재미있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 14 | 게임하는 기회가 주어진다면 또 게임을 하고 싶게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 15 | 다른 사람에게도 이 게임을 추천하고 싶다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 16 | 게임이 상상력을 자극한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 17 | 게임이 창의성을 돋운다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 18 | 게임이 호기심을 자극한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 19 | 게임이 독창적이다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 20 | 게임의 사운드 효과가 게임 내용과 잘 맞는다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 21 | 게임의 사운드가 게임하는 재미를 높인다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 22 | 게임 플레이 시 높은 성취를 하도록 긴장감을 유지하게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 23 | 게임에서 과업 완수 시 성취감을 느끼게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 24 | 레벨을 올리도록 동기 부여가 된다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 25 | 게임을 통해 발성 훈련 기술 향상 효과가 있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 26 | 게임에서 최선을 다하도록 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 27 | 다른 게임 참여자들과의 사회적 관계를 형성하도록 돕는다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 28 | 부모 혹은 치료사와의 유대 관계를 증진시킨다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 29 | 게임 그래픽이 시각적으로 매력적이다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 30 | 게임 그래픽이 게임 내용과 잘 맞는다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |

| No | 세부요소 | 해당 없음 | 매우 불만 | 불만 | 약간 불만 | 보통 | 약간 만족 | 만족 | 매우 만족 |
|---|---|---|---|---|---|---|---|---|---|
| 31 | 게임이 환자를 격려하는 긍정적 기능을 준다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 32 | 소리 입력 신호의 지속시간, 강도, 음도가 적절하게 처리되어 게임 컨텐츠와 유기적으로 연동한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 33 | 게임 조건(난이도, 반복 등)을 맞춤형으로 설정할 수 있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 34 | 게임 결과를 저장하고 체계적으로 관리해 준다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 35 | 게임 결과를 분석하여 유용한 정량적 정보를 제공해 준다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 36 | 치료실에서 게임을 활용한 치료 활동이 가정에서 연계할 수 있도록 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |

III. 사용하는 발성훈련 **게임에 대한 선호사항, 불편사항, 그리고 개선 방안을 제시**하여 주시기 바랍니다.

| 선호 사항 | 불편 사항 | 개선 방안 |
|---|---|---|
| (1) _____ | (1) _____ | (1) _____ |
| _____ | _____ | _____ |
| (2) _____ | (2) _____ | (2) _____ |
| _____ | _____ | _____ |

Appendix B. Vocal Training Games Needs Questionnaire Result

| Vocal Training Games Absolute Assessment (n=18) | | | | | |
|---|---|---|---|---|---|
| No | Parameter | Mean | Que. No. | Mean | SD |
| 1 | Usability | 4.5 | 1 | 4.7 | 1.2 |
| | | | 2 | 4.8 | 0.9 |
| | | | 3 | 4.6 | 1.6 |
| | | | 4 | 4.3 | 1.3 |
| | | | 5 | 4.7 | 1.2 |
| | | | 6 | 4.2 | 1.1 |
| | | | 7 | 4.2 | 1.2 |
| 2 | Narratives | 4.1 | 8 | 3.9 | 1.6 |
| | | | 9 | 4.3 | 1.4 |
| 3 | Play Engrossment | 4.0 | 10 | 4.4 | 1.5 |
| | | | 11 | 3.9 | 1.5 |
| | | | 12 | 3.7 | 1.3 |
| 4 | Enjoyment | 4.3 | 13 | 4.2 | 1.4 |
| | | | 14 | 4.4 | 1.3 |
| | | | 15 | 4.3 | 1.3 |
| 5 | Creative Freedom | 3.5 | 16 | 3.2 | 1.5 |
| | | | 17 | 3.3 | 1.5 |
| | | | 18 | 3.6 | 1.5 |
| | | | 19 | 3.7 | 1.4 |
| 6 | Audio Aesthetics | 4.3 | 20 | 4.4 | 1.3 |
| | | | 21 | 4.2 | 1.3 |
| 7 | Personal Gratification | 4.6 | 22 | 4.4 | 1.1 |
| | | | 23 | 4.8 | 1.1 |
| | | | 24 | 4.5 | 1.3 |
| | | | 25 | 5.1 | 1.1 |
| | | | 26 | 4.6 | 1.2 |
| | | | 31 | 4.1 | 1.1 |
| 8 | Social Connectivity | 3.6 | 27 | 3.3 | 1.5 |
| | | | 28 | 3.8 | 1.3 |
| 9 | Visual Aesthetics | 4.1 | 29 | 3.9 | 1.6 |
| | | | 30 | 4.3 | 1.3 |
| 10 | Accuracy | 4.0 | 32 | 4.0 | 1.5 |
| 11 | Customization | 3.9 | 33 | 3.9 | 1.6 |
| 12 | Game Analytics | 4.2 | 34 | 4.1 | 1.9 |
| | | | 35 | 4.3 | 1.6 |
| 13 | Therapy Continuity | 3.6 | 36 | 3.6 | 1.8 |

