Comparison Research Between ICT-Based Design and Traditional Design for Hearing Impaired Children

A Case Study on Speech Training Tool

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Abstract. There are about 27.8 million hearing impaired people in China, and among them 137 thousand are children under six. Traditional approaches of hearing and speech rehabilitation for children are using medical treatments at first and subsequently following a speech training in professional institutes, to make up the delayed speech development. It has been found that there are some weaknesses in traditional approaches.

Since the emergence of ICTs (Information and Communication Technologies), they have been applied in many different fields, especially in the education field. ICTs have an obvious advantage in education. In this paper, the application of ICTs in speech training has been proposed, and a comparison with traditional speech training approaches has been made. Based on these research findings, a speech training prototype, New Voice was developed.

Keywords: Design for pleasure of use · Human Factors / System Integration · Training design and analysis · ICT-based design

1 Introduction

1.1 Speech Training Condition in China

There are about 27.8 million hearing impaired people in China, and among them 137 thousand are children under six. This number is increasing at an annual rate of 23 thousand. At present, more than 80% hearing and speech impaired children in developed countries can recover, while the proportion is only 29.7% in China. Hearing impairment usually hinders the development of children's speech competence and greatly impacts on their education level and social involvement [1].

Some researchers claimed that most families with hearing impaired children are in a low income. Some families in poor areas pay little attention to the rehabilitation and education of hearing impaired children due to the low level of culture, long distance to schools and poor economic conditions [2].

In addition, the number of hearing impaired children varies from different areas. The conditions of hearing impaired children in developed areas are generally better than those in less developed areas. In Shanxi Province (a less developed area in China),

M. Antona and C. Stephanidis (Eds.): UAHCI 2015, Part III, LNCS 9177, pp. 252–263, 2015.
DOI: 10.1007/978-3-319-20684-4_25

only 40% hearing impaired children are able to enter normal school, while the percentage in more developed provinces can reach 80% [2].

Security and service systems for hearing impaired children in China are in great challenge. According to WHO global Fangrong Cooperation Center, there are still 5 provinces without hospitals that can do cochlear operation; 68 cities without rehabilitation institutions for hearing impaired children. In all the Chinese hearing rehabilitation institutions, 57% lack conditions to test hearing and 68% lack conditions to fit audiphones [3].

Currently, some hearing impaired children are diagnosed and assessed in medical institutions in preschool age, and then have speech training there. However, in school age, most of them enter special education schools, where speech training is beyond the abilities and duties of medical institutions. As a result, special education teachers have to be responsible for education and rehabilitation of hearing impaired children. It is quite a heavy task for special education teachers [4].

1.2 The Development of ICTs

Since the emergence of ICTs (Information and Communication Technologies), they have been applied in many different fields, especially in the education field. ICTs are formed by information technology and communication technology.

ICTs have an obvious advantage in education. For example, it is found that ICTs are of vital significance in preschool educational process [5]. Furthermore, in music education, ICTs successfully contribute to young children's musical learning, music creativity and cognitive development [6]. In recent decades, more and more studies about ICTs focus on the needs of disadvantaged groups, for instance, the rehabilitation and training for hearing impaired children [7].

One type of information technologies, speech signal digital processing technology has been applied to the diagnosis and rehabilitation in speech therapy [8]. Other ICTs, Real-time feedback control technology and multimedia means have been applied to the speech training to improve the efficiency and intuition [4]. In countries with large geographical space or limited resources, ICTs also offer a method of reaching families who may otherwise have missed out on services altogether [9]. For instance, VidKids®, used a video conferencing approach to provide services to families in remote areas [10]. One type of ICTs, Online technology is a viable alternative to face-to-face sessions. For example, Constantinescu examined both therapist and parent satisfaction with the online delivery of auditory verbal therapy and overall satisfaction was high with the majority of therapists and parents [11]. An e-training tool was designed to help hearing impaired children learn and practice words in Thai language more correctly [12]. The tool used speech recognition technology, to overcome the limitations of the traditional face-to-face speech therapy.

