ISBN: 978-989-8533-63-0 © 2017

PHYSICAL INTERACTIVE GAME FOR ENHANCING LANGUAGE COGNITIVE DEVELOPMENT OF THAI PRE-SCHOOLER

Noppon Choosri and Chompoonut Pookao
College of Arts, Media and Technology, Chiang Mai University , 239 Huaykaew Rd., Suthep, Muang, Chiang Mai, Thailand 50200

ABSTRACT

The intervention for cognitive language development is required to conduct at the young ages. As children usually gain the skill through their plays, this study proposed a physical interactive game to help children improve their language skill in both Thai and English language for pre-schooler. The motivation of this research is to create a game that has a characteristic of a toy where children require bodily engagement to touch and move the objects to enhance their cognitive for gaining language skill using interactive and game technologies. The game is evaluated in three methods: paired t-test is used to determine the overall performance of the proposed game; the 90/90 standard evaluation is also applied to see whether if the game is used for formal education majority of the group (>90%) will achieve the objective of learning. Also, the feedbacks from expert validation are collected. All three evaluations method indicate the primary success of the game to assist Thai pre-schooler in improving their skill at the young age.

KEYWORDS

Physical User Interface, Interactive game, E-learning, Education, Language development, Pre-schooler

1. BACKGROUND

Child development test is a measurement conducted to evaluate a development of children in a certain age covered several aspects including language, fine motor, and adaptation, gross motor, personal and social aspects. Several studies indicated that the most occurred development delayed at all times to Thai children is the language development (Voramongkol and Wongdejakul, 2011, Jintana, 2015, Pongpol, 2014).

Developmental problems of children can associate with many problems in their future such as risk of academic failures, behavioural and psychiatric problems, unemployment and economic and social impairment (Bishop, 2014). However, the golden period of language development exists as the brain research indicated that Children would gain biological advantage to learn foreign languages in pre-primary or primary school (Hinton et al., 2008).

A child development in pre-school ages is usually progressed from their activities and parenting. Plays are primary activities of children contributing several aspects to child development such as the cognitive, physical, social, and emotional well-being of children and youth (Goldstein, 2012). Also, many studies have reported that knowledge can be created when children play (Plowman et al., 2010). In addition, a play is a mean to improve language in fun and supportive ways (Jackie M. Oddo et al., 2013).

Nowadays, children are grown up with the new era of Information Technology (IT) and new kind of media and toys. This is inevitably affected the way children are fostered and play. There are several studies showing evidence that interactive digital media can enhance language development skills such as boosting children's vocabulary skills and their acquisition of spelling and reading/writing skills as well as improving word recognition and word creation (Lieberman et al., 2009). The digital media presented as digital toys can both catalysts new form of child play and augment the content of traditional play to bring challenges as well as opportunities to early childhood education (Meyer, 2012). With a bodily engagement, abstraction learning of children can be improved (Resnick et al., 1998). This association with the Piagetian developmental theory

on the manipulation of concrete physical objects in supporting and developing thinking, particularly in young children.

Currently, computer games are widespread plays for children. Education game is a genre of game that has a purpose of offering benefits of child learning development rather than fun. A kind of this games is considered as one of the effective channels that can enhance language learning as they can increase intrinsic motivation, and providing meaningful exposure to the target language (Meyer, 2012). This study is motivated by the study of Hengeveld et al. (2008) where physical interfaces are integrated into the computer game to amplify the advantages to intervene development of toddlers with multiple disabilities. The major benefits of that system to children compared to the familiar PC interface were that it was closer to the usual style of exploration of children and enhancing their concentration (Hengeveld et al., 2008). That system also offered the practical benefit to slowed down the interaction of children with computer interface and creating the human-to-human interventional environment between children and caregivers (Hengeveld et al., 2008).

Jamil et al. (2012) identified that majority of the current literature on the study of using digital objects for children intervention only based on the cases in Western countries, the little understanding on how children in another part of the globe who are living in different cultural settings interact with digital objects.

