

# AustimSpace: A Visualized Scenario Learning Aid on Tablet PC for Chinese Children with High-Functioning Autism

Chien-Hsing Chou<sup>1\*</sup>, Yi-Hsiang Chien<sup>1</sup>, Yung-Long Chu<sup>1</sup> and Yi-Zeng Hsieh<sup>2</sup>

<sup>1</sup>*Department of Electrical Engineering, Tamkang University,  
Tamsui, Taiwan 251, R.O.C.*

<sup>2</sup>*Department of Management and Information Technology, Southern Taiwan University of Science and Technology,  
Tainan, Taiwan 710, R.O.C.*

## Abstract

In this paper, a visualized scenario learning aid on Tablet PC is developed for children with high-functioning autism. The aid assists autistic children in learning how to use daily living equipments or daily living skills with specific scenarios. Caretakers of autistic children can directly design learning targets on the corresponding space, e.g. bathroom or kitchen. When the autistic children select a specific space, this aid shows the possible learning targets. After they click on a learning target, then the corresponding videos or pictures are given. The developed aid links the specific space and its learning objective, thereby enhancing the autistic child's learning outcome. Furthermore, the developed aid employs a cloud server that enables caretakers to upload and share their self-produced learning scenarios with other caretakers who have similar needs. In addition, the developed aid is available to download cost-free from the iTunes App Store, and the software content is presented in Mandarin Chinese. Users of this aid do not require any cost and a specific level of English ability to use it.

**Key Words:** Aid Development, Scenario Learning, High-Functioning Autism, Tablet PC, Living-Skill Learning

## 1. Introduction

After their birth, children undergo numerous stages of learning: from focusing on faces as an infant, making “ah” and “goo” sounds and visually tracking moving objects while two months, making meaningful gestures (e.g., clapping and waving) at six months, understanding certain words (e.g., “daddy” and “mommy”) after 12 months, to speaking sentences comprising five to six words and slowly learning life skills after 30 months. The above process outlines the typical development and learning of children [1]. However, a particular group of children experience physical and learning developmental delays because of cranial nerve dysfunction [2]. From 1 to 3 years of age, these children begin to exhibit beha-

aviors that differ conspicuously from those of other children, including difficulty interacting with family members, fixation on certain objects, unusual play, inappropriate responses, and delayed reactions to pain, etc. Researchers have labeled these delays autism spectrum disorders (ASDs). According to statistical data from the Executive Yuan, Taiwan, an average of approximately 1,000 children are diagnosed with ASDs every year.

Research has indicated that the idiosyncratic behaviors of autistic children [3] can be categorized into the following three main impairment domains, including (a) Interpersonal relationships and social interaction; (b) Verbal communication; (c) Repetitive behaviors. Nevertheless, the symptoms vary between autistic children. Some children may display minor dysfunction in social interaction, whereas others may show severe impairments in verbal communication and repetitive behavior. Fur-

\*Corresponding author. E-mail: chzhou@mail.tku.edu.tw

thermore, symptoms can be classified as minor, intermediate, or severe according to the level of manifestation. In academia, autism is classified as low-functioning autism and high-functioning autism.

The learning development of children with ASDs (hereafter referred to as autistic children) is the primary concern of their parents. Students with autism typically exhibit language disorders; therefore, learning scenarios that feature role playing should be established, while these students learn daily living skill. General learning models usually focus on listening and speaking. Autistic children are necessitated to possess particular levels of concentration and semantic processing capabilities to understand the themes and contents of learning. Additionally, the transience of spoken messages does not provide autistic children with sufficient time to master the learning content. Compared with spoken messages, visual messages exist for a longer period, providing children with sufficient time to analyze and understand the meaning of the messages. Furthermore, most children with autism are sensitive to visual messages; therefore, appropriately designed visual learning contents can further improve their learning outcomes.