Appendix C. Smart Speech Assessment

| No | Subscale | Statement No | Description |
|---|---|---|---|
| 1 | Usability | 1 ~ 7 | The ease in which the game can be played with clear goals/objectives in mind and with minimal cognitive interferences or obstructions from the user interfaces and controls. |
| 2 | Narratives | 8 ~ 10 | The story aspects of the game (e.g., events and characters) and their abilities to capture the player's interest and shape the player's emotions. |
| 3 | Play Engrossment | 11 ~ 13 | The degree to which the game can hold the player's attention and interest. |
| 4 | Enjoyment | 14 ~ 16 | The amount of pleasure and delight that was perceived by the player as a result of playing the game. |
| 5 | Creative Freedom | 17 ~ 20 | The extent to which the game is able to foster the player's creativity and curiosity and allows the player to freely express his or her individuality while playing the game. |
| 6 | Audio Aesthetics | 21 ~ 22 | The different auditory aspects of the game (e.g., sound effects) and how much they enrich the gaming experience. |
| 7 | Personal Gratification | 23 ~ 28 | The motivational aspects of the game (e.g., challenge) that promote the player's sense of accomplishment and the desire to succeed and continue playing the game |
| 8 | Social Connectivity | 29 ~ 30 | The degree to which the game facilitates social connection between the player, trainer, and/or parents through its tools and features. |
| 9 | Visual Aesthetics | 31 ~ 33 | The graphics of the game and how attractive they appeared to the player. |
| 10 | Accuracy | 34 | The accurate interoperation of the input device with the game contents. |
| 11 | Customization | 35 | The degree to which game parameters are customizable to the player. |

# 발성/구음이 불완전한 대상자용
# 발성훈련 게임 만족도 및 요구 조사
## - Smart Speech 평가 전문가용 -

먼저 귀하의 소중한 시간을 내어 본 조사에 협조하여 주셔서 깊은 감사를 드립니다. 본 설문지는 발성/구음이 불완전한 대상자의 **발성훈련(소리 지속, 크기, 높이 훈련)을 효과적으로 지원하기 위해 본 연구진이 개발한 기능성 게임 "Smart Speech"**에 대한 **전문가의 만족도와 요구를 조사**하기 위해 작성되었습니다. 본 연구는 전북대학교병원의 의료 기능성 게임 개발사업의 지원을 받아 진행되고 있습니다. 본 설문 응답에 **소요되는 시간은 10분 ~ 15분**입니다. 본 설문의 응답 내용은 연구 목적 이외에 다른 용도로 사용되지 않으며, 응답 내용과 관련된 개인적인 신상이나 의견은 외부에 유출되지 않습니다.

소리 지속 훈련
(소리 지속 시간에 따라
풍선이 커지는 게임)

소리 크기 훈련
(소리 크기에 따라
눈사람 모자 크기가 변하는 게임)

소리 높이 훈련
(소리 높낮이에 따라
비행기 높이가 변하는 게임)

**2016년 11월**


**연구진**

- 가야대학교 언어치료청각학과 김유경 교수
- 제주국제대학교 언어치료학과 이지윤 교수
- 전북대학교병원 재활의학과 고명환 교수
- 포항공과대학교 산업경영공학과 유희천 교수


**참여자 정보**

설문에 참여하신 분들께는 **소정의 문화상품권을 email로 발송** 드립니다. 행정적인 처리를 위해 아래 정보를 제공해 주시기 바라며, 보내 주신 개인정보는 개인정보 보호법을 준수하여 보호될 예정입니다. **이전 설문에서 참여자 정보를 제공해 주신 경우는 이름과 휴대폰 번호만 제공**하시면 됩니다

생년월일: _____년 _____ 월　　성별: ❑ 남성 ❑ 여성

언어치료 경력: _____년　　직무유형: _____

성　　명: _____　　휴대폰번호: _____

Email 주소: _____

## I. 발성훈련 게임 사용 경험 (이전에 제공하신 경우 "II. 발성훈련 게임 평가" 진행 바람)

1. 발성훈련 시 게임을 사용한 기간

❑ 1년 이하 ❑ 1 ~ 2년 ❑ 2 ~ 3년 ❑ 3 ~ 5년 ❑ 5년 이상

2. 발성훈련 게임 사용 빈도

❑ 거의 사용 안함 ❑ 월 1회 이하 ❑ 주 1회 이하 ❑ 주 2 ~ 4회 ❑ 주 5회 이상

3. 발성훈련 게임 운용 시 사용하는 기기

❑ 데스크 탑 PC ❑ 노트북 PC ❑ 태블릿 PC ❑ 스마트 폰 ❑ 스마트 TV

4. 발성훈련 게임 활용 대상 연령

❑ 학령기 이전 (0~6세) ❑ 초등생 (7~12세) ❑ 중고생 (13~18세) ❑ 청년기 (19~29세) ❑ 장년기 (30 ~ 59세) ❑ 노년기 (60세 이상)

## II. 발성훈련 게임 평가: 절대적 만족도 평가

본 설문 안내 메일에서 함께 제공된 **"Smart Speech" 기능성 게임의 사용 동영상을 보시거나 프로그램을 사용하신 후 "Smart Speech" 게임의 사용성에 대해 평가**( √ 표기)하여 주시기 바랍니다.

| No | 세부요소 | 해당 없음 | 매우 불만 | 불만 | 약간 불만 | 보통 | 약간 만족 | 만족 | 매우 만족 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 게임 방법(규칙)이 배우기 쉽다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 2 | 게임 조작이 직관적이다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 3 | 게임에서 목표(고득점 혹은 성공)를 성취하는 방법이 명료하다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 4 | 게임을 위해 사용설명서를 읽을 필요가 없다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 5 | 게임 메뉴를 사용자가 쉽게 이해하고 사용할 수 있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 6 | 게임 플레이를 위해 필요한 정보를 적절하게 제공한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 7 | 게임 플레이 중 화면이나 도움말에서 제공되는 정보가 명료하다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 8 | 게임 시나리오(스토리)가 흥미롭다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 9 | 게임 시나리오(스토리)가 명료하게 이해된다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 10 | 게임 시나리오(스토리)가 다양하다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |

| No | 세부요소 | 해당 없음 | 매우 불만 | 불만 | 약간 불만 | 보통 | 약간 만족 | 만족 | 매우 만족 |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 게임에 몰입하게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 12 | 게임을 마치면 다음에 또 게임하는게 기다려진다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 13 | 게임하느라 시간 가는 줄 모른다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 14 | 게임이 재미있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 15 | 게임하는 기회가 주어진다면 또 게임을 하고 싶게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 16 | 다른 사람에게도 이 게임을 추천하고 싶다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 17 | 게임이 상상력을 자극한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 18 | 게임이 창의성을 돋운다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 19 | 게임이 호기심을 자극한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 20 | 게임이 독창적이다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 21 | 게임의 사운드 효과가 게임 내용과 잘 맞는다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 22 | 게임의 사운드가 게임하는 재미를 높인다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 23 | 게임 플레이 시 높은 성취를 하도록 긴장감을 유지하게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 24 | 게임에서 과업 완수 시 성취감을 느끼게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 25 | 게임에서 레벨을 올리도록 동기 부여가 된다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 26 | 게임을 통해 발성 훈련 기술 향상 효과가 있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 27 | 게임에서 최선을 다하도록 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 28 | 게임이 환자를 격려하는 긍정적 피드백 기능을 준다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 29 | 다른 게임 참여자들과의 사회적 관계를 형성하도록 돕는다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 30 | 부모 혹은 치료사와의 유대 관계를 증진시킨다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |

| No | 세부요소 | 해당 없음 | 매우 불만 | 불만 | 약간 불만 | 보통 | 약간 만족 | 만족 | 매우 만족 |
|---|---|---|---|---|---|---|---|---|---|
| 31 | 게임 그래픽이 시각적으로 매력적이다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 32 | 게임 그래픽이 게임 내용과 잘 맞는다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 33 | 게임 그래픽이 현대적이다(구태의연하지 않다). | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 34 | 소리 입력 신호의 지속시간, 강도, 음도가 적절하게 처리되어 게임 컨텐츠와 유기적으로 연동한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 35 | 게임 조건(난이도, 반복 등)을 맞춤형으로 설정할 수 있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |

## III. 발성훈련 게임 평가: 상대적 만족도 평가

**사용하였거나 사용 중인 발성훈련 게임들 중 가장 유용한 게임** 정보를 적어 주시기 바랍니다.

게임 제품명 _____ 제조회사 _____

**본 "Smart Speech" 게임을 상기 선정하신 게임과 비교하여 사용성에 대해 상대적 평가를** ( √ 표기)하여 주시기 바랍니다. **"Smart Speech" 게임이 선정하신 게임과 비교하여 보다 좋은 경우는 "좋음"에 표기**하여 주시고, **나쁜 경우는 "나쁨"에 표기**하여 주시기 바랍니다.

| No | 세부요소 | 해당 없음 | 매우 나쁨 | 나쁨 | 약간 나쁨 | 동등 | 약간 좋음 | 좋음 | 매우 좋음 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 게임 방법(규칙)이 배우기 쉽다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 2 | 게임 조작이 직관적이다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 3 | 게임에서 목표(고득점 혹은 성공)를 성취하는 방법이 명료하다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 4 | 게임을 위해 사용설명서를 읽을 필요가 없다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 5 | 게임 메뉴를 사용자가 쉽게 이해하고 사용할 수 있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 6 | 게임 플레이를 위해 필요한 정보를 적절하게 제공한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 7 | 게임 플레이 중 화면이나 도움말에서 제공되는 정보가 명료하다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 8 | 게임 시나리오(스토리)가 흥미롭다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |

| No | 세부요소 | 해당 없음 | 매우 나쁨 | 나쁨 | 약간 나쁨 | 동등 | 약간 좋음 | 좋음 | 매우 좋음 |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 게임 시나리오(스토리)가 명료하게 이해된다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 10 | 게임 시나리오(스토리)가 다양하다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 11 | 게임에 몰입하게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 12 | 게임을 마치면 다음에 또 게임하는게 기다려진다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 13 | 게임하느라 시간 가는 줄 모른다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 14 | 게임이 재미있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 15 | 게임하는 기회가 주어진다면 또 게임을 하고 싶게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 16 | 다른 사람에게도 이 게임을 추천하고 싶다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 17 | 게임이 상상력을 자극한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 18 | 게임이 창의성을 돋운다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 19 | 게임이 호기심을 자극한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 20 | 게임이 독창적이다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 21 | 게임의 사운드 효과가 게임 내용과 잘 맞는다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 22 | 게임의 사운드가 게임하는 재미를 높인다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 23 | 게임 플레이 시 높은 성취를 하도록 긴장감을 유지하게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 24 | 게임에서 과업 완수 시 성취감을 느끼게 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 25 | 게임에서 레벨을 올리도록 동기 부여가 된다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 26 | 게임을 통해 발성 훈련 기술 향상 효과가 있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 27 | 게임에서 최선을 다하도록 한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 28 | 게임이 환자를 격려하는 긍정적 피드백 기능을 준다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 29 | 다른 게임 참여자들과의 사회적 관계를 형성하도록 돕는다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |

| No | 세부요소 | 해당 없음 | 매우 나쁨 | 나쁨 | 약간 나쁨 | 동등 | 약간 좋음 | 좋음 | 매우 좋음 |
|---|---|---|---|---|---|---|---|---|---|
| 30 | 부모 혹은 치료사와의 유대 관계를 증진시킨다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 31 | 게임 그래픽이 시각적으로 매력적이다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 32 | 게임 그래픽이 게임 내용과 잘 맞는다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 33 | 게임 그래픽이 현대적이다(구태의연하지 않다). | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 34 | 소리 입력 신호의 지속시간, 강도, 음도가 적절하게 처리되어 게임 컨텐츠와 유기적으로 연동한다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |
| 35 | 게임 조건(난이도, 반복 등)을 맞춤형으로 설정할 수 있다. | ❑ | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ |

## III. 선호사항, 불편사항, 개선방안 조사

**본 "Smart Speech" 게임에 대한 선호사항, 불편사항, 그리고 개선 방안을 제시**하여 주시기 바랍니다.

| 선호 사항 | 불편 사항 | 개선 방안 |
|---|---|---|
| (1) _____ | (1) _____ | (1) _____ |
| _____ | _____ | _____ |
| (2) _____ | (2) _____ | (2) _____ |
| _____ | _____ | _____ |

Appendix D. Smart Speech Assessment Result

| **Smart Speech Absolute Assessment (n=20)** | | | | | |
|---|---|---|---|---|---|
| No | Scale | Mean | Que. No. | Mean | SD |
| 1 | Usability | 5.2 | 1 | 5.3 | 0.9 |
| | | | 2 | 5.3 | 1.0 |
| | | | 3 | 5.6 | 0.9 |
| | | | 4 | 5.1 | 1.0 |
| | | | 5 | 5.1 | 1.1 |
| | | | 6 | 4.9 | 1.2 |
| | | | 7 | 5.2 | 1.4 |
| 2 | Narratives | 5.0 | 8 | 5.0 | 1.1 |
| | | | 9 | 5.2 | 0.7 |
| | | | 10 | 5.0 | 1.1 |
| 3 | Play Engrossment | 4.5 | 11 | 4.9 | 1.0 |
| | | | 12 | 4.4 | 0.8 |
| | | | 13 | 4.2 | 0.8 |
| 4 | Enjoyment | 4.9 | 14 | 4.9 | 0.9 |
| | | | 15 | 4.6 | 0.8 |
| | | | 16 | 5.3 | 1.0 |
| 5 | Creative Freedom | 4.4 | 17 | 4.2 | 0.9 |
| | | | 18 | 4.3 | 0.7 |
| | | | 19 | 4.6 | 0.9 |
| | | | 20 | 4.4 | 1.4 |
| 6 | Audio Aesthetics | 5.0 | 21 | 5.0 | 1.2 |
| | | | 22 | 5.0 | 1.1 |
| 7 | Personal Gratification | 5.2 | 23 | 4.8 | 1.2 |
| | | | 24 | 5.2 | 1.0 |
| | | | 25 | 5.0 | 0.9 |
| | | | 26 | 5.4 | 0.7 |
| | | | 31 | 5.3 | 0.9 |
| | | | 27 | 5.5 | 0.9 |
| 8 | Social Connectivity | 4.5 | 28 | 4.3 | 1.4 |
| | | | 29 | 4.8 | 0.7 |
| 9 | Visual Aesthetics | 5.3 | 30 | 5.4 | 1.0 |
| | | | 32 | 5.4 | 0.9 |
| | | | 33 | 5.2 | 1.1 |
| 10 | Accuracy | 5.1 | 34 | 5.1 | 0.9 |
| 11 | Customization | 5.2 | 35 | 5.2 | 0.9 |

| Smart Speech Relative Assessment (n=19) | | | | | |
|---|---|---|---|---|---|
| No | Scale | Mean | Que. No. | Mean | SD |
| 1 | Usability | 5.1 | 1 | 5.0 | 1.0 |
| | | | 2 | 5.2 | 0.9 |
| | | | 3 | 5.1 | 1.1 |
| | | | 4 | 5.1 | 1.1 |
| | | | 5 | 5.2 | 1.0 |
| | | | 6 | 5.3 | 0.9 |
| | | | 7 | 5.1 | 1.0 |
| 2 | Narratives | 5.2 | 8 | 4.9 | 1.3 |
| | | | 9 | 5.3 | 1.2 |
| | | | 10 | 5.3 | 1.3 |
| 3 | Play Engrossment | 4.7 | 11 | 4.8 | 1.0 |
| | | | 12 | 4.7 | 1.2 |
| | | | 13 | 4.6 | 1.0 |
| 4 | Enjoyment | 5.1 | 14 | 4.9 | 1.1 |
| | | | 15 | 4.9 | 1.2 |
| | | | 16 | 5.4 | 1.2 |
| 5 | Creative Freedom | 4.8 | 17 | 4.9 | 1.0 |
| | | | 18 | 4.6 | 0.8 |
| | | | 19 | 4.9 | 1.0 |
| | | | 20 | 4.8 | 1.3 |
| 6 | Audio Aesthetics | 5.0 | 21 | 5.1 | 1.2 |
| | | | 22 | 4.9 | 1.1 |
| 7 | Personal Gratification | 5.1 | 23 | 4.9 | 1.0 |
| | | | 24 | 5.0 | 1.2 |
| | | | 25 | 5.3 | 1.2 |
| | | | 26 | 5.4 | 1.2 |
| | | | 31 | 5.1 | 1.2 |
| | | | 27 | 5.1 | 1.3 |
| 8 | Social Connectivity | 4.6 | 28 | 4.5 | 0.9 |
| | | | 29 | 4.7 | 0.9 |
| 9 | Visual Aesthetics | 5.2 | 30 | 5.2 | 1.1 |
| | | | 32 | 5.3 | 1.0 |
| | | | 33 | 5.2 | 1.1 |
| 10 | Accuracy | 5.2 | 34 | 5.2 | 1.1 |
| 11 | Customization | 5.5 | 35 | 5.5 | 0.8 |