The motivation of this study is to implement and investigate the solution of a physical and interactive game that can improve language recognition skill in both Thai and English for Thai pre-schooler at the same time they feel enjoy to play but are not being forced to learn. The rest of the paper is Section 2 review the current research in this area, Section 3 explains the design and implementation detail. Section 4 discusses the method to verify and validate the proposed system and finally, Section 5 is a discussion.

2. RELATED WORKS

Computer games are common plays of children in digital ages. There are some games especially dedicated for language skill development of pre-schoolers. For instance, “My name is Haas” is a game that create a playful learning environment for children aged 3 to 7 having purposes to increase young children’s vocabulary as well as story comprehension and problem solving skills (Schuurs, 2012). “weMakeWords” is a game that has an aim to make children learn to read through motivating stories (Demmel et al., 2011). For example, the mission to save the animal in the game, they are asked to combine alphabetical words or Chinese ideographs out of individual letters (Demmel et al., 2011). Agudo et al. (2007) developed a Web-based adaptive hypermedia system called SHAIEx focusing on the adaptive mechanism of the game that fit user background such as educational level and the psychomotor skills captured from mouse interaction.

Since currently there are several off-the-shelf embedded development platforms i.e. sensors, actuators, and microcontroller and their cost are competitive. They are utilized to generate tangible game interfaces to create toy-like feeling to users. Wang et al. (2014) proposed a StoryCube which is children ‘s storytelling tool in a 3D environment. The tool has a controller integrated several tangible inputs and sensors including button, joystick, RFID, and accelerometer. Another story telling tool called StoryTech offers children a mixed reality environment in which to tell imaginative stories using RFID tags attached to plush dolls (Kara et al., 2014). Hengeveld et al. (2008) explored a language development system for multiple disabilities toddlers aged between 1–4 years. The study demonstrates the evolution of developing three different of tangible interfaces.

3. DESIGN AND IMPLEMENTATION

The important challenge of this research involved designing and implementing a game system for the specific type of users. To be precise, children have limited ability and experience interacting with the computer system. Another challenge is that the game shall lead the user to achieve the aim of improving language recognition skills. The design of the system this are intended to meet these two requirements. In general, the UX/UI design for children follow the guideline of Hourcade (2008) as shown in Table 1.

Table 1. General principle of interactive design for children (Hourcade, 2008)

Interactive design principle
1. Minimize using Text and using Icon instead in particular for children who are pre-literate.
2. Minimize visual complexity of the user interfaces
3. Deploy direct manipulation which is: visibility of objects and actions of interest; rapid, reversible, incremental actions
4. Providing menu for actions
5. Avoid using text-based interaction i.e. typing
6. Choose the most appropriate pointing input device for children
7. If a mouse is used as pointing device, consider the following guideline a. be aware of inaccurate click; b. expect an unexpected click such as "machine gun style" click; c. compound action such drag-an-drop can be a challenge, d. the speed of the curser shall be slow down e. Use only one button or enabling only one button to control the system (the experiment left button is outperformed the right button)

The game developed for this research is entitled "Kid Society". It is functionally designed based on the Developmental Surveillance and Promotion Manual (DSPM). DSPM is one of the most recognized medical batteries for monitoring growth and development for Thai children (MOPH, 2016). The battery covers five areas of developmental monitoring including Gross Motor (GM), Fine Motor (FM), Receptive Language (RL), Expressive Language (EL), Personal and Social (PS) (MOPH, 2016). This research investigates the solution focusing on RL improvement for pre-schooler (children aged from 3-5 years old). DSPM suggests the protocol to practice to gain certain skill together with the guideline to operate them. The training activities of selected skill (RL) for 3-5 year children are indicated in Table 2. They are used to mapped to the game mechanical design of the system.