Accompanying the advancements in technology, several researchers have used integrated interactive environments as learning and teaching tools to enhance the learning outcomes of autistic children [4–12]. Cai et al. developed a virtual dolphinarium for use in potential autism intervention [4]. Instead of emulating the experience of swimming with dolphins, the virtual dolphin interaction program allows children with autism to act as dolphin trainers at the poolside and learn (nonverbal) to communicate with virtual dolphins by using hand gestures. Lahiri et al. developed a virtual reality (VR)-based interactive system with gaze-sensitive adaptive response technology [5]. This system integrated VR-based tasks with eye-tracking techniques to facilitate engagement in tasks that cultivate social communication skills. Weilun et al. developed virtual games as an augmentative aid to engage autistic students in rehabilitative and academic training [6]. Their system featured a virtual agent and a robotic agent to improve the social skills of children. Robins et al. employed a humanoid robot as interactive playmates for autistic children [7]. The small humanoid robot helped children to encourage their social interaction skills. Kozima et al. designed an interactive robot (Keepon) as a playful toy used in remedial practice for

children with autism [8]. The interactive robot had a simple appearance and some actions to express emotional states, and relating to autistic children spontaneously.

Since the release of the iPhone in 2008, mobile devices have become essential to the lives of numerous people. Several researchers have developed aids on mobile devices for children with autism [13,14]. Autismate is a well-known mobile device aid [13] that was developed to assist autistic children with cultivating communication and behavioral skills. The aid is a form of communication used to enhance non-verbal speech or build on existing speech to express thoughts, wants and needs. In additions, this aid also provides a grid display layout of individual symbols and icons that represent words or phrases. However, these aids are expensive; for example, the price of Autismate is USD\$ 149.99. In addition, English is the interface language typically used for these aids. Consequently, such aids are difficult to promote in countries where Mandarin Chinese is the native language (e.g., Taiwan, Hong Kong, and China).

Based on the above analysis, using a tablet PC, a visualized scenario learning aid named as AustimSpace is designed for children with high-functioning autism. The developed aid is available to download cost-free from the iTunes App Store, and the software content is presented in Mandarin Chinese. Users don't spend any cost to download this aid, and they are not required to possess a specific level of computer knowledge and English ability. In addition, the designed aid also employs a cloud server that enables parents of autistic children to upload and share their self-produced communication picture cards with other parents who have similar needs.

## 2. The Proposed Visualized Scenario Learning Aid

Because autistic children have limited linguistic comprehension, this best strategy to motivate their learning outcomes is through a visualized learning method using pictures or videos. In this study, a visualized scenario learning aid named as AustimSpace is developed performing on a tablet PC and integrating the technique of cloud server. The designed aid lets caretakers define the specific spaces (e.g. bathroom and living room), and then layer learning targets on top of the picture in the form of brightly colored icons.

### 2.1 The Usage Scenario for the AustimSpace

Figure 1 shows the usage scenario for AustimSpace, which connects learning objectives and space. In this scenario, the tablet PC displays a realistic scene of a home bathroom. Subsequently, caretakers set three learning targets on the picture of bathroom: the toilet, sink, and bathtub, and embed the corresponding videos or pictures for learning these targets. When an autistic child clicks on the bathtub, a set of showing pictures or a learning video of showering is displayed on the tablet PC. Through this learning strategy, AustimSpace directly links the bathtub and the corresponding space to learn shower, and enhances the autistic child’s learning outcome. With AustimSpace, caretakers can easily use a tablet PC to construct spatially realistic scenes and provide corresponding pictures and teaching videos without using personal computers or digital cameras. Consequently, AustimSpace provides a simple and intuitive editing mode to help caretakers constructing their learning contents, and no other computer or image-capturing equipment is required.

### 2.2 The Procedure of Conducting Learning Content

The purpose of AustimSpace is to assist autistic children in learning how to use daily living equipments or daily living skills conduct in specific scenarios (e.g., showering and tooth brushing). To achieve the objectives, AustimSpace provides caretakers with a simple and intuitive editing mode to set scenarios and construct practice materials on a tablet PC. In addition, caretakers may use the spatially realistic scenes, pictures and videos as the scenario background and learning contents, which are familiar to autistic children. This would help autistic children to improve their motivation and attention during applying the developed aid.

