VOLUME 14 NO.2
DECEMBER 2017
ISSN 1675-7017

SOCIAL and MANAGEMENT RESEARCH JOURNAL

Institute of Research Management Innovation (IRMI)

SOCIAL and MANAGEMENT RESEARCH JOURNAL

Institute of Research Management Innovation (IRMI)

Vol. 14 No. 2 **December 2017** **ISSN 1675-7017**

Modelling Basic Numeracy Learning Application for Children with Autism: A Pilot Study

Muhamad Fairus Kamaruzaman [1], Harrinni Mohd Noor [2], Mustaffa Halabi Hj Azahari [3]

[1]Formgiving Design Research Group, Faculty of Art & Design, Universiti Teknologi MARA
40450 Shah Alam, Selangor, Malaysia
[2]Faculty of Education, Universiti Teknologi MARA,
42300 Puncak Alam, Selangor, Malaysia
[3]Faculty of Art & Design, Universiti Teknologi MARA,
42300 Puncak Alam, Selangor, Malaysia
[1]Email: muhamadfairus@salam.uitm.edu.my

Received: 24 January 2017
Accepted: 8 November 2017

ABSTRACT

Children with autism have various difficulties in developing cognitive abilities and attaining new knowledge. However, it is essential they obtain a competence approach in order to achieve independence. The state of art has shown that a significant aspiration for children with autism is to become independent. Part of attaining independence includes achieving skills that allow for self-determination and involvement in social activities. Hence, it is essential for every child with autism to acquire basic numeracy skills to enhance their self-determination. With the emergence of assistive learning technology such as smartphones, PDAs, tablets, and laptops with touchscreen features, there are extensive ways to improve the quality of life for children with autism. This study, therefore, aims to explore the basic numeracy skills-based dynamic visual for children with autism that will possibly be of assistance to parents, educators, and facilitators in the development of digital assistive learning tools to meet the requirements of children with autism in learning environments. From the proposed theoretical framework, an application was designed and tested with several children with autism. Based on observations from the experiment, the users showed positive attitudes towards the outcome of the application.

Keywords: *children with autism, assistive learning technology, apps, numeracy, education*

INTRODUCTION

Autism spectrum disorders (ASDs) are a group of developmental disabilities characterised by impairments in social interaction and communication and by restricted, repetitive, and stereotyped patterns of behaviour (Association, 2000). Symptoms are typically apparent before the age of three. Since the early 1990s, elevated public concern about continued reported increases in the number of children receiving services for ASDs and reports of higher-than-expected ASD prevalence estimates have underscored the need for the systematic public health monitoring of ASDs (Rice *et al*., 2007). Autism symptoms can be present in a variety of combinations and may accompany other disabilities. Some individuals with autism have normal levels of intelligence, although most individuals with autism have some level of intellectual disability, ranging from mild to severe. This range is often referred to as high-functioning autism to low-functioning autism. Autism is a life-long developmental disability that prevents society from understanding what people with autism see, hear, and otherwise sense. Autism counts differently when compared with typically developing individuals (Ingvarsson & Hollobaugh, 2010). Those with autism typically develop differently from other individuals in their counting skills by having a slower reaction time when naming quantities, a later development of sequencing skills and recalling positions, and no benefit from recognising a canonical placement of dots. The exemplary development of number knowledge, especially counting skills and the working memory is crucial for accumulated brain development. Hence, children with autism were believed to calculate in a different way when it comes to measuring up to normal emergent individuals (Kamaruzaman, Rahman, Abdullah, Anwar, 2013; Wehmeyer *et al*., 2012). Characteristically raising these individuals need special attention and special goals when it comes to their education as this disability may affect their level of self-determination.

Previous studies have found that children with autism prefer instructions delivered through digital devices such as tablets (Ayres, Mechling & Sansosti, 2013; Pellicano, 2010) while the skilled application of assistive learning technology may increase many areas of independence for them and provide support for their lack in psychomotor skills. It is believed that the bright screen and interactivity of an assistive touch-screen applications learning technology has made the device much more attractive.

The assistive learning technology will complement the conventional method of learning as it certainly can provide a reliable level of predictability, from the device's touch response to the calm, steady voice emitted from the device when children with autism explore basic numeracy knowledge. This allows children with autism not only to display emotion and other personal aspects of calculation, but also answer questions and work together with the teacher, instructor, and course material. This research may result in a better alternative and be useful for children with autism as they develop their motor skills. Since basic numeracy skill is essential in one's life to cope with the surrounding world, a touch-screen-based device with an application for basic counting skill has been developed in this research to support children with autism in their learning environment, independence, and quality of life.

SIGNIFICANCE OF STUDY

This study provides opportunities for new knowledge in the learning styles of children with autism, especially in mathematics, and to foster academic and self-determination capabilities. It is also believed that these children will probably share their understanding of the application and basic numeracy with their peers both within and outside the classroom.

