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A PILOT STUDY OF THE SITUATED GAME FOR AUTISTIC CHILDREN LEARNING ACTIVITIES OF DAILY LIVING

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Daily living skills are difficult for autistic children to learn because they have low motivation in learning new things. Some research had developed virtual environments to assist parents and teachers in teaching autistic children daily living skills. Educators still need to spend a lot of time in preparing personalized and more realistic tasks for children to practice in the virtual environments. The research team developed a situated game which is capable of generating personalized and non-repeated daily living activities for individual children. A small pilot had designed and conducted for verifying the effectiveness of the game and gathering the users' (including parents and the autistic children) perceptions toward the game and the game-play. Questionnaire and interviews were used to collect user perceptions. While quantitative analysis method (with SPSS) was used to give readers an overview idea of what users felt, thematic analysis (with NVivo) was taken for analyzing interview transcripts and results could be the basis of our game's future improvements. The results show that both of autistic children and their parents all gave positive feedback to the game. Suggestions for the game development for autistic children are also given based on the analysis results of questionnaire and parents' interview.

Keywords: Game-based learning; autism; preadolescence; activities of daily living; situated learning.

1. Introduction

To live independently, people always need to know how to do some activities on their own, such as dressing and bathing. These activities usually have more than one step involved. Take dressing as example, people need to get clothes from closets and drawers first, then they put on clothes, outer garments, and manage fasteners step by step (Iowa Geriatric Education Center, n.d.). These activities are called activities of daily living

(Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963). Activities of daily living are usually developed in our childhood (Pinto & Denucci, 2006). However, parents who have autistic children report that they have difficulty in teaching their children to do the activities of daily living (Koegel & Egel, 1979).

To help autistic children learn the procedure of doing activities of daily living, researchers use photo books and videos (Pierce & Schreibman, 1994; Shipley-Benamou, Lutzker, & Taubman, 2002). Autistic children may make mistakes when they do activities of daily living in the authentic environment. Some mistakes may hurt autistic children themselves, such as cutting their fingers by the broken cup. To make the authentic environment safer to autistic children, Charitos and colleagues (2000) use virtual reality technology to build a virtual house for children learning (Charitos, Karadanos, Sereti, Triantafillou, Koukouvinou, & Martakos, 2000). However, children may have problem in adopting the procedure that they had learned in real life, because the real world may be different from the authentic environment and virtual house. For example, the procedure of "having lunch" activity has six steps: "taking the tableware to the table from the cupboard", "putting foods onto the plate", "feeding yourself", "taking the tableware to the kitchen sink", "washing the tableware", and "putting the tableware back to the cupboard". In the real world, clean dishes are needed for the first step of "having lunch" activity. If there is no clean dish, an autistic child may not be able to apply what he or she learned. Moreover, if the child failed to put the washed dishes back to the cupboard, then he or she may not be able to find the clean dishes and to bring it to the table next time.

The pedagogical methods used in the previous research are fixed and educators may need to do a lot of extra works to have every situation considered in their materials to teach the autistic children. The research team designs a web-based Flash educational game which can generate activities automatically to give children immersive learning experience based on the time in the game world as well as the object's status, for example, it would be weird to ask children to do "having breakfast" activity in the noon of a day in the game; or to ask children to "clean dinning table" when there is nothing on the table. To reach the goal, the research team first analyzes the attributes of activities of daily living and uses final state automata to store and represent the relations among activities, and rough set to classify and represent activity relevant objects (Chang, Kuo, Lyu, & Heh, 2012). Secondly, with the help of fuzzy theory and self-designed weighting measures, the research team is capable of designing a mechanism for picking up most appropriate activity for the players (i.e. the autistic children) according to the time in the game and all objects in the virtual world. This mechanism not only makes children practice what they have learned, but also gives them opportunities to see more real situations which are either caused by incomplete procedure they had done previously or being realistic scenario as real world has. Their ability of doing activities of daily living can be sharpened further by having such chance to apply every possible skill that they have learned to solve real world complex situation.

A small pilot is conducted and used to verify the acceptance and appreciation that autistic children and their parents may have toward the proposed game. Four children, one female and three male students, from 4th grade to 7th grade and their parents are recruited in this pilot. This paper starts with some important background of educational games and quantitative and qualitative research approach. Section 3 briefly introduces the method of generating activities of daily living in the game that the research team designed. Section 4 talks the game itself and uses an example to give readers better idea of the game-play. The pilot design and the data collection method are explained in Section 5. Section 6 reveals the research results. At the end, Section 7 briefly discusses the findings and makes a simple conclusion.

2. Background

2.1. *Game-based Learning*

More and more games are designed for teaching and learning in the last decade (Anderson & Barnett, 2013). The research in Kovačevića, Minovića, Milovanovića, de Pablosb, and Starčevića (2013) shows that educational game can raise students' curiosity in learning. Students can learn in a friendly environment (i.e. game) if the game is designed for specific subject or skill (Gee, 2003; van Eck, 2007). Furthermore, some research finds out that educational games can help students learning complex contents (Garris & Ahlers, 2001; Honey & Hilton, 2010; Ricci, Salas, & Cannon-Bowers, 1996). For example, Kalloo and Mohan (2012) use mobile educational games to teach algebra, and Rodriguez, Kerby, and Boyer (2013) design computer game to teach programming language.

There are many different game genres, including simulation, strategy, action, and role-playing (Novak, 2011). This research aims to use computer game to help autism training their daily-living skills for activities in the real world. For achieving this objective, the research team chooses to develop a simulation game. Klabbers (2009) has also pointed out that game can be used to simulate a certain social system. A social system model is proposed for this research as Table 1 shows.