To generate the learning contents, in the first step,

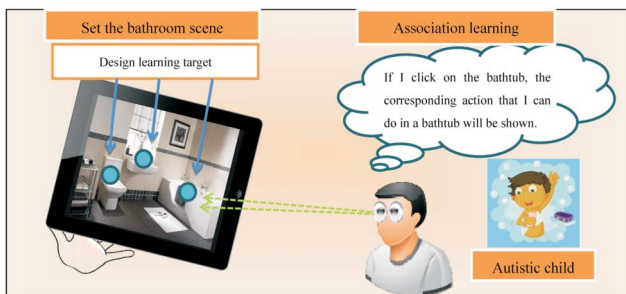


Figure 1. Usage scenario for AustimSpace.

caretakers define a specific space (e.g. kitchen or bathroom; Figure 2), and import a background picture of this space with some descriptions. The picture of the specific space is primarily based on real-life spaces, such as household scenes (e.g., the kitchen and bathroom), and other scenes (e.g. classroom and restaurant).

In the second step, the caretakers click on the screen of tablet PC to layer learning targets on top of the scenario picture. In Figure 3, the mirror, toothbrush, and washbasin of the scenario picture are set as learning targets. The contents of these learning targets, which are including washing face, washing hands and tooth brushing, are shown as colored icons on the scenario picture, respectively. After setting a learning target, the caretakers then embed the corresponding pictures or videos. The embedded method is quite simple and intuitive.



Figure 2. The scenario space of kitchen and bathroom.



Figure 3. Setting the mirror, toothbrush, and washbasin as learning targets on the scenario space.

tive. Figure 4 shows an example. First the caretakers click on a learning target, and then an edit model is provided for adding the photographs or videos. The caretakers sequentially construct practice materials from the tablet PC to finish the contents of corresponding learning target. In Figure 4, six pictures of washing hands are edited sequentially for the learning target of washbasin. When the autistic child clicks on the washbasin, the pictures of washing hands appears sequentially on the tablet PC.

### 2.3 Sharing the Contents of Scenario Space with Cloud Server

For some specific caretakers of autistic children, e.g. special education teachers, they may repeatedly produce

the same contents of scenario space for each autistic student. The time spent producing scenario spaces can be extremely burdensome. Additionally, some caretaker may not possess sufficient computer knowledge and skills to manage these practice materials. Thus, in this study, AustimSpace employs a cloud server that enables caretakers of autistic children to share their self-produced learning scenarios. As shown in Figure 5, the caretakers can easily and effectively share these self-produced learning scenarios while using AustimSpace.

### 3. Testing of the AustimSpace

AustimSpace is published on the iTunes App Store [15], and the source code of AustimSpace is also pro-



Figure 4. Six pictures of washing hands are edited sequentially for the learning target of washbasin.



Figure 5. AustimSpace employ a cloud server to share the contents of learning scenario for caretakers.

vided as open source [16]. To test AustimSpace, a child psychiatry physician and two parents of autistic children participated in testing the AustimSpace. Subsequently, the physician and the parents agreed that AustimSpace provides the following advantages:

- (1) AustimSpace features comprehensive functions that can achieve the expected effects.
- (2) The editing function of AustimSpace enables caretakers to use scenes, pictures, and videos that are familiar to autistic children to design teaching content for various learning scenarios.
- (3) All pages of the AustimSpace offer corresponding notes, enabling parents to pronounce the words with their children.
- (4) A cloud server is used to share various learning scenarios, reducing the time that caretakers spend editing.
- (5) Children’s concept of space is enhanced.
- (6) AustimSpace features Mandarin Chinese as interface and free downloads for every user, making it highly promotable in regions where Mandarin Chinese is the native language.