Table 2. DSPM guideline for receptive language skill evaluation (MOPH, 2016)

RL Skills	DSPM
Continuously perform 2 actions with 2 objects	1. Put 4 items in front of the children in a grabbable distance then asking children to perform 2 actions. 2. Shuffle the items. 3. If children ca not perform the action, change the command **Passed criteria**: child can perform successfully at least 1 out of 3 attempts
Able to differentiate between large and small items	1. Prepare set of items by making sure that all items are not located in the order of size 2. Select the item that has a middle size among the group, then asking a question "which item is larger/smaller than this one?" **Passed criteria**: children can perform successfully at least 2 out of 3 attempts

Able to differentiate between daytime and nighttime	1. Prepare one picture indicated daytime, and one picture indicated night time, then asking a question "which one is depicted a daytime picture?", and "which one is depicted a nighttime picture?" 2. Asking a child to choose 3 times, each time swap the pictures **Passed criteria**: child can perform successfully at least 2 out of 3 attempts
Able to differentiate 8 different colours	1. Prepare 10 coloured blocks, and asking a child to choose each colour of block. When each selection is finished, return that block to its position **Passed criteria**: child can select all colour of block correctly

Regarding there are four objectives to achieve, this research introduces four computer games mapped to each learning objectives of RL skills.

As it was indicated that the game for small children should immerse children to a toy play, one of the important focuses is to build a game interface that has a look and feel the same tone as a toy. A physical interface is tailored for this game by the support of Makey Makey (MakeyMakey) as shown in Figure 1. It has a specification turning everyday objects into touchpads.

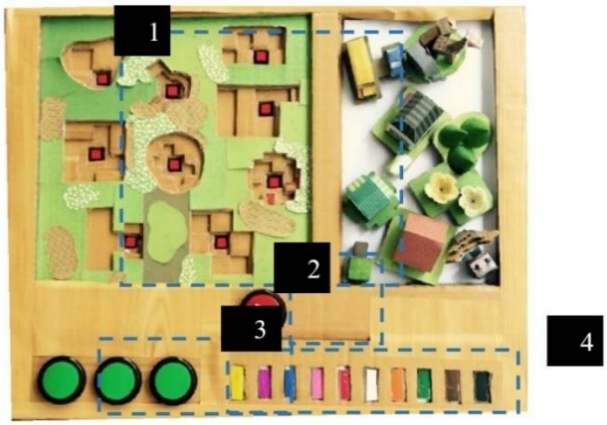

Figure 1. Controller of the game

The developed controller is tailored to operate the four mini games that are designed based on the DSPM guideline discussed in Table 1. There are four types of buttons which are 1) a group of buttons that are embedded to operate as switches to trigger the action when the shapes are located to the correct position, 2) a confirm/forward button,3) a group of buttons to represent the direction (i.e. for Left centre and Right), and 4) a group of buttons for colour section. All buttons are extended their functions from the Makey Makey. Regarding the proposed controller is identical, to make sure that a player can play the game. The tutorial on how to use the controller to play the game is also provided at the beginning of the game.

The game system contains four mini-games designed to associate with the developed controller. In general, the story of the game is progressed through a boy who is designed to have a similar age to players. The boy will challenge a player to perform certain tasks indicated in DSPM using voice instructions. During the play, when a player answers a question/perform the correct action. The applause will be given to a player as a small reward. Otherwise, the encouraging sound will response back to encourage a player to try again. When players can achieve the mission of that mini-game, the game will lead the player to the new game. The interfaces of the four mini-games are illustrated in Figure 2.

Figure 2. Game interfaces

The details of four minigame games are:

Game 1: A player is encouraged to build a town using jigsaw-liked 3D-items representing basic objects and places in everyday life such as car, tree, house, market and zoo. A player will ask one vocabulary at a time, and he/she requires to pick the item to locate in a block. Only correct item can be filled in the block. If a play selects the correct item, a switch located underneath the item will be activated to give a response back by commending players together with repeating the pronunciation of the word in both English and Thai. The physical interface of this game is demonstrated in Figure 3 when a user is asked to locate a bus into a block.