2 Methodology Description

2.1 Study Framework

The study framework is as follows (Fig. 1):

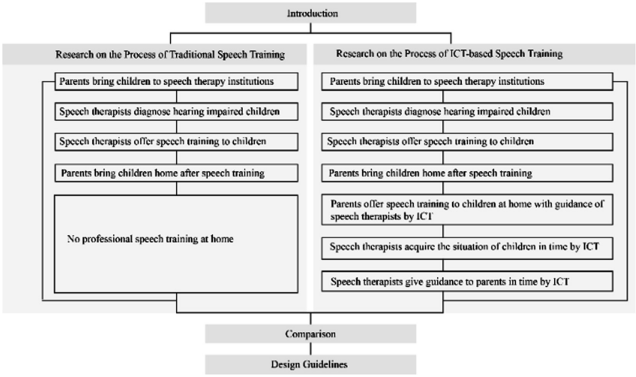

Fig. 1. Study framework

2.2 Traditional Speech Training in China

In China, traditional approaches of hearing and speech rehabilitation for children are using medical treatments at first and subsequently following a speech training in professional institutes, to make up the delayed speech development.

Parents usually choose special school for their own hearing impaired children to receive speech training, since there are professional speech therapists.

Usually, the traditional speech training process in China is as follows:

1. Parents bring children to speech therapy institutions.
2. Speech therapists diagnose hearing impaired children according to subjective audition and other medical equipment.
3. Speech therapists offer speech training to children. They often use cards, toys, games and other interesting forms, leading children to speak and then correcting their wrong pronunciation. Children learn to speak by repeated exercise.
4. Parents bring children home after speech training. Since parents are lack of professional skills, children cannot have professional speech training at home.
5. Parents bring children back to speech therapists the next day. In fact, parents have to take children to speech therapy institutions every day, aiming for good training effects.

It has been found that there are some shortcomings in traditional approaches as follows.

1. Best time for speech training is likely to be delayed due to expensive medical fees and defective health care system. The best ages for speech development are 2 $\sim$ 7 years old [7]. Receiving speech training earlier is more beneficial to the rehabilitation. According to the survey of China Disabled Persons Federation, only 50% hearing impaired children can be admitted to rehabilitation institutions and then only half of them can enter the normal kindergartens or primary schools, whereas the rate in developed countries is 90%.
2. Parents have no chance and condition to participate in the speech training. Children spend most time with their parents, thus parents play an important role in training

[14]. However, there is a lack of speech training professionals in China. According to the developed countries level, 55000 audiology staff and 490000 speech therapy professionals are demanded in China, while in fact there are only 7775 and 100, respectively. One speech training teacher has to take charge of several children. As a result, each child receives less training [15].

3. Monotonous training models result in the loss of children's learning interest. Existing speech training tools are simple and mainly focus on the mechanical training of vocal organs. Experts state that interesting training models and effective feedbacks contribute to children active participation in training [16].

2.3 ICT-Based Speech Training

The speech therapy profession has expanded rapidly with complex clinical education and practices over the past 30 years, while recently making use of available ICTs [17].

ICTs are mainly used for assessment and intervention purposes of speech and language disorders both in children and adults. As speech training is sometimes time-consuming and laborious for both therapists and patients, intelligent diagnosis and therapy systems have been created as a way to enhance speech therapy efficiency [18]. A study in Greek introduced an internet-based Speech Pathology Diagnostic Expert System, which is used for assessing the oral language abilities of children aged between 4 and 7 [19].

It is also found that ICTs impact on intervention in people with hearing impairment. ICTs in intervention should be designed in accordance to the disability, in an easy and understandable manner for the user, in order to allow speakers to achieve the highest speech, language and cognitive performances possible [20, 21]. A software system was developed for Persian hearing impaired children, which promotes the interaction of language learning activities both at home and in clinic [22].