- Actors: the social actors in this research are the autistic children.
- Rules: the rules that the proposed game simulates and the actors use in the social system are the procedures of activities of daily living.

Table 1. Relation between the proposed game and social system.

Social System as Reference System	Game	Examples
Social actors, agents, social organization	Actors (i.e. players of the game)	Autistic child
Laws, customs, codes of conduct	Rules	Procedures of activities of daily living
Resources (renewable/nonrenewable resources, infrastructure, etc.)	Resources	Movable pictures of objects used in the daily living

- Resources: the resources that the proposed game has and the actors can use in the social system are movable pictures of real objects used in the daily living.

2.2. *Theoretical model of experiment*

To evaluate the game designed in the research, some theoretical models are applied to gather autistic children's attitudes toward games and computers as well as attitudes toward the game designed in this research.

2.2.1. *Computer game attitude*

Autistic children's attitude toward computer game is important for this research. If they are interested in computer games, they might have higher motivation of learning activities of daily living with the proposed game. Computer Game Attitude Scale (CGAS) developed by Chappell and Taylor in 1997 has three subscales: anxiety, liking, and confidence. Some researchers have revised Chappell and Taylor's CGAS to add their own subscales. This research uses CGAS designed and altered by Chen (2010) and Liu, Lee, and Chen (2013). Chen (2010) has added three other subscales and his revised CGAS has six subscales: anxiety, liking, confidence, learning, leisure, and behavior.

2.2.2. *Computer anxiety*

Another attitude toward computers we would like to know is computer anxiety. Computer anxiety is an affective response of someone's feelings of nervousness, intimidation, and hostility while using computers (McInerney & McInerney, 1994). If autistic children have higher anxiety toward computer, they might have lower motivation on learning activities of daily living through the game. Chen (1998) has developed a questionnaire to understand the computer anxiety of students in vocational high school. Shen (2002) also has designed a questionnaire to examine the computer anxiety that elementary school teachers have. This research adopts Chen's and Shen's research for autistic children.

2.2.3. *Computer self-efficacy*

Self-efficacy indicates how confident someone is in his/her ability and skills (Kinzie, Delcourt, & Powers, 1994). Computer self-efficacy reflects individual's belief of capability of using computers (Compeau & Higgins, 1995). Prior research has shown that computer self-efficacy can influence individuals' learning efficiency by using computer (Francescato, Porcelli, Mebane, Cuddetta, Klobas, & Renzi, 2006; Wu, Tennyson, & Hsia, 2010). This research uses the questionnaire designed by Wong (2000) to collect autistic children's computer self-efficacy.

2.2.4. *Digital literacy*

Digital literacy is "*the ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers*" (Gilster, 1997). Autistic children's digital literacy may also influence their usage of the game. The lower digital literacy the children may need to spend more time on figuring out how to play this game then learning activities of daily living. Furthermore, the design of educational game for autistic children with different digital literacy levels may also be dissimilar. Lower digital literacy children may need easier user interface.

Though Gilster (1997) doesn't list the skills or competencies the digital literacy should have, many researchers have developed specific skills for describing the digital literacy. For example, Larsson (2002) has designed digital literacy checklist and has identified the three major abilities: "keyboard, mouse and related skills", "desktop competencies", and "internet competencies." This research uses the questionnaire altered by Tsai (2003) based on Larsson's research.

2.2.5. *Computer coping strategies*

Autistic children's attitudes toward computer may influence their coping strategies when they meet problems of using computers. Ropp (1999) has proposed Computer Coping Strategies scales to measure teachers' coping process. The scale measures eight categories of coping strategies based on Folkman and colleges' research (Folkman, Lazarus, Dunkel-Schetter, DeLongis, & Gruen, 1986). The eight categories are confrontive, distancing, self-controlling, seeking social support, accepting responsibility, escape, avoidance, planful problem solving, and positive reappraisal. This research uses Hsieh's research which is adopted from Ropp's research (Hsieh, 2001; Yang, Hsieh, & Chen, 2011). The questionnaire is used to measure four coping strategies: planful problem solving, distancing, seeking support, and escape-avoidance.

2.2.6. *Technology Acceptance Model*

Technology Acceptance Model (TAM) questionnaire introduced by Davis and colleges (1989) is used for collecting the autistic children and their parents' perceptions toward the game. Many studies use TAM to exam users' acceptance toward technological systems, such as Web-based instruction system (Chen, Lin, Yeh, & Lou, 2013) and electronic portfolio system (Shroff, Deneen, & Ng, 2011). This research uses TAM for collecting the following perceptions that both of the children and their parents have:

- Perceived usefulness: does user believe if the system could help him or her improve his or her job performance (Davis, 1989)?
- Perceived ease of use: does user feel easy while using the system (Davis, 1989)?
- Perceived enjoyment: does user think the system is playful (Moon & Kim, 2001)?
- Social influence: is user's acceptance behavior influenced by others (Venkatesh, Morris, Davis, & Davis, 2003)?
- Behavior intention: does user have intention on using the system continuously and have intention on introducing the system to others (Davis, 1989)?

3. In Game Activity Generation

The relationships among activities of daily living can be presented by a finite state automaton as Figure 1 shows. During weekdays, we "have lunch" after "breakfast". If the day is Wednesday, the next activity of "having lunch" is "cleaning living room". After reaching the state of "going to sleep", the machine will go back to the initial state of the automaton, i.e. "having breakfast".

To accomplish an activity of daily living, children must do a series of tasks, i.e. the procedure of doing activity of daily living. For example, children have to "wash hand" first according to the procedure of "having breakfast" activity. After that, they have to "prepare the tableware" before having breakfast on the table and "clean the table" after they finish their breakfast. Once the children complete all tasks in the procedure, the activity is considered complete and they are ready to do another activity.