Figure 3. Demonstration of using physical interface in game 1

Game 2.: This game has an objective to encourage children to achieve the identified goal of DSPM in which he/she shall be able to differentiate between the item that has larger and smaller sizes. 3 choices of items are provided on the screen and asking a play which item is larger/smaller than another. The selection will be made by the controller type 3. From Figure 2, the question is asking that "Which item is larger than the ball?"

Game 3: This game has an objective to encourage children to achieve the identified goal of DSPM in which he/shall be able to differentiate between daytime and nighttime. The game will randomly show the picture indicating a nighttime or daytime, and asking children to use type 3 controller to answer the questions. Figure 2 is asking a question that 'which picture is showing a nighttime?'

Game 4: This game has an objective to encourage children to achieve the identified goal of DSPM in which he/shall be able to differentiate 8 colours. 3 picture of things having different colour is shown, a player is asked what colour of the specific item has. A player uses a controller type 4 to answer this kind of questions. Figure 2 is asking a question that "which one has the red colour?"

Another game components include a scoring system to evaluate the performance of players and to test that a child can pass DSPM test. The score can be viewed per mini-games, record a statistic to analyse the progress of learning, and can also share the results to the Facebook to motivate other children/parent and to build up society. The game also has administration menu for the flexibility to expand and adjust the content of the game. The software is designed to allow new vocabulary can be updated to associate with the new tangible items (i.e. in game 1). New pronunciations can also be re-recorded. New graphic can be added as well.

4. VERIFICATION AND VALIDATION

The implementation of this project is under the supervision of the two experts who have the strong experiences about child development. The background of the experts is listed in Table 3.

Table 3. Issue detection and action conducted to improve the system

Qualification	**Expert I**	**Expert II**
Position	Registered Nurse (Experienced level)	Registered Nurse (Operational level)
Academic degree	M.N.S. (Psychiatric and Mental Health Nursing)	B.N. S
Working experience	1) Working at Institute of Child Development 2) 20-year experiences 3) Child development trainer in several Thailand guidelines including TDSI DSPM TEDA 4I	1)Working at Institute of Child Development 2) Child development trainers in several Thailand guidelines including TDSI DSPM TEDA 4I

When the first version of the system was developed, it was then first evaluated by the experts. The comments received from the experts which were used to improve the implementation are:

- The icons in the games shall be larger.
- The pictures indicated nighttime and day time in the game should have more variation and indicate common activities or atmosphere of the famous festival.
- At the result page, it shall not indicate that the result either pass or fail. If the score is lower than the standard it shall indicate the message to encourage children to practice by playing more instead.
- The system shall provide more guideline on which controller shall be used for specific game i.e. showing the picture of the controller to use on the screen.

The verification is also conducted by trying the drafted prototype with the representative of Three to five year's old pre-schooler (1 representing each age). Then, the field observation is conducted to capture the User experience to detect the problems from the design to improve them. The results from the field investigation and the improvement actions are provided in Table 4.

Table 4. Issue detections and actions proceeded to improve the system

Issues	**Actions**
1. For the game 1, a player can select the item correctly, but confuse to locate the block where the selected item is fitted due to the boundary is unclear	1. Make a boundary of each block more obvious using space and colour
2. A child is over-enthusiastic about the game kit when he first saw it, he is distracted by the game items before the game can start	2. Modify the game package to have a cover sheet such that a caregiver control opening the box when a child is ready.
3. Sometimes a child cannot pick up words and cannot manage to repeat the word in time	3. Slow down the speed of the game especially the speech
4. A child has a difficulty to reach a far-end of the controller	4. Adjust position of buttons so that small children can reach them all

After the modification was made from the verification procedure, the evaluation was conducted at the kindergarten in Chiang Mai, Thailand. There are fifteen participants broken down into five of Kindergarten level 1 (3 year's old), five of kindergarten level 2 (4 year 's old), and five of kindergarten 3 (5 year 's old). They were invited to play the game then; the results were recorded for analysis by 3 evaluation method.