Based on the brief overview of ICTs in speech training, most ICT-based speech training tools are designed for a certain language and for therapists, in order to raise training efficiency. However, there are no tools designed for home use and improving the user experience of patients. Therefore, based on the national conditional in China, an ICT-based speech training progress for Chinese hearing impaired children are designed as follows:

1. Parents bring children to speech therapy institutions.
2. Speech therapists diagnose hearing impaired children.
3. Children have speech training.
4. Parents bring children home after speech training.
5. Parents offer speech training to children at home with guidance of speech therapists by ICT. Thanks to ICTs, parents are more accessible to professional speech training knowledge. Multimedia offer a variety of training modes, which are more attractive to children.
6. Speech therapists acquire the situation of children in time by ICTs. Speech therapists can communicate with parents through ICT-based speech training tools.
7. Speech therapists give guidance to parents in time by ICTs.

8. Parents bring children back to speech therapists institutions after a period of time. Speech training from both parents and speech therapists can accelerate this learning process of children.

2.4 Design Guidelines

Based on the shortcomings of traditional speech training and previous researches on ICTs in the field of speech therapy, the needs of parents and hearing impaired children in speech therapy should be given attention. Their needs are concluded as follows:

- Hearing impaired children should have speech training as early as possible.
- Parents should be professionally trained with speech training skills and offer speech training to their children by themselves.
- Hearing impaired children prefer interesting speech training.
- Speech training has remarkable effects for hearing impaired children.

In accordance to the needs of parents and hearing impaired children, four design guidelines for ICT-based speech training tool are concluded as follows:

- The speech training tool is more accessible.
- Parents can participate in speech training more.
- The speech training tool is more attractive to hearing impaired children.

3 Case Study of Speech Training Tool

3.1 Design Framework

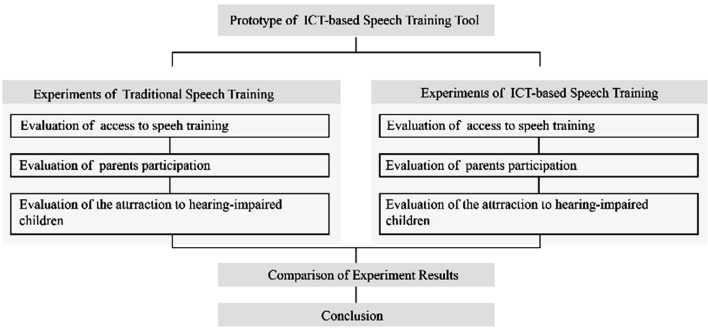

Fig. 2. Design framework

3.2 Prototype

Based on above research findings, a prototype of an ICT-based speech training tool, named New Voice, was developed. The prototype includes a speech training app for iPad and a smart toy. It is an auxiliary speech training tool for parents and hearing

impaired children to easily use at home. It is recommended for hearing impaired children with residual hearing by means of hearing aid devices or operations, since it is more effective for them to use than for totally deaf children (Fig. 2).

The Speech Training App for iPad. The app is designed for both parents and hearing impaired children to use. It has three main functions: speech training, training records, course recommendation.

- **Speech training.** A series of speech training courses is designed for users. There are 21 consonants and 6 vowels in Chinese pinyin. It is more systematic for children to learn Chinese beginning with pinyin. Therefore, every course is aimed that children learn one consonant or one vowel of Chinese pinyin through three different two-character Chinese words. Parents can choose proper courses for children with guidance of speech therapists at homepage (Fig. 3). Subsequently, parents are guided to record teaching videos for chosen courses. The video can teach children to speak Chinese in case that parents do not stay with children. Besides videos, children can also learn to speak Chinese by game at the study page (Fig. 3). The game, whack-a-mole, is designed to offer visual learning feedbacks to children. The voice of children can be captured through speech recognition technologies and parsed to Chinese pinyin. The parse results will be compared with the correct pinyin and it shows corresponding animations to children at the study page. If children speak the right Chinese word of this course, a mole will be whacked, otherwise it will not be whacked. Children win the game when wracking moles for a certain times. That also means children have mastered this course for a certain degree.