| Smart Speech Subjective Evaluation | | | |
|---|---|---|---|
| No | Scale | Positive responses | To be Improved |
| 1 | Usability | Easy to play | |
| | | Child-friendly menu | |
| | | Not requiring to read a manual | Provide help and pause function |
| 2 | Narratives | Various game scenario (stories, contents) | Provide games for adult |
| 4 | Enjoyment | Interesting & fun (especially for children) | |
| 7 | Personal Gratification | Motivating | Provide more motivating feedback (speech balloon, encouraging message "Ajah~! Or "More force!", etc.) |
| 8 | Social Connectivity | Multi player mode | |
| 9 | Visual aesthetics | Appealing, clear, and various graphics | |
| 10 | Accuracy | Input can control the game element well | Eliminate noise and delay (microphone quality) |
| 11 | Customization | Game difficulty level adjustable and repetition function | |
| 12 | Game Analytics | | Provide result table |
| | | | Provide voice recording function |
| 13 | Therapy continuity | | Provide mobile version |

Appendix E. Smart Speech Institutional Review Board Certification and Documents

[POSTECH IRB format #14] Certification of Exemption from IRB Review

# Certification of Exemption from IRB Review

| Principal Investigator | Name | Affiliation | Position |
|---|---|---|---|
| | Heecheon You | Dept. of Industrial and Management Engineering | Professor |
| Exemption Number | PIRB-2016-E044 | | |
| Title of Research | Development of an Serious Game for Vocal Training in Speech Therapy | | |
| Research Information | ■ Human subjects | □ Human biological materials | |
| Date of Exemption | December 20th, 2016 | | |

The Board confirms that the above research project is Exemption from Review.

※ All researchers need to follow below.

1) Researcher must lead the research as already stated on the research proposal. Please note that the research will be subject to additional review if any changes occur.
2) Researcher must submit reports on the progress of the research if the Board needs.
3) There can be site inspections for research ethics if needed.
4) Researcher must keep the documents and records related to the research for at least 3 years after the completion of research.



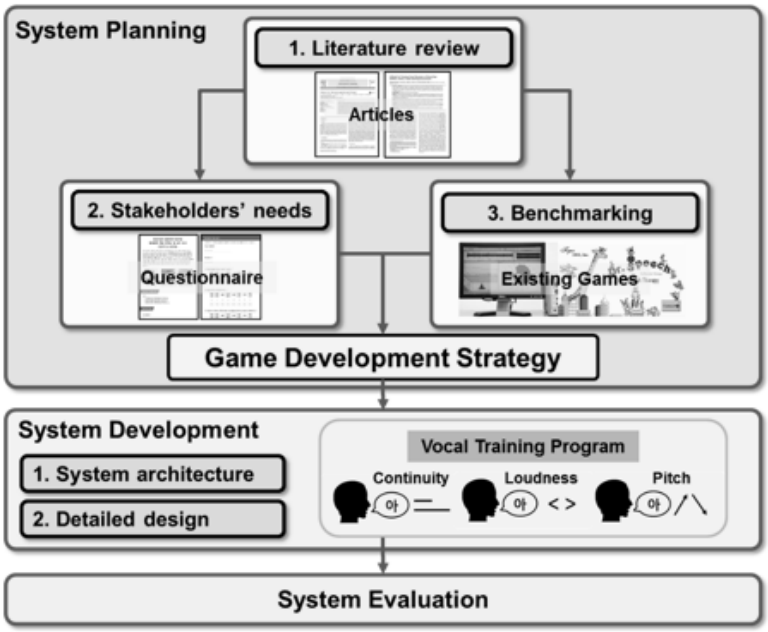
December 20th, 2016

Chairman of POSTECH Institutional Review Board

ver 1.0 (Dec 2015)

# Research Proposal for Human subjects

| Title of Research Project | Development of Serious Game for Vocal Training in Speech Therapy |
|---|---|
| Research Project Period | Date of approval: 15/12/2016 ~ 31/12/2017 |
| Research background | **1. Definition of voice disorders**<br>Voice disorder, a type of speech disorders, is characterized by an abnormal production and/or lack of vocal quality, pitch, loudness, and/or duration.<br>**2. Explanation of speech therapy**<br>Speech therapy can help patient with voice disorder to acquire self-confidence, independence, and social skills. According to Saz (2009), the conventional speech therapy is conducted in three steps including voice production, articulation, and fluency. Vocal training plays an important role as a fundamental basis of speech therapy where patient needs to practice to control their voice production. Skill of breathing, intensity, and voice tone control are essential for further steps of speech therapy and need to be conducted regularly. However, the conventional speech therapy has limitations in maintaining patients' motivation and attention during the training session.<br>**3. Explanation of serious game**<br>Serious games can contribute to maintaining patients' motivation and attention during therapy by providing fun learning or teaching for skill development. Serious games have started to be applied in healthcare, including health monitoring, health detection, treatment & therapy, and rehabilitation (Wattanasoontorn et al., 2013). Therapists and patients provided positive responses to utilization of serious games in speech therapy (Grossinho et al., 2014; Navarro-Newball et al., 2014; Visci, 1995). Shtern et al. (2012) reported that immediate feedback and intuitive gaming scenarios led to higher levels of motivation and sustainment than conventional therapy. |