First, A paired-t-test was used to examine whether a child who plays with the game gain better receptive language skill. The Pre-test was conducted to measure the skill of the group before the intervention by playing the proposed game. The Mean of the Pre-test is 28.87 and the SD. is 3.29. Children are then asked to play the game and after the Post-test is conducted and the mean has risen to 31.60 with the SD =3.29. Both Pre-test and Post-test were tested for normality and they are normally distributed. The analysis results in Table 5 is shown that the P value < 0.01 which indicates the effectiveness of the intervention by the proposed game.

Table 5. Paired t-test result

Score	Mean	SD	T	P value
Pre-test	28.87	3.29	3.030	0.009
Post-test	31.60	2.06		

The second evaluation was analysed having a purpose to explore the feasibility to apply the proposed system for formal education in a school. One of the most recognized evaluation methods for instructional material and media in Thai academic society is the 90/90 Standard (Kumut, 1976).The main principle was underpinned by the Mastery Learning theory stating that everyone can learn if appropriate learning environment is arranged and adequate time is supplied (Yamkasikorn, 2007). The first 90 indicates the average score in the percentage of the group. The second 90 indicate the percentage of the learners who can achieve every objective of the lesson (Yamkasikorn, 2007) cited (Kumut, 1976).

The evaluation conducted by allocating the game to each player adequately (approximately 15-20 minutes). Players can explore the system freely under the observation of the research team who provided the guidance and assist the players in using the developed game system. Then, the players are evaluated their learning outcome again. The evaluation result found that the average score of the participant is 95.75%. Also, the number of the players who can pass the receptive language test is 14 out of 15 equivalents 93.33 % (to pass the test, the DSPM requires children achieve at least 3 out of 4 activities). The score 95.75% and 93.33% are both higher than 90/90. Therefore, it can be concluded that the developed game achieves 90/90 standard.

The final evaluation investigates the effectiveness from the experts point-of-view. The two experts who are the consultant of this project invite their colleague to join the evaluation. The evaluation measures the satisfaction of the system in several aspects using a Likert scale. The summary of the evaluation result is shown in Table 6.

Table 6. Result of expert satisfaction evaluation

Satisfactory criteria	Average score
Game mechanics and interactivity	3.52
Game administration system	3.83
The Proposed game controller	3.22
Look and feel	3.55
Total	**3.53**

The game can achieve relatively high satisfaction from the expert in Likert scale. The expert judge that the best part of the proposed game is the system administration part where the new set vocabulary can be added to provide flexibility for tweaking or amending the game content in the future. However, the evaluation result indicated the lowest score in the physical interactive controller which shall require further research to improve it.

Additionally, this game apparently contributes extra benefit to the child development apart from the primary goal to improve language skill as in the game 1 children are required to have a tangible interaction of grasping the objects and locating objects to the blocks, and this encourages children to practice and develop their fine-motor during the play.

5. CONCLUSION AND FUTURE WORK

The paper discusses the investigation of the game solution to improve the language skill of Thai pre-schooler. The game system is composed of 4 mini computer games designed to operate with the proposed game controller to enhance interactivity between children and the game. The process of the game implementation is under the supervision of the expert, and the game is evaluated in 3 methods including paired t-test, the 90/90 standard, and expert evaluation. The evaluation results, in general, show promise of the proposed system. The further research is to focus on the improvement of the design of the interface of the controller to be more effective. Even though the result of the expert evaluation indicated that the satisfaction to the system is high, the satisfaction to the proposed controller is relatively lower compared to the other aspects. Another direction is to expand the functionalities of the system to serve other skills necessary for child development and to apply proper measurement to the game.

REFERENCES

Agudo, J. E., Sánchez, H., Holguín, J. M. & Tello, D. Adaptive computer games for second language learning in early childhood. Proceedings of the 3rd International Online Conference on Second and Foreign Language Teaching and Research, 2007. 167-180.