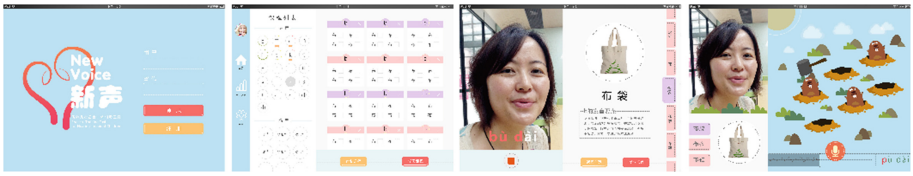

Fig. 3. From left to right: login Page, homepage, recording page; study page

- **Training records.** The app can record game results, which reflects training effect of a certain course. *Accuracy* is used to describe the training situation. Higher *Accuracy* indicates better training effects.

$$Accuracy = \frac{\text{Right times in the game}}{\text{Total times in the game}} \tag{1}$$

Accuracy is showed at the homepage of the app (Fig. 3), in shape of circle around the course name. A grey circle means unlearned; a red circle means $0 \sim 25\%$ *accuracy*; a yellow circle means $25 \sim 75\%$ *accuracy*; a green circle means $75 \sim 100\%$ *accuracy*.

- **Course recommendation.** According to the training records, the app can automatically recommend those courses with low *Accuracy* to parents. At the homepage (Fig. 3), those courses will be marked with an orange icon.

The Smart Toy. Tongue movement is one of the essential factors for speech. Hence, New Voice also includes a speech training toy for children (Fig. 4), which can display the tongue movement as a real man speak Chinese. The toy is a tumbler, in case children drop and break it. The shape of the toy is like a bird. Children can observe and touch its mouth and tongue when having speech training. In that way, they can understand the right way to pronounce and imitate the tongue and mouth movement from the toy.

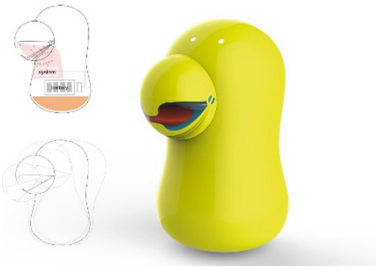

Fig. 4. Smart toy

The tongue and mouth movement is under the control of the app. When the video in the app is playing, the tongue and the mouth of the toy move according to the content of video.

3.3 Experiments

The experiments were designed based on the design guidelines, aiming to compare ICT-based speech training with traditional speech training. The comparison experiments were divided to 3 parts: access to speech training, parent participation and attraction to children.

Comparing Access to Speech Training. Three experts (two doctors and a speech therapist from Shanghai Children's hospital) were invited to compare the two approaches in the aspect of access to speech training. They assessed and graded the two speech training approaches on the aspect of access.

Comparing Parent Participation. Eight families with hearing impaired children and one therapist were invited to the experiments. All the hearing impaired children had regain part hearing by operation,but still needed to have speech training. The eight children were divided into two groups. Four children needed to learn a Chinese word by traditional way first and then another similar Chinese word by ICT-based way. These two words were of an equivalent level of difficulty. The other four children learned in reverse order. The traditional training was offered by a therapist and the ICT-based one was offered by a parent with New Voice. Each process lasted for half an hour and were divided into 4 parts:

- Review: children were led to review last course and required to answer questions about last course.
- Study: children learned the assigned words.
- Practice: children practiced the assigned words constantly.
- Reinforce: children were led to practice the less skilled words.

The experiments were both recorded by camera. Two experimenters observed and took notes. The duration of parent participation were recorded by experimenters. Parents finished questionnaires and graded the participation degree of themselves after the experiments.

Comparing Attraction to Children. This comparison experiment was the same with the above one. The parents finished questionnaires and graded the attraction degree to children after the experiment. The emotion performance of children in the two processes was recorded by experimenters with emotion scores. The scores ranged from -2 to 2. -2 means very unhappy; -1 means a little unhappy; 0 means no obvious emotion; 1 means a little happy; 2 means very happy. Experimenters took notes of what happened when emotion varied.