Each task in the procedure will change the object status in the game world as it always does in the real world. Each object in the procedure has its required final-status for completing the activity. For example, the fork has to be clean and placed on the table for "having breakfast". And yes, an activity may cover more than one stage such like "prepare tableware", "clean the table", and "wash the dishes" in the "having breakfast" activity.

Figure 2 shows the flow of object's status changes during the game-play. At very beginning, the game generates objects randomly including their status and location. The children are supposed to make all objects' status right as the final-status requirement on the right of Figure 2 shows. The example is about preparing tableware for a meal. In order to have clean tableware for the meal, the children need to wash the bowl and put the bowl back on the table and to take the spoon from the cupboard to the table. At the end, the objects' status and locations are used for next quest.

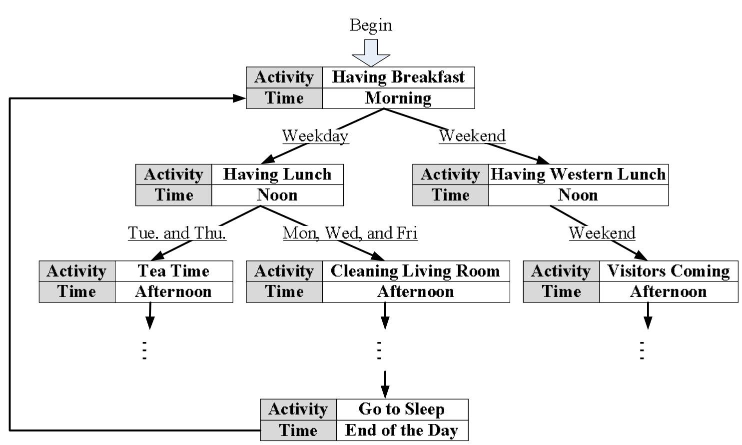

Figure 1. Finite state automaton presents the activities of daily living.

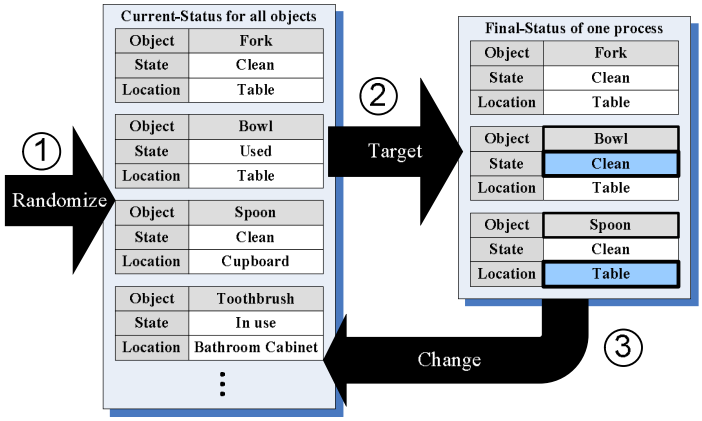

Figure 2. Example of random-status of all objects and final-status requirement of "prepare tableware" stage.

With the help of finite state automaton and required object's final status settings, we can store the activities of daily living and provide children with opportunity to see personalized activities of daily living in the game world. There are two problems for transforming the activities of daily living in Figure 1 to digital game system. First, it is linguistic variable for representing the time of activity (e.g. morning), which is different from the numeric variable (e.g. 8:00) used in the computer system. On the other hand, there might be more than one activity that the children can do as follow-up activity.

The research team uses fuzzy set to solve the linguistic time variable issue. Take Figure 3 as example. There are four important time points for an activity: usually start

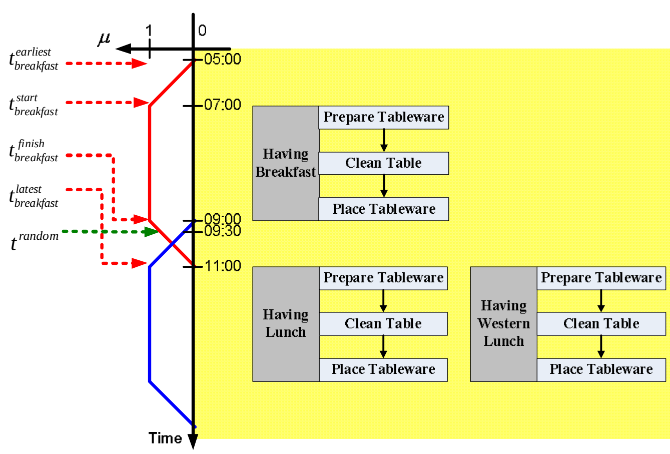

Figure 3. Time-based activities of daily living and its fuzzy membership functions.

time, usually finished time, earliest start time, and latest finished time. Example in Figure 3 shows that children usually have their breakfast before going to school; therefore, the usually start time for "having breakfast" activity is 7:00 AM and the usually finished time could be 9:00 AM. Some families with elders might get up earlier and have their breakfast in the early morning; therefore, the earliest start time for "having breakfast" activity could be 5:00 AM. If autistic children get up late or have had some trouble when having breakfast, they may finish their breakfast before noon; therefore, the latest finish time for "having breakfast" activity is 11:00 AM.