Bishop, D. 2014. Ten questions about terminology for children with unexplained language problems. *International Journal of Language & Communication Disorders,* 49**,** 381-415.

Demmel, R. B., Köhler, B., Krusche, S. & Schubert, L. The serious game: wemakewords. Proceedings of the 10th SIGPLAN symposium on New ideas, new paradigms, and reflections on programming and software, 2011. ACM, 109-110.

Goldstein, J. 2012. Play in children's development, health and well-being. *Toy Industries of Europe. Brussels.*

Hengeveld, B., Voort, R., Hummels, C., De Moor, J., Van Balkom, H., Overbeeke, K. & Van Der Helm, A. 2008. The development of LinguaBytes: an interactive tangible play and learning system to stimulate the language development of toddlers with multiple disabilities. *Advances in Human-Computer Interaction,* 2008**,** 1.

Hinton, C., Miyamoto, K. & DellaChiesa, B. 2008. Brain Research, Learning and Emotions: implications for education research, policy and practice1. *European Journal of education,* 43**,** 87-103.

Hourcade, J. P. 2008. Interaction design and children. *Foundations and Trends in Human-Computer Interaction,* 1**,** 277-392.

Jackie M. Oddo, M.S., O. L. & Leigh, C. 2013. *The Importance of Play in the Development of Language Skills* [Online]. Atlanta Speech School. Available: https://www.atlantaspeechschool.org [Accessed].

Jamil, I., Perry, M., O'hara, K., Karnik, A., Marshall, M. T., Jha, S., Gupta, S. & Subramanian, S. Group interaction on interactive multi-touch tables by children in India. Proceedings of the 11th International Conference on Interaction Design and Children, 2012. ACM, 224-227.

Jintana, P. 2015. The study of Thai Early Child Development. *Silpakorn Educational Research Journal,* 7**,** 256-269.

Kara, N., Aydin, C. C. & Cagiltay, K. 2014. User study of a new smart toy for children's storytelling. *Interactive Learning Environments,* 22**,** 551-563.

Kumut, P. 1976. *Technic of instuctional program,* Faculty of education, Srinakharinwirot University

Lieberman, D. A., Bates, C. H. & So, J. 2009. Young children's learning with digital media. *Computers in the Schools,* 26**,** 271-283.

Makeymakey. *What 's Makey Makey?* [Online]. Makey Makey LLC. Available: http://makeymakey.com/ [Accessed 16 January 2017].

Meyer, B. Game-based language learning for pre-school children: a design perspective. Proceedings of the 6th European Conference on Games Based Learning: ECGBL, 2012. Academic Conferences Limited, 332.

Moph 2016. Developmental Surveillance and Promotion Manual (DSPM). Ministry of Public Health.

Plowman, L., Stephen, C. & Mcpake, J. 2010. Supporting young children's learning with technology at home and in preschool. *Research Papers in Education*, 25**,** 93-113.

Pongpol, V. 2014. The study of early childhood development screening in Kongkrailas, Sukhothai. *Rajanukul Journal* 29**,** 10-19.

Resnick, M., Martin, F., Berg, R., Borovoy, R., Colella, V., Kramer, K. & Silverman, B. Digital manipulatives: new toys to think with. Proceedings of the SIGCHI conference on Human factors in computing systems, 1998. ACM Press/Addison-Wesley Publishing Co., 281-287.

Schuurs, U. 2012. Serious gaming and vocabulary growth. *Serious Games: The Challenge*. Springer.

Voramongkol, N. & Wongdejakul, S. 2011. Early Childhood Growth And Development in Thailand, 2007. *J Health Res vol*, 25.

Wang, D., He, L. & Dou, K. 2014. StoryCube: supporting children's storytelling with a tangible tool. *The Journal of Supercomputing*, 70**,** 269-283.

Yamkasikorn, M. 2007. How to use efficiency criterion in media research and development : The Difference between 90/90 Standard and E1/E2. *Journal of Education*, Vol 19,.