3.4 Results

Access to Speech Training. Experts graded traditional speech training approach and ICT-based approach in the aspect of access (full mark is 10). The scores are shown in Table 1. The score of ICT-based approach is higher than the traditional one.

Table 1. Scores of two approaches in the aspect of access

Expert No.		1	2	3	Average
Score	Traditional	4.5	3	5	4.17
	ICT-based	7	6.5	8	7.17

Experts affirmed that portable autonomous household medical supplies is trend of the development. Due to lack and misallocation of professional resources, it is hard to access to professional speech training in some remote areas of China. Traditional speech training is based on the direct interaction between children and therapist via a set of activities developed by the therapist. This direct interaction is essential and effective in giving a personal feedback to each child, but this approach requires a high number of therapists to help all the hearing impaired children in case of slowing down the maximum progress in speech, that, unfortunately, is not feasible now in most of the cases. New Voice is a good ICT-based household medical supply. With it, doctors and speech therapists can guide parents to participate in speech training in the distance. In a degree, ICT-based speech training makes up of professional resources shortage, for professional knowledge is popularized among ordinary families through ICTs and more children can have speech training in time.

Table 2. Participation duration of eight parents in two training processes

Parent No.		1	2	3	4	5	6	7	8	Average
Participation Duration (min)	Traditional	5	8	4.5	8.5	10	5	7	7	6.875
	ICT-based	22	23	24	30	28	21.5	22	26	24.5625

Parent Participation. Participation duration of parents in two training processes was recorded in Table 2.

According to the experimental data, all the eight parents participated much longer in ICT-based process than in the traditional one. It proves that parent participation is improved in speech training process by ICT.

In the traditional process, the speech therapist was mainly responsible for the whole training process, while parents dominantly participated in the review part to inform the therapist of the practice performance of children at home and consulted corresponding questions.

However, in the ICT-based process, parents offered speech training by themselves. They received professional training knowledge by app. When they needed to leave temporarily, children practiced with the video in the app.

Attraction to Children. Emotion performance of the eight children in the two training processes was marked by emotion scores by each minute. For example, the emotion performance of one child was recorded in Table 3 and Fig. 5, according to which average emotion score of the two processes was calculated and displayed in Table 4 and Fig. 6.

Table 3. Emotion performance of one child in two training processes

Time(min)		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Emotion Score	Traditional	0	-1	-1	0	1	1	0	0	0	0	0	0	0	0	0	2	2	2
	ICT-based	0	-1	-1	0	1	1	1	1	1	2	2	2	2	2	2	2	2	0
Time(min)		18	19	20	21	22	23	24	25	26	27	28	29	30	Average				
Emotion Score	Traditional	2	1	0	-2	1	1	-1	-2	-2	-2	-2	-2	-2	**-0.13**				
	ICT-based	2	0	-1	-2	1	1	1	1	1	1	2	2	2	**0.97**				

According to the experimental data, seven children were happier in ICT-based process than in the traditional one and only one child was on the contrary. It proves that ICT-based speech training process is more attractive to children.

In the traditional training process, children learned words by repeating what the speech therapist said. The speech therapists corrected pronunciation mistakes of children again and again. In that way, children were easy to be tired of monotonous and repeating training modes. They were forced to have training. On the contrary, parents taught children words and demonstrated how to pronounce with the smart toy in the ICT-based training process. Children were guided to practice with the toy and reinforce words in games on their own. Children were happy naturally and the fun of speech training was significantly increased through games and toys.