To choose the follow-up activity, this research uses the time in the game world as a trigger and uses fuzzy membership function value to weight activity candidates to decide which activity should be chosen as the follow-up activity (Ross, 1997, p.9). Taking Figure 3 as example, with the definition of time points, the fuzzy membership function can be defined as

$$\mu_i(t^{random}) = \begin{cases} \dfrac{(t^{random} - t_i^{earliest})}{(t_i^{start} - t_i^{earliest})} & , where\ t_i^{earliest} < t^{random} < t_i^{start} \\ \dfrac{(t_i^{latest} - t^{random})}{(t_i^{latest} - t_i^{finish})} & , where\ t_i^{finish} < t^{random} < t_i^{latest} \\ 1 & , where\ t_i^{start} < t^{random} < t_i^{finish} \\ 0 & , where\ t^{random} > t_i^{latest}\ or\ t^{random} < t_i^{earliest} \end{cases}$$

If the time in the game is randomly generated as 9:30 AM, then the fuzzy value of the time for "having breakfast" activity is

$$\mu_{breakfast}(9:30) = \frac{(11:00 - 9:30)}{(11:00 - 9:00)} = \frac{90\text{mins}}{120\text{mins}} = 0.75$$

Similarly, because the time is also in-between the earliest start time ($t_{lunch}^{finish} = 9:00$) and the usually start time ($t_{lunch}^{latest} = 11:00$) of "having lunch" activity, the fuzzy value of the time for "having lunch" activity is

$$\mu_{lunch}(9:30) = \frac{(9:30 - 9:00)}{(11:00 - 9:00)} = \frac{30\text{mins}}{120\text{mins}} = 0.25$$

Beside the use of time-based fuzzy membership values for generating activities, the game needs to take "learning" into consideration while generating activities for the autistic children. The game's goal is to help autistic children learn how to do activities of daily living, so it would be meaningless if the game picks up an activity that the children don't need to learn further.

With the help of rough set theory (Pawlak, 1982), we are able to categorize all objects into three sets - positive set, boundary set, and negative set – according to object's status and activity's requirement as Figure 4 shows. Objects in the positive set meet the required condition of the activity; the objects in the negative set mean their status doesn't meet the activity requirement.

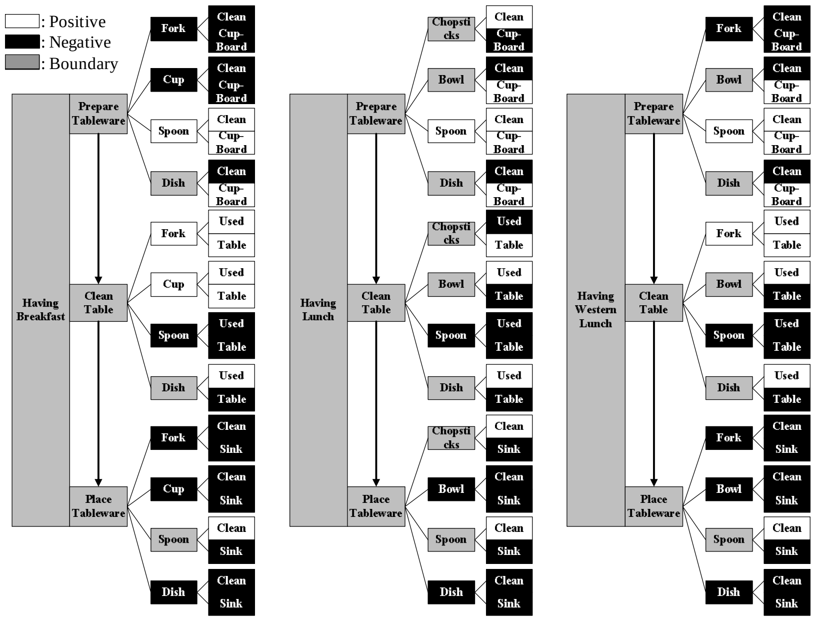

Figure 4. Categorizing objects into three sets based on its status and activity requirements.

In such case, we can count how many negative and boundary set items that each activity at particular stage has and can know how complex the activity would be for children to complete. The objects used at "prepare tableware" stage are fork, cup, spoon, and dish as Figure 4 shows and can be denoted as $O_{prepare\_tableware} = \{o_{fork}, o_{cup}, o_{spoon}, o_{dish}\}$ and the number of objects used is $|O_{prepare\_tableware}| = 4$. We use condition-pair in the game to present an object's status requirements at the end of particular stage of an activity. For example, the status requirement of "dish" is

$$C_{dish}^{prepare\_tableware} = \{(\text{state, clean}), (\text{location, cupboard})\}.$$

It means the dish should be clean and be placed in the cupboard at the end of "prepare tableware" stage.

We also define the condition-pairs for object k at time t as CT_k^t. At time t, the set of object's status which meets the requirement at the end of jth stage is the intersection of C_k^j and CT_k^t:

$$CX_k^j = \{c \mid c \in C_k^j \cap CT_k^t\}$$

For example, when autistic children play the game, the dish is dirty and placed in the cupboard. The condition-pairs for the "dish" at that time is $CT_{dish}^t = \{(\text{state, dirty}), (\text{location, cupboard})\}$. To finish the "prepare tableware" stage of "having breakfast" activity, the dish should be clean and put in the cupboard. Therefore, the intersection of

$C_{dish}^{prepare\_tableware}$ and CT_{dish}^{t} is $CX_{dish}^{prepare\_tableware} = \{(\text{location, cupboard})\}$, which means the number of requirement fitted condition-pairs for the "dish" is $\left|CX_{dish}^{prepare\_tableware}\right| = 1$.