To popularize AustimSpace, the field trials were preceded at the Maker Faire Taipei (as shown in Figure 6).

Additionally, we also designed a questionnaire completed by 19 persons to evaluate the user interaction satisfaction of AustimSpace. The content of questionnaire is given as Appendix I. The questionnaire contains five rating scale, the higher score in the scale means that user is satisfied with AustimSpace. Table 1 lists the average scores of the five questions. According the questionnaire results, most users agreed that AustimSpace is effective and useful.

#### 4. Conclusions

In this study, a visualized scenario learning aid for autistic children is developed. The aid assists autistic children in learning how to use daily living equipments or daily living skills in specific scenarios; and employs a cloud server that enables caretakers to share their self-produced learning scenarios. Through the visualized strategy, the developed aid directly links the specific space and its learning objective to enhance the autistic child’s learning outcome. Additionally, users are not required any cost and a specific level of English ability to use the developed aid.

#### Acknowledgments

We would like to thank Dr. Ya-Fen Huang for valuable comments. This work was supported by the National Science Council, Taiwan, R.O.C., under the Grant NSC 102-2221-E-032-041, and MOST 103-2221-E-032 -045.

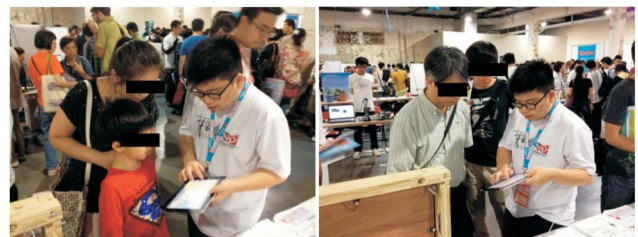


Figure 6. Field trails of AustimSpace in Maker Faire Taipei.

Table 1. The average scores of the five questions in the questionnaire

Question	Average score
I found the various functions in this system were well integrated	4.1
I thought the system was novelty and interesting	3.7
I thought that learning with the videos and pictures were effective	4.2
I found the edition function in this system was useful	4.6
I found the internet function in this system was useful	4.6

## Appendix I

### Questionnaire for User Interaction Satisfaction

Gender:  Male  Female

Age: \_\_\_\_\_

Have you (or your children) used traditional learning material, for example, story books and learning cards?

in the past 6 months  in the past 1 year  in the past 2 year  never

Have you (or your children) used digital learning material?

in the past 6 months  in the past 1 year  in the past 2 year  never

	Strongly disagree								Strongly agree
1. I found the various functions in this system were well integrated	1	2	3	4	5				
2. I thought the system was novelty and interesting	1	2	3	4	5				
3. I thought that learning with the videos and pictures were effective	1	2	3	4	5				
4. I found the edition function in this system was useful	1	2	3	4	5				
5. I found the internet function in this system was useful	1	2	3	4	5				