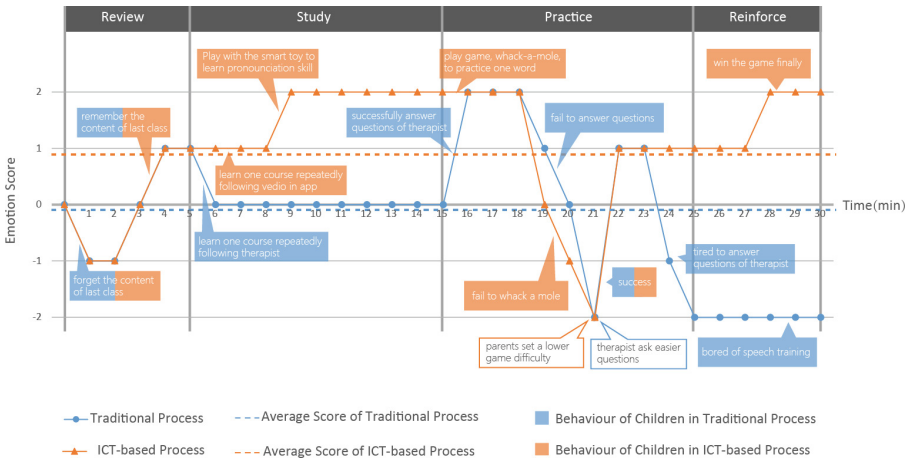

Fig. 5. Emotion performance of one child in two training processes

Table 4. Average emotion scores of each child in two training processes

Child No.		1	2	3	4	5	6	7	8
Average Emotion Score	**Traditional**	-0.13	0.3	-0.26	0.56	1.34	-1.21	1.27	0.13
	ICT-based	0.97	0.47	1.03	0.73	1.57	-0.75	1.02	1.16

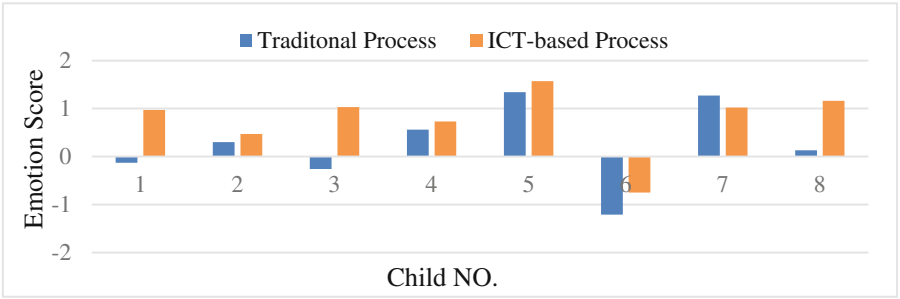

Fig. 6. Average emotion scores of each child in two training processes

4 Conclusion

In this paper, the application of ICTs in speech training has been proposed, and a comparison with traditional speech training process has been made. The comparison results are as follows:

1. ICT-based speech training are more accessible. In result, families with hearing impaired children can have access to speech training in time.

2. Parents can participate more in ICT-based speech training. Besides, it is more convenient for the communication between parents and therapists with the help of ICTs. Parents can receive professional guidance from experts by ICTs.
3. ICT-based speech training is more attractive to children. ICTs make it possible to offer more interesting and interactive speech training modes and improve the user experience. As a result, the efficiency of training is improved.

There are also some research limitations and shortcomings due to time limit, it is necessary to further the content of the paper and to add further study. Future work includes more tests on families with hearing-impaired children and then there will be a next iteration of ICT-based speech training.

Acknowledgement. This paper is sponsored by Shanghai Pujiang Program (13PJC072), Shanghai Philosophy and Social Science Program (2012BCK001), Shanghai Jiao Tong University Interdisciplinary among Humanity, Social Science and Natural Science Fund (13JCY02). Moreover, we thank to Children's Hospital of Shanghai, Lanxilu Kindergarten, Co-funding TV Program-the Makers and the students of Shanghai Jiao Tong University who have contributed to this research.