With the defined notations, the similarity of object conditions between time *t* and the end of *j*th stage is

$$M_j = \sum_{k}^{|O_j|}\left(\frac{\left|CX_k^j\right|}{\left|C_k^j\right|}\times\frac{1}{\left|O_j\right|}\right)$$

Take the "prepare tableware" stage in Figure 4 as example. There are four objects used at the stage and each object has two condition-pairs. The similarity for the "prepare tableware" stage is

$$M_{prepare\_tableware} = \frac{0}{2}\times\frac{1}{4}+\frac{0}{2}\times\frac{1}{4}+\frac{2}{2}\times\frac{1}{4}+\frac{1}{2}\times\frac{1}{4}=\frac{3}{8}$$

Using this formula, we can find similarity values for all activities. At the end, we use the fuzzy membership value as a coefficient parameter to calculate the complexity for children to complete an activity at time *t*. For example, the complexity for children to do the following three activities at 9:30 AM in the game world is

$$w_{breakfast}(9:30) = 0.75\times(\frac{3}{8}\times\frac{1}{3}+\frac{5}{8}\times\frac{1}{3}+\frac{1}{8}\times\frac{1}{3}) = 0.28125$$

$$w_{lunch}(9:30) = 0.25\times(\frac{5}{8}\times\frac{1}{3}+\frac{3}{8}\times\frac{1}{3}+\frac{2}{8}\times\frac{1}{3}) = 0.10417$$

$$w_{western-lunch}(9:30) = 0.25\times(\frac{4}{8}\times\frac{1}{3}+\frac{3}{8}\times\frac{1}{3}+\frac{1}{8}\times\frac{1}{3}) = 0.08333$$

Therefore, the game could pick-up appropriate activity for the children accordingly, i.e. "having breakfast" activity in this case.

4. The Game-Play

With the proposed activity generation mechanism, the research team uses Flash ActionScript 3.0 to develop situated game which automatically generates personalized quests for the children (i.e. particularly the autistic children in this research). Before children start to play the game, they can select the scene they are interested in, such as at home or in school. Figure 5 is the snapshot of scene selection.

Figure 5. The screenshot of choosing a scene to play.

After children select the scene, the game randomly generates and places objects in the game world. The game as also generates the in-game time so it can calculate the time-based weights for all activities and picks activity candidates by ignoring those activities whose time-based weight value is zero. For those activity candidates, the game further measures its complexity according to the current status that associated objects have. At the end, the game chooses one activity from the candidates and uses it as a quest for the children to complete as Figure 3 shows. Due to the time and the object status are randomly generated when the children first play the game, everyone may receive different quests even they play the game together and start the game at the very same moment.

The game is developed by Flash ActionScript 3.0 and accesses to mySQL database via Java Server Pages. The mySQL database stores eleven activities involved in four rooms: dinning room (with kitchen), living room, bedroom, and washroom. Figure 6 shows “Clean Table” stage for one of a “dinning” activity happens in the dining room.

Figure 6. An activity in the dinning room.

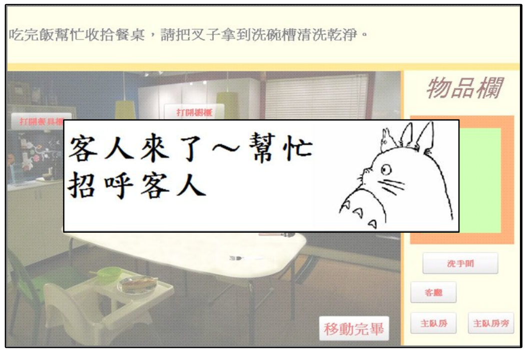

Figure 7. Animation alert for telling the children what is next.

The activity description is shown in area A of Figure 6, which asks the children to bring the fork to the sink in the kitchen and wash it. The dinning room is shown in area C of Figure 6, in which some moveable objects like spoons and forks are there. If the children want to go to the other rooms, they can click either the buttons with room name on it in area D of Figure 6 or the adjacent room button (i.e. button E on Figure 6) at left hand side of the main screen. The children can drag and drop objects from one place to another within this room directly. If they want to move objects from this room to another, they need to bring the objects with them while going to another room by first drag and drop the objects to area B of Figure 6.

When the children complete the activity, they can click button F on Figure 6 to notify the game that they are done. The game will then determine if the actions the children have done are correct. If they have done it not right, the game will play an audio clip to tell them they are wrong. On the contrary, the audio clip will tell them they did a very good job if they have done it right. The game will also show them an animation as transition to alert them next event and to prepare them for doing next activity. Figure 7 is an animation which tells the children that a guest is coming and asks them to help their parents take care of the visitor.

5. Pilot Study

5.1. *Pilot design*

The research team had done a small pilot to verify if the game is helpful and appreciated for the autistic children and their parents. To make the children feel comfortable while playing the game, the game-play location was their home. The pilot spent four weeks and the tasks in every week are listed in Table 2.

Table 2. Tasks in every week.

Week	Tasks	Spending Time
1	• Parents sign consent letter	N/A
	• Children do the pre-test	30 mins
	• Parents help children fill questionnaire	N/A
	• Introduce the game to parents and children	30 mins
	• 1st game play	60 mins
2	• 2nd game play	30 mins
3	• 3rd game play	30 mins
4	• 4th game play	30 mins
	• Children do the post-test	30 mins
	• Parents fill questionnaire	N/A
	• Parents help children fill questionnaire	N/A
	• Interview with parents	N/A

The consent form was signed by parents in the first week before we started the pilot. In the consent form, we explained the pilot purpose, gaming time length, and the required gaming environment. Children then were asked to answer 15 multiple-choice questions which associate with the activities of daily-living as the pre-test in 30 minutes. Furthermore, they are asked to fill a questionnaire which includes five parts - demographics, computer game attitude, digital literacy, computer anxiety, and computer coping strategies. Due to autistic children sometimes might require help in filling questionnaire, parents were asked to be with them all the time during the pilot. After the children filled questionnaire, we gave the children and their parents a user guide of the game play and did live demonstration on how to play the game for 30 minutes. In the first round of game play, autistic children were accompanied with parents and researchers. Figure 8 shows the photo when the research assistant taught one of the autistic children and his father. Because it is their first time to play the game, the first round of the game play was set to 60 minutes to help them get familiar with the game environment. Children

Figure 8. A photo of researcher teaching autistic children and his parent playing the game.

were asked to take a break every 15 or 20 minutes. In the followed rounds of the game play, they played the game only for 30 minutes each round. Moreover, parents and researchers were asked to not help the children but only to watch their game-play.