| | |
|---|---|
| Research purpose | 1. **Identify needs and game development strategies of vocal training games to support speech therapy for people with speech disorders** by literature review, stakeholder needs survey, and benchmarking<br>2. **Develop a motivating and effective program ("Smart Speech") consisting of various serious games for vocal training as a part of speech therapy** by implementing the identified game development strategy<br>3. **Evaluate the proposed vocal training program ("Smart Speech")** by conducting absolute and relative assessments<br>  |
| Research subject | Participants of the survey will be **experts in speech therapy** with **experience of using serious games for vocal training**.<br>1. Serious game: a contest with explicit and implicit goals, according to a specific set of rules, challenges, and interactions<br>2. Vocal training: a practice to produce voice by controlling breath, tone, and intensity of voice |

| | |
|---|---|
| Target number of subject enrollment and basis of calculation | **1. Number of participants**<br>In total, 20 participants will be recruited for the stakeholders' needs survey of vocal training games.<br>**2. Basis of calculation**<br>We will recruit speech therapists with experience of using serious game for vocal training in speech therapy. |
| Recruitment of subjects | **1. Participation in survey**<br>Participant recruitment will be done through survey participation announcement.<br>**2. Confidentiality**<br>We will not disclose personal information of the subjects that will be collected in this survey or use them for any purpose other than conducting the research. The identity of the subjects will be kept confidential when the results of the research are published. |
| Informed consent | 1. **How to obtain the consent from the subject**<br>Consent form will be enclosed on the beginning part of questionnaire.<br>**2. Confidentiality**<br>We will not disclose personal information of the subjects that will be collected in this experiment or use them for any purpose other than conducting the research. The identity of the subjects will be kept confidential when the results of the research are published. |
| Research method | **1. Participants**<br>In total, 20 experts who have experience of using serious games for vocal training will participate in the stakeholders' needs survey of vocal training games.<br>**2. Apparatus**<br>Two questionnaires will be used to evaluate satisfaction of existing vocal training games and evaluate "Smart Speech" program. |

a. Vocal training games questionnaire will be used including 13 scales and 36 statements to evaluate existing games by a 7-point Likert scale.

b. "Smart Speech" program questionnaire will be used including 11 scales and 35 statements to evaluate existing games by a 7-point Likert scale.

| No | Subscale | Description |
|---|---|---|
| 1 | Usability | The ease in which the game can be played with clear goals/objectives in mind and with minimal cognitive interferences or obstructions from the user interfaces and controls. |
| 2 | Narratives | The story aspects of the game (e.g., events and characters) and their abilities to capture the player's interest and shape the player's emotions. |
| 3 | Play Engrossment | The degree to which the game can hold the player's attention and interest. |
| 4 | Enjoyment | The amount of pleasure and delight that was perceived by the player as a result of playing the game. |
| 5 | Creative Freedom | The extent to which the game is able to foster the player's creativity and curiosity and allows the player to freely express his or her individuality while playing the game. |
| 6 | Audio Aesthetics | The different auditory aspects of the game (e.g., sound effects) and how much they enrich the gaming experience. |
| 7 | Personal Gratification | The motivational aspects of the game (e.g., challenge) that promote the player's sense of accomplishment and the desire to succeed and continue playing the game |
| 8 | Social Connectivity | The degree to which the game facilitates social connection between the player, trainer, and/or parents through its tools and features. |
| 9 | Visual Aesthetics | The graphics of the game and how attractive they appeared to the player. |
| 10 | Accuracy | The accurate interoperation of the input device with the game contents. |
| 11 | Customization | The degree to which game parameters are customizable to the player. |
| 12 | Game Analytics | The extent to which game results are managed and analyzed for effective training. |
| 13 | Therapy Continuity | The extent to which treatment activities in a treatment facility to practices at home. |

**3. Survey procedure**

There are 4 parts of vocal training games questionnaire, which will need 10 minutes to be completed.

a. Introduction and general information (1 min)

b. Serious game use experiences (1 min)

c. Main assessment of 13 scales (8 min)

d. Likes & dislikes, and suggestions to improve existing vocal training games (3 min)


There are 5 parts of "Smart Speech" program questionnaire, which will need 15 minutes to be completed.

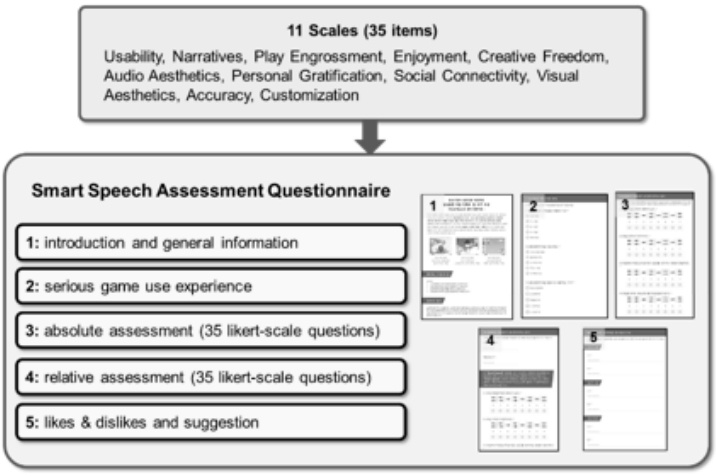
a. Introduction and general information (1 min)

b. Serious game use experiences (1 min)

c. Absolute evaluation of 11 scales (5 min)

d. Relative evaluation of 11 scales (5 min)

e. Likes & dislikes, and suggestions to improve "Smart Speech" program (3 min)