References

1. Sun, X., Yu, L., Qu, C.: An epidemiological study on the hearing impaired population identified in China and proposed intervention strategies 中国听力残疾构成特点及康复对策. Chin. Sci. J. Hear. Speech Rehabil. **2**, 21–24 (2008)
2. Summary of hearing impaired children. http://www.infzm.com/content/104975
3. The whole rehabilitation service for hearing impairment children in China lags behind 中国听力障碍儿童康复服务水平整体落后. Chinese Journal of Clinical Medicine Maternal and Child 9(3), 419(2013)
4. Zhu, Q.: Special Children's Speech Rehabilitation Status Investigation and Performance Research under the Background that Medical Combined with Education "医教结合" 背景下特殊儿童言语康复的现状调查及绩效研究. East China Normal University (2014)
5. Liu, X., Toki, E.I., Pange, J.: The use of ICT in preschool education in Greece and China: a comparative study. Procedia – Soc. Behav. Sci. **112**, 1167–1176 (2014)
6. Panagiotakou, C., Pange, J.: The use of ICT in preschool music education. Procedia – Soc. Behav. Sci. **2**, 3055–3059 (2010)
7. Drigas, A., Petrova, A.: ICTs in speech and language therapy. Int. J. Eng. Pedagogy (iJEP) **4** (1), 49–54 (2014)
8. Huang, Z., Du, X.,: Speech therapy 言语障碍的评估与矫治 29 (2006)
9. Leigh, G.: Changing parameters in deafness and deaf education: greater opportunity but continuing diversity. In: Marschark, M., Hauser, P.C. (eds.) Deaf Cognition Foundations and Outcomes, pp. 24–51. Oxford University Press, New York (2008)
10. VidKids (2014). http://www.vidkids.org
11. Constantinescu, G.: Satisfaction with telemedicine for teaching listening and spoken language to children with hearing loss. J. Telemedicine & Telecare **18**(5), 267–272 (2012)
12. Witsawakiti, N., Suchato, A., Punyabukkana, P.: Thai language e-training for the hard of hearing. Spec. Issue Int. J Comput. Internet and Management **14**(1), 41.1–41.6 (2006)
13. Meng, Z.: Baby Psychology 婴儿心理学. Beijing University Press, Cambridge (1997)

14. Li, S.: Discuss the role of parents in rehabilitation education of hearing impaired children 浅谈家长在听障儿童康复教育中的作用. Educ. Chin. After-sch. **2**, 26 (2011)
15. Wang, X., Tao, Y.: Recommendations for the hearing impaired infants family early intervention 关于听障婴幼儿家庭早期干预的建议. Sci. Innov. **16**, 131–132 (2014)
16. Yan, Q.: How to arouse hearing impaired children's interest in speech learning 寓教于乐寓学于趣_如何在语言训练中激发聋童的学习兴趣. The New Course **10**, 419 (2012)
17. Hoben, K., Morris, J.: PATSy: Innovations in Learning for Speech and Language Therapy. Bulletin of the Royal College of Speech and Language Therapists (2005)
18. Popovici, D.V., Buică-Belciu, C.: Professional challenges in computer-assisted speech therapy. Procedia-Soc. Behav. Sci. **33**, 518–522 (2012)
19. Toki, E.I., Pange, J., Mikropoulos, T.A.: An online expert system for diagnostic assessment procedures on young children's oral speech and language. Procedia Comput. Sci. **14**, 428–437 (2012)
20. Paniagua Martín, F., Colomo Palacios, R., García-Crespo, Á.: MAS: Learning support software platform for people with disabilities. In: Proceedings of the 1st ACM SIGMM International Workshop on Media Studies and Implementations that Help Improving Access to Disabled Users, pp. 47-52 October (2009)
21. Öster, A.M., House, D., Protopapas, A., Hatzis: A presentation of a new EU project for speech therapy: OLP (Ortho-Logo-Paedia). In: Proceedings of the XV Swedish Phonetics Conference (Fonetik 2002), pp. 29-31 May 2002
22. Bastanfard, A., Rezaei, N.A., Mottaghizadeh, M., Fazel, M.: A novel multimedia educational speech therapy system for hearing impaired children. In: Qiu, G., Lam, K.M., Kiya, H., Xue, X.-Y., Kuo, C.-C., Lew, M.S. (eds.) PCM 2010, Part II. LNCS, vol. 6298, pp. 705–715. Springer, Heidelberg (2010)