After the last round of game play, the children were asked to take the post-test in which all items were exactly same as the pre-test but in different order. Also, both of parents and children were asked to fill in a questionnaire regarding their acceptance of such game. We conducted interviews with parents after to get more detailed perceptions and suggestions toward the game and the effectiveness of improving children's ability of doing activities of daily living.

5.2. *Questionnaire filled in the first week*

The children were asked to fill a questionnaire at very beginning to help us understand their background. Besides the demography information, the questionnaire had five parts for getting children's attitude toward computer games, their anxiety of using computer, their digital literacy, and their strategy of computer coping.

5.2.1. *Computer game attitude*

The items in the computer game attitude part were adopted from previous research results and its validity and reliability had been proven (Chappell & Taylor, 1997; Chen, 2010; Liu et al., 2013). Five factors including anxious, liking, leisure, confidence, and learning factors were chosen from the original research (Chen, 2010). This part had twelve five-point Likert scale items (5 for "strongly agree" to 1 for "strongly disagree").

5.2.2. *Computer anxiety*

The items in the computer anxiety part were adopted from the research of Shen (2002) and Chen (1998). Twelve five-point Likert scale items were chosen to be included in the questionnaire by eliminating items which were not for autistic children.

5.2.3. *Computer self-efficacy*

Four five-point Likert scale items suitable for autistic children were selected from Wong's research in 2000.

5.2.4. *Digital literacy*

The items in the digital literacy part were adopted from Tsai's research in 2003. Eight competencies including digital tools operating, self-learning, critical thinking, the use of Internet, information organizing, the use of application software, communication and collaboration, and digital creation and appreciation competencies were chosen from the original research. This part had thirty-two five-point Likert scale items.

5.2.5. *Computer coping strategies*

The items in the computer coping strategies part were adopted from Hsieh's research in 2001. Four factors include planful problem solving, distancing, seeking support, and escape-avoidance factors were chosen from the original research (Hsieh, 2001; Yang, Hsieh, & Chen, 2011). This part had eleven five-point Likert scale items.

5.3. *Questionnaire filled in the last week*

Two methods were used for evaluating the effectiveness of the game. The first method was to compare the performance difference that the children had in the pre-test and the post-test. Both of tests had fifteen multiple-choice items associated with the daily-living abilities, for instance, "what we should do before having breakfast? a) playing video games; b) making the bed; c) washing hands; and, d) cleaning up the desk". All items in both of the pre-test and the post-test were same but in different order.

The second method was the use of Technology Acceptance Model scales. The questionnaire was adopted from previous research (Davis et al., 1989; Moon & Kim, 2001; Venkatesh et al., 2003). Five factors including perceived usefulness, perceived ease of use, behavior intention, perceived enjoyment, and social influence factors were chosen from the original research. The questionnaire had twenty-six five-point Likert scale items. We asked both of parents and children to fill this questionnaire at the end of the pilot. The only difference between the questionnaires for children and for parents was the removal of the social influence factor in the parents' one.

6. Results

6.1. *Demography*

Four parents had signed the consent form and agreed to join the pilot. All autistic children including three boys and one girl were living at Taoyuan County, Taiwan. The three boys were in mild symptom degree and the girl was in moderate symptom degree. All children used computer in school and at home and had experience of playing computer games. Only Child D treated the use of computer as a leisure activity. Table 3 shows the demography information of the children.

Table 3. The demography of the autistic children.

	Child A	Child B	Child C	Child D
Gender	Male	Male	Female	Male
Grade	5th-grade	4th-grade	7th-grade	6th-grade
Symptom degree	Mild	Mild	Moderate	Mild
Can use computer besides school	Yes	Yes	Yes	Yes
Have played computer games	Yes	Yes	Yes	Yes
Using computer is one of the leisure activities	No	No	No	Yes

Table 4. The computer game attitude of the autistic children.

Factors	Child A	Child B	Child C	Child D
Anxious	5	5	5	2
Liking	3	3	1	5
Leisure	4	4	5	3
Confidence	3	2.5	2	5
Learning	5	2.5	1	5

6.2. *Computer game attitude, computer anxiety, and computer self-efficacy*

Table 4 shows the statistics results of children's computer game attitude in different factors. Child C doesn't like playing computer games and doesn't have confidence in playing computer games. Both of Child B and Child C don't believe that computer games could help them in learning.

Higher value a child has for his or her computer anxiety level, he or she is more anxious while using computer. We can see that only Child C has middle level of anxiety toward the use of computers. On the other hand, Child D has highest computer self-efficacy level and Child B has lowest level. Table 5 lists the statistics.

Table 5. The children's computer anxiety and self-efficacy level.

Factors	Child A	Child B	Child C	Child D
Computer anxiety	1.08	1.5	3	1
Computer self-efficacy	2.5	1	3	5

6.3. *Digital literacy*

Table 6 lists the results of children's ability of using computer technology. We can find

Table 6. The children's digital literacy competencies.

Factors	Child A	Child B	Child C	Child D
Digital tools operating competencies	1.45	1.55	1.73	5.00
Self-learning competencies	2.00	1.00	1.00	5.00
Critical thinking competencies	1.00	1.00	1.00	3.00
Internet competencies	2.75	1.25	2.00	5.00
Information organizing competencies	2.33	1.00	1.00	5.00
Application software competencies	1.00	1.80	1.80	5.00
Communication and collaboration competencies	1.00	1.00	1.00	5.00
Digital creation and appreciation competencies	1.00	1.00	1.00	5.00
Average	**1.56**	**1.34**	**1.50**	**4.88**

Table 7. Average value of examinees' computer coping strategies.