Observation item

1. **Participants Demographic and Experience**
   a. Name, date of birth, gender, cell phone, email
   b. Years of experience in speech therapy
   c. Years of vocal training games use
   d. Frequency of vocal training games use
   e. Devices used for vocal trainings games
   f. Age groups of trainees served for vocal training

2. **Satisfaction Evaluation of the Vocal Training Game**
   a. Seven-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" of participants' satisfaction of vocal training games used, which will be measured in 13 scales (36 statements).
   b. Subjective opinion of participants' satisfaction (likes & dislikes) and their suggestions to improve the vocal training games

3. **Absolute and Relative Evaluation of "Smart Speech" Game**
   a. Seven-point Likert scale from "Strongly Disagree" to "Strongly Agree" of participants' satisfaction of "Smart Speech" program, which will be measured in 11 scales (35 statements)
   b. Seven-point Likert scale from "Strongly Worse" to "Strongly Better" of participants' opinion in comparing "Smart Speech" program and vocal training games they used, which will be measured in 11 scales (35 statements)
   c. Subjective opinion of participants' satisfaction (likes & dislikes) and their suggestions to improve the "Smart Speech" game

| No | Subscale | Vocal Training Questionnaire Statement No. | "Smart Speech" Questionnaire Statement No. |
|---|---|---|---|
| 1 | Usability | 1 ~ 7 | 1 ~ 7 |
| 2 | Narratives | 8 ~ 9 | 8 ~ 10 |
| 3 | Play Engrossment | 10 ~ 12 | 11 ~ 13 |

<table>
<tr><td></td><td>
<table>
<tr><td>4</td><td>Enjoyment</td><td>13 ~ 15</td><td>14 ~ 16</td></tr>
<tr><td>5</td><td>Creative Freedom</td><td>16 ~ 19</td><td>17 ~ 20</td></tr>
<tr><td>6</td><td>Audio Aesthetics</td><td>20 ~ 21</td><td>21 ~ 22</td></tr>
<tr><td>7</td><td>Personal Gratification</td><td>22 ~ 26, 31</td><td>23 ~ 28</td></tr>
<tr><td>8</td><td>Social Connectivity</td><td>27 ~ 28</td><td>29 ~ 30</td></tr>
<tr><td>9</td><td>Visual Aesthetics</td><td>29 ~ 30</td><td>31 ~ 33</td></tr>
<tr><td>10</td><td>Accuracy</td><td>32</td><td>34</td></tr>
<tr><td>11</td><td>Customization</td><td>33</td><td>35</td></tr>
<tr><td>12</td><td>Game Analytics</td><td>34 ~ 35</td><td>-</td></tr>
<tr><td>13</td><td>Therapy Continuity</td><td>36</td><td>-</td></tr>
</table>
</td></tr>
<tr><td>Outcome evaluation criteria and evaluation methods</td><td>1. Comparison of satisfaction score among existing vocal training games<br>2. Identification of strengths and weaknesses of the existing games<br>3. Evaluation of the “Smart Speech” program which will be proposed in this study</td></tr>
<tr><td>Safety evaluation criteria and evaluation methods</td><td>Expected time to complete the questionnaire is approximately 10~15 minutes. Therefore, it is considered that the risk of stress or any other related adverse effect will be very minimum.</td></tr>
<tr><td>Data analysis and statistical methods</td><td>Descriptive statistics such as average score and standard deviation will be needed to calculate satisfaction score of vocal training games and “Smart Speech” program.</td></tr>
</table>

| | |
|---|---|
| Expected adverse effects and precautions | There is no adverse effects expected during or after the survey. |
| Disqualification/withdrawal criteria | In case of<br>1. Subjects have no experience of using any vocal training games.<br>2. Subjects, who give the same score for all questions. |
| Risks and benefits for research subjects | **1. Expected risk of research**<br>There is no specific adverse effect associated with the study.<br>**2. Advantages of participating in research**<br>Subject will be provided monetary compensation for their participation in this study. |
| Reference | American Speech-Language-Hearing Association. (2016). Voice Disorders. Retrieved from http://www.asha.org/<br>Grossinho, A., Cavaco, S., & Magalh˜aes, J. (2014). An Interactive Toolset for Speech Therapy. 11th Conference on Advances in Computer Entertainment Technology. Funchal.<br>Navarro-Newball, A., Loaiza, D., Oviedo, C., Castillo, A., Portilla, A., Linares, D., & Álvarez, G. (2014). Talking to Teo: Video game supported speech therapy. Entertainment Computing, 5, 401-412.<br>Phan, M. H., Keebler, J. R., & Chaparro, B. S. (2016). The Development and Validation of the Game User Experience Satisfaction Scale (GUESS). Human Factors, 1-31.<br>Saz, O., Yin, S.-C., Lleida, E., & Rose, R. (2009). Tools and Technologies for Computer-Aided Speech and Language Therapy. Speech Communication, 51, 948-967.<br>Shtern, M., Haworth, M. B., Yunusova, Y., & Baljko, M. (2012). A Game System for Speech Rehabilitation. In M. Kallmann, & K. Bekris (Ed.), 5th International Conference on Motion In Games (MIG) (pp. 43-54). Rennes: Springer Berlin Heidelberg.<br>Vicsi, K. (1995, October). A Product-Oriented Teaching and Training System for Speech Handicapped Children. Journal of Microcomputer Applications, 18(4), 287-297.<br>Wattanasoontorn, V., Boada, I., García, R., & Sbert, M. (2013). Serious Games for Health. Entertainment Computing, 4(4), 231-247. |