## References

- [1] Gately, S. E., "Facilitating Reading Comprehension for Students on the Autism Spectrum," *Teaching Exceptional Children*, Vol. 40, No. 3, pp. 40–45 (2008).
- [2] Mower, E., Black, M. P., Flores, E., Williams, M. and Narayanan, S., "Rachel: Design of an Emotionally Targeted Interactive Agent for Children with Autism," *2011 IEEE International Conference on Multimedia and Expo*, pp. 1–6 (2011). doi: 10.1109/ICME.2011.6011990
- [3] Conn, K., Liu, C., Sarkar, N., Stone, W. and Warren, Z., "Affect-Sensitive Assistive Intervention Technologies for Children with Autism: an Individual-Specific Approach," *IEEE International Symposium on Robot and Human Interactive Communication*, pp. 442–447 (2008). doi: 10.1109/ROMAN.2008.4600706
- [4] Cai, Y., Chia, N. K. H., Thalmann, D., Kee, N. K. N., Zheng, J. and Thalmann, N. M., "Design and Development of a Virtual Dolphinarium for Children with Autism," *IEEE Trans. on Neural Systems and Rehabilitation Engineering*, Vol. 21, No. 2, pp. 208–217 (2013). doi: 10.1109/TNSRE.2013.2240700
- [5] Lahiri, U., Bekele, E., Dohrmann, E., Warren, Z. and Sarkar, N., "Design of a Virtual Reality Based Adaptive Response Technology for Children with Autism," *IEEE Trans. on Neural Systems and Rehabilitation Engineering*, Vol. 21, No. 1, pp. 55–64 (2013). doi: 10.1109/TNSRE.2012.2218618
- [6] Weilun, L., Elara, M. R. and Garcia, E. M. A., "Virtual Game Approach for Rehabilitation in Autistic Children," *2011 International Conference on Information, Communications and Signal Processing*, pp. 1–6 (2011). doi: 10.1109/ICICS.2011.6174256
- [7] Robins, B., Dautenhahn, K., Te Boekhorst, R. and Billard, A., "Robotic Assistants in Therapy and Education of Children with Autism: Can a Small Humanoid Robot Help Encourage Social Interaction Skills?" *Universal Access in the Information Society*, Vol. 4, No. 2, pp. 105–120 (2005). doi: 10.1007/s10209-005-0116-3
- [8] Bekele, E. T., Lahiri, U., Swanson, A. R., Crittendon, J. A., Warren, Z. E. and Sarkar, N., "A Step Towards Developing Adaptive Robot-Mediated Intervention Architecture (ARIA) for Children with Autism," *IEEE Trans. on Neural Systems and Rehabilitation Engineering*, Vol. 21, No. 2, pp. 289–299 (2013). doi: 10.1109/TNSRE.2012.2230188
- [9] Konstantinidis, E. I., Luneski, A., Frantzidis, C. A., Costas, P. and Bamidis, P. D., "A Proposed Framework of an Interactive Semi-Virtual Environment for Enhanced Education of Children with Autism Spectrum Disorders," *22nd IEEE International Symposium on Computer-Based Medical Systems*, pp. 1–6 (2009). doi: 10.1109/CBMS.2009.5255414
- [10] Munson, J. and Pasqual, P., "Using Technology in Autism Research: the Promise and the Perils," *Computer*, Vol. 45, No. 6, pp. 89–91 (2012). doi: 10.1109/MC.2012.220
- [11] Kientz, J. A., Hayes, G. R., Westeyn, T. L., Starner, T. and Abowd, G. D., "Pervasive Computing and Autism: Assisting Caregivers of Children with Special Needs," *IEEE Pervasive Computing*, Vol. 6, No. 1, pp. 28–35 (2007). doi: 10.1109/MPRV.2007.18
- [12] Kozima, H., Nakagawa, C. and Yasuda, Y., "Interactive Robots for Communication-Care: a Case-Study in Autism Therapy," *IEEE International Workshop on Robot and Human Interactive Communication*, pp. 341–346 (2005). doi: 10.1109/ROMAN.2005.1513802

- [13] *Autismate* [Online]. Available: <https://itunes.apple.com/us/app/autismate/id512132428?mt=8>.
- [14] Blommaert, A., Philippart, P., Rassaerts, C., Theunissen, E., Widdershoven, S. and Shahid, S., "Day Pad: a Daily Life Assistant for Autistic Children," *Proceedings of the 12th International Conference on Human Computer Interaction with Mobile Devices and Services*, pp. 473–474 (2010). doi: [10.1145/1851600.1851711](https://doi.org/10.1145/1851600.1851711)
- [15] *AustimSpace* [Online]. Available: <https://itunes.apple.com/tw/app/autismspace/id669999299?l=zh&mt=8>.
- [16] *Source Code of AustimSpace* [Online]. Available: [http://mail.tku.edu.tw/chchou/CILAB/Research\\_result/AustimSpace.html](http://mail.tku.edu.tw/chchou/CILAB/Research_result/AustimSpace.html).

***Manuscript Received: May 5, 2014***

***Accepted: Feb. 24, 2015***