Factors	Child A	Child B	Child C	Child D
Planful Problem Solving	1	1	1	5
Distancing	1	1	1	5
Seek Support	3.7	1	3.7	3
Escape-Avoidance	2	1	2	1.5

out that Child D has highest digital literacy and Child B has lowest one. This result is consistent with their self-reported self-efficacy in using computers.

6.4. *Computer coping strategy*

The children's computer coping strategies results are listed in Table 7. We can find that Child D prefers to use positive strategies (such as Planful problem solving and Distancing strategies) than the passive ones. On the other hand, Child A and Child C prefer to seek for supports rather than solving problems by themselves. Child B has low motivation on solving problems and has low scores in all types of strategies.

6.5. *Behavior improvement*

To exam the autistic children's improvement in terms of understanding the activities of daily living after they play the proposed game, we compare the performance difference between their pre-test and post-test results. Table 8 lists the performance differences that the children had. Child A, B, and D are mild symptom degree autistic children who has less problem on their daily-living skills and the test results show the same. Child B and D have full marks in both of the pre-test and the post-test. Child A's performance is improved as he gets full marks for the post-test. The only child who has moderate symptom degree is Child C, and she gets half of marks for the pre-test. After playing the game, she also performs well and has great improvement for the post-test at the end of the pilot. With these results, we find that the game does help autistic children learn the activities of daily-living.

6.6. *Technology Acceptance Model*

We asked both of the children and their parents to fill the Technology Acceptance Model questionnaire in the last week. Table 9 lists the statistics of their acceptance degrees

Table 8. The performance difference between pre-test and post-test results.

Factors	Child A	Child B	Child C	Child D
Pre-test	12/15	15/15	7/15	15/15
Post-test	15/15	15/15	12/15	15/15
Improvement	+3	0	+5	0

Table 9. Technology acceptance degrees toward the game.

Factors	Child A (& parents)	Child B (& parents)	Child C (& parents)	Child D (& parents)	Average
Perceived Usefulness	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	3.0 (5.0)	4.5 (5.0)
Perceived Ease of Use	5.0 (5.0)	3.3 (2.8)	5.0 (5.0)	5.0 (5.0)	4.6 (4.5)
Perceived Enjoyment	5.0 (5.0)	4.0 (5.0)	5.0 (5.0)	3.3 (4.3)	4.3 (4.8)
Social Influence	3.9 (--)	4.1 (--)	3.0 (--)	2.1 (--)	3.3 (--)
Behavior Intention	5.0 (5.0)	5.0 (5.0)	5.0 (5.0)	3.0 (5.0)	4.5 (5.0)

toward the game. Almost all parents perceived very positive for the technology acceptance factors, which shows the game is highly accepted by the parents. Only Child B's parents perceived not easy to play the game which is consistent with what Child B's perceived.

Beside Child D, the other three children perceived high usefulness, enjoyment, and behavior intention very much. On the other hand, Child B is the only one who perceived medium level of ease of use toward the game.

6.7. *Interview analysis*

At the end of the pilot, we interviewed the parents. We used NVivo 10 to analyze the interviews with thematic coding of four major themes – children's learning situation in school (LS), children's computer experience (CE), children's behavioral improvement after playing the game (IMP), and parents' comments to the game (PC). The parents' comments theme has two sub-themes which are positive comments to the game (PC_POS) and suggestions for the game improvement (PC_SUG). Table 10 lists the coding.

Regarding the children's learning situation in school (LS), Child B and Child C easily lost their attention when they were studying in school. Parents needed to accompany with them in school. Child A and Child B had problem in learning new things, especially when they felt the things they need to learn is difficult. Only Child D had positive attitude toward learning new things. Table 11 summarizes the children's learning situation in school.

Table 10. Codings for interview analysis.

Code	Description
LS	Children's learning situation in school
CE	Children's computer experience
IMP	Children's behavioral improvement after playing the game
PC	Parents' comments to the game
PC_POS	positive comments to the game
PC_SUG	suggestions for the game improvement

Table 11. Children's learning situation in school.

	Child A	Child D	Child C	Child D
Attention		−	−	
Learning New Things	−	−		+

−: negative attitude; +: positive attitude;
blank means the parents didn't mention the character of children

All children had experience of using computer (CE). Child A used computer at home only when parents asked him to check the weather of tomorrow and he also had computer class at school. Both Child B and Child C had computer therapy in the hospital, and Child B enjoyed playing computer games. Child D liked to play computer games at home, and his father put time limits on his game-play. Table 12 summarizes children's computer attitude and where they used the computer according to their parents.

Though the parents of Child B told us that Child B has positive attitude toward computer games:

> *... The hospital uses quiz games to train his attention. So, he would have great attention when he uses computer to learn.*

We has observed that Child B didn't pay much attention to the game and his computer game attitude scale showed that he was very nervous toward computer games and had less confidence in playing computer games as the results listed in Table 4.

On the other hand, Child A also showed us his anxiety toward the computer games and little confidence in playing games, which was consistent with his parents' perception. However, he believed that computer games could help him learn and we did observe he focused on the game during the experiment very much. Child D perceived the game differently from other children in terms of his technology acceptance toward the game as Table 9 listed. The possible reason might be Child D had highest digital literacy and had ability to find more attractive games from Internet on his own. This assumption might be true due to his parents told us that:

> *... He likes to play computer games in his free time every day. He also plays some simple online games at home.*

Table 12. Children's computer experience.