# Informed consent form for Human subjects

| Basic Information | | | | |
|---|---|---|---|---|
| Approval Number | | | | |
| Title of Research | Development of an Serious Game for Vocal Training in Speech Therapy | | | |
| Principal Investigator | Name | Affiliation | Position | Major |
| | Heecheon You | Dept. of Industrial and Management Engineering | Professor | Ergonomics |
| | Tel: 054-279-2210 | | E-mail: hcyou@postech.ac.kr | |

This research is regarding understand the satisfaction and needs of serious games in order to effectively support the vocal training (voice continuity, loudness, and pitch). Before you decide whether you will participate in the research, please carefully read the instructions and informed consent form. It is important for you to understand the purpose and method of the research. The researcher who will conduct the study will explain this to you. This will take place only when you voluntarily participate. Please read below thoroughly, and discuss with your family or friends if needed. If you have any questions, the researcher in charge will give you detailed answers.
Your signature means that you have been informed of the research and the risks of the research, and it also means that you would like to participate in the research.

**1. This research is conducted for research's sake only.**

**2. The method of research and expected virtues and effects**
This research is about development of vocal training games for people with speech disorder. This survey is intended to evaluate the satisfaction of existing vocal training games and “Smart Speech” developed by our team.

**3. The expected period of participation and the estimated total number of subjects**
The expected participation duration of each survey session will be 10~15 minutes. The number of subjects is 20 with experience of using serious game for vocal training

**4. Test and procedure that you have to go through by participating in the research**

If you are selected as a subject suitable for this survey, you will fill questionnaire, which need 10~15 minutes to be completed. You will undergo the following survey procedure.

a. Vocal training game questionnaire will be used including 13 scales and 36 statements to evaluate existing games by a 7-point Likert scale.
    - Introduction and general information (1 min)
    - Serious game use experiences (1 min)
    - Main assessment of 13 scales (8 min)

- Likes & dislikes, and suggestions to improve existing games (3 min)

b. "Smart Speech" program questionnaire will be used including 11 scales and 35 statements to evaluate existing games by a 7-point Likert scale.
    - Introduction and general information (1 min)
    - Serious game use experiences (1 min)
    - Absolute evaluation of 11 scales (5 min)
    - Relative evaluation of 11 scales (5 min)
    - Likes & dislikes, and suggestions to improve existing games (3 min)

**5. Risk (side effect) or inconvenience that is expected to be imposed on the subject (or a fetus if the subject is a pregnant woman or an infant if the subject is a breast feeder) by participating in this research**

As questionnaire to be used in this research does not include an invasive treatment, you are informed that no side effects are known or expected.

**6. Benefit that you expect to obtain by participating in the research**

Subjects participating in this study will receive a monetary compensation (KRW10,000). By participating in this study, it is possible to identify strengths and weaknesses of vocal training games. Moreover, result of this survey will contribute to the improvement of vocal training games.

**7. When the subject refuses to participate in a test**

The final decision regarding whether or not to participate in the research is to be made by you. You can always decide not to participate in the tests and can withdraw your participation in the tests anytime. Even if you refuse to participate in this research, you will not be disadvantaged at all and your decision will not have any effect in the future.

**8. Strict confidentiality of personal information (by setting privilege to view, save, manage and delete data, concealment of the subject's identity in publishing the result of a clinical trial**

Your private and personal information will be kept confidential and access to it by the general public will be restricted. However, as long as the relevant law or regulation allows, your personal information can be made available to the review board and to governmental institutions with the aim of verifying the reliability of the survey procedure and data. However, even in such a case, the information will be kept in the strictest confidence. When the result of this research is published, your identity will remain confidential.

**9. The compensation and treatment options for any damage that may incur on the subject due to a clinical trial**

If any research-related adverse effect occurs during the survey, you may inform us the event and we will take appropriate treatment.

**10. What the subject must observe for this research**

During the research, you should comply with the following. You need to abide by general health rules such as getting a good night's sleep on the day before the test, refraining from excessive drinking, and maintaining full cooperation in following the fixed schedule and directions.

**11. You can be notified of any new information obtained by a researcher while the research is in progress that may affect yourself.**

▶ I would like to be notified (  )

▶ I would not like to be notified (  )

**12. The name of the person to contact and relevant phone number in the event you require additional information or if you suffer any injury related to this research are given below.**

If you have any questions or with to express any discomfort related to this research, please feel free to contact the researcher below.

<Research Director: Prof. Heecheon You, Contact number (☎) 054-279-2210 or 010-3213-2210

Co-researcher: Edwina Dwi Sadika, Contact number (☎) 054-279-8246 or 010-3473-9211>

**※ If you have any queries regarding your rights as a human subject of research, Please contact the secretary of Institutional Review Board for details and consultation. Tel 054-279-3633**

**1. I have read this Informed Consent and received the response to each and every question.**
**2. I have learned the risks and benefits, and received satisfying answers regarding my questions.**
**3. I would like to voluntarily participate in the research by signing this.**
**4. I consent to let the researcher collect my information through the research in the boundary of legality.**
**5. I can withdraw the decision of participation anytime and I understand that it will make me no disadvantages.**
**6. My signature means that I have received the copy my this consent form and I will keep the copy until the research ends.**

**Subject (If the subject is a juvenile, his or her legal agent signs below and writes down the name of a juvenile here :_____ )**
Address /
Contact number /
Date of Informed Consent /
Name / (Signature or stamp)

**Researcher who explained about the consent form**
Date / Name / (Signature or stamp)

**Principal Investigator**
Date / Name / (Signature or stamp)