	Child A	Child D	Child C	Child D
Computer (Game) Attitude	−	+		+
Computer Using Location				
Home	✓			✓
Hospital		✓	✓	
School	✓			

−: negative attitude; +: positive attitude;
✓: has computer using experience in the location;
blank means the parents didn't mention the character of children

Regarding children's behavioral improvement after playing the game (IMP), Child A's parents said:

> *... After playing the game, Child A sometimes helps me prepare or clean the objects which have been seen in the game.*

Child B's and Child C's parents also told us that their children had better sentence comprehension after playing the game.

All of the parents gave us positive feedback toward the game (PC_POS). Both of Child A's and Child D's parents believed the game could help their children learn activities of daily living at home. Child D's parents said:

> *... This system may be too easy for him, but I think this system is good for him to learn daily life activities.*

Child C's parents told us more specific about why they liked the game:

> *... Sometimes her teacher would teach her and other children in the class to wash dishes or other real things. That might be a little dangerous for her and some other parents have the same concern. Using this system is very safe for her learning daily life activities.*

Child B's parents also hoped the research could be continued and used to train their child in the future.

Parents also gave us some suggestions to improve the game (PC_SUG). Parents of Child B and Child C wished the game could have more situations. Child D's parents also suggested that:

> *... This game might have questions in different levels for different children.*

Child C's parents also enlightened us in terms of designing games for autistic children:

> *... Some autistic children often accompany with bad eyesight. For this reason, I hope that the system could have bigger words and larger pictures. That could be much better for autistic children.*
> *... The pictures of the system also could be designed simpler for autistic children to recognize.*

7. Conclusion

Some findings were found from the data and some suggestions were summarized based on the interview results.

7.1. *Findings*

7.1.1. *The effectiveness of the game is positive*

Children's understanding of activities of daily living is improved after playing the game. Child A and Child C who didn't get full marks in the pre-test were getting better marks in the post-test after the game-play. Parents and children all perceived positively according to their TAM questionnaire responses. Although both of Child B and his parents rated the ease of use of the game low, considering Child B is the youngest in the pilot with lowest digital literacy competencies (listed in Table 6) and self-efficacy (listed in Table 5) we may need to consider the design of simpler user interface for younger kids.

7.1.2. *Computer anxiety and digital literacy have negative relationship*

In Table 6, Child D has highest digital literacy and Child B has lowest one. The results are consistent with their computer anxiety listed in Table 5. The children with higher digital literacy may have lower computer anxiety, and the children with lower digital literacy may have higher computer anxiety.

The results are also in line with Beckers and Schmidt's research in 2003. Beckers and Schmidt (2003) have found out that having more computer experiences leads to higher perception of being more computer literacy. Moreover, Beckers and Schmidt's experiment also has revealed the negative relationship between computer experience and computer anxiety. That means people who have more computer experiences also have lower computer anxiety.

7.1.3. *Computer anxiety and computer coping strategies had negative relationship*

In Table 7, Child D prefers to use positive computer coping strategies and others prefer to use passive ones. The results are consistent with their computer anxiety listed in Table 5. Children with lower computer anxiety might prefer to solve problems by themselves, like Child D. Ropp (1999) has also similar experiment result and believes that the computer anxiety has negative relation to computer coping strategies.

7.2. *Suggestions*

7.2.1. *Challenge design*

Challenge is one of the most important factors of game design (Aarseth, 2004). We should consider providing quests at different levels as challenges for children with different abilities in doing activities of daily living. The research results have confirmed this idea. Child D receives full mark in both of the pre-test and the post-test. He also has high digital literacy, self-efficacy and positive computer coping strategies. His parents comment on the game is too easy for him to use and suggest us to have different level quests for different children.

7.2.2. *Simpler user interface design*

During the pilot, Child A sometimes didn't know how to move from one scene to another (e.g. from kitchen to washroom). This phenomenon might be caused by the user interface design. The suggestion made by Child C's parent also points out that autistic children might have bad eyesight problem. The results fit in with Grynszpan and colleagues' research in which they suggest that game design for autistic children should consider their executive dysfunction condition (Grynszpan, Martin, & Nadel, 2008). Research by Tsai and Lin (2011) also supports this point of view and suggests that excessive game elements may cause distraction and pressure to autistic children.

7.2.3. *User manual for children*

User manual is important for autistic children to get familiar with the game. We have observed that Child A took a lot of time in reading the user manual and perceived ease of use the game very positively. Tsai and Lin (2011) also points out that user manual can help children avoid being confused and understand the game rules.

7.2.4. *Design elements for low motivation children*

Child D receives full marks in both of the pre-test and the post-test but shows low intention of using the game. On the other hand, Child B and Child C also easily get lost attention to the game. According to Laarhoven and colleagues' research, video prompting mechanism has higher efficacy to autism than the picture prompting (van Laarhoven, Kraus, Karpman, Nizzi, & Valentino, 2010). Research by Gotsis and colleagues also points out that storytelling can be used when users are first introduced to the system (Gotsis, Piggot, Hughes, & Stone, 2010). These design elements should be integrated in our future research.

7.3. *Brief summary and future works*

This research designed a situated game for autistic children to learn activities of daily living in a leisure environment. The game used finite automata and context-awareness knowledge structure to store and represent activities of daily living. Fuzzy set and rough set theories were applied to design activity generation mechanism. We conducted a small pilot to collect autistic children's perceptions toward the situated game and interviewed their parents to see the effectiveness of the game. The results showed that all autistic children and their parents perceived the game positively. According to the parents' suggestions, we could improve the game by providing children quests at different difficulty levels. Also, the integration of attractive game design elements such as storytelling or intelligent agents could be helpful and were considered as future research directions.

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