LITERATURE REVIEW

Children with autism have a psycho-educational profile that is different from typically developing children. Studies show that there may be deficits in many cognitive functions, yet not all are affected. Though there may be deficits in complex abilities; nevertheless, the simpler abilities in the same area may be intact. Some children with autism have stronger abilities in the areas of rote memory and visual-spatial tasks than they have in other areas (Cohen & Sloan, 2007). Children with autism also often display other kinds of visual-spatial talents, such as putting puzzles together, and perform well at spatial, perceptual, and matching tasks. Some may be able to recall simple information but have difficulty recalling more complex information (Grandin, 2011). Yet some others perform at superior levels on 'local' visual-spatial tasks that require finding parts within wholes. The local processing

tasks on which children with autism excel include the Embedded Figures Task (Carmo *et al.*, 2016; Edgin & Pennington, 2005) in which one must find a small part hidden in a larger pattern, and the block design task (Pellicano, Maybery, Durkin, & Maley, 2006), in which one must use blocks to copy a two-dimensional pattern. Strength in visual-spatial skills has been described in personal accounts of children with autism.

Apart from visual-spatial skills, these children can easily learn and remember information that is presented in a visual format (Grandin & Panek, 2013; Mukerji, Mottron & McPartland, 2013) often demonstrating essential strengths in concrete thinking, rote memory, and understanding of visual-spatial relationships, but have difficulties in abstract thinking, social cognition, communication, and attention (Carnahan, Musti-Rao, & Bailey, 2009). Visual graphics and written cues can often help them learn, communicate, and develop self-control (Rani, Rahman & Kamaruzaman, 2015). Visual game therapy however needs specific game design that incorporates deep study on target users, which have often been overlooked (Alankus & Kelleher, 2012). One of the advantages of using mobile game-based learning is that children or adolescents can practice it for as long as they need to process the information. This technology has enriched, motivated, and empowered the human mind (Kamaruzaman & Zainol, 2012; Rani, Zainol, & Kamaruzaman, 2015). According to Rani, Yusoff, Azman and Kamaruzaman (2015) by using mobile game-based learning assistance, the individual learns to emphasise and concentrate on the message.

THE COUNTING MODEL OF INSTRUCTION

Various counting patterns have been developed in the past thirty years. Based on Schaeffer, Eggleston, and Scot's (1974) counting model, there are three steps required for the acquisition of counting. Firstly, children have to obtain knowledge in counting words sequence. Secondly, the children should learn enumeration, which is the aptitude to point to and calculate each object. Finally, children should learn the cardinality rule which understands that the last number they count in a particular set represents the number in the set.

THE COUNTING PRINCIPLES

Counting is one of the earliest and most essential skills for every child to learn in order to gain self-reliance. Scholars have recommended that learning basic numeracy and calculation is an important element in the enhancement of number perception (Kim & Cameron, 2016). Additionally, it has been documented that counting skills are essential prerequisites that can lead to an independent adult life. It is believed that counting skills develop in a hierarchal approach according to five most important principles (Gallistel & Gelman 1992). The first three principles involve how children count (process), the fourth principle deals with what to count (explanation), and lastly, it involves a combination of the features of the other four principles. It consists of the one-to-one principle; the constant classify theory; the cardinality theory; the conceptual theory; and the order inconsequence theory. Table 1 summarises the principles of counting as described by Gallistel and Gelman (1992) in Preverbal and verbal counting and computation.

Table 1: Gallistel and Gelman's Principles of Counting

Principle	Description
One to One	Items are identified one by one with a name given to each one.
Stable Order	The tags used in counting are arranged in a fixed order.
Cardinality	Final tag counted represents the total number of items in the set.
Abstraction	The counting procedure can be applied to all kinds of things whether concrete or mental.
Order Irrelevance	Items can be counted in any order so long as each item is tagged once.

More and more special educational needs children are using technological devices to carry out tasks and activities (Muñoz, Barcelos, Noël & Kreisel, 2012). There has been a variety of applications developed for use by children with autism in the past few years. Many applications were designed as an instructional tool to teach children with autism the skills they need in order to enhance their self-determination. It has been found that the use of such applications was well received by children with autism and incorporated into the regular activities of their school. In this

research paper, a numeracy design learning application was developed to support basic counting skill for children with autism. Since children with autism have a psycho-learning outline that varies from typical children, there may be countless insufficiencies in their cognitive tasks, though not all (Kamaruzaman, Rahman, Abdullah, Anwar, 2013). Compared to typical children, children with autism count up in a different way (Hasnah Toran, 2013; Torii, Ohtani, Niwa, Yamamoto, & Ishii, 2012), differing from characteristically emergent development by a slower consequence moment in time when inaugurating figures; a later maturity of series dexterities and evoking arrangements, and no advantage from identifying a canonical position of marks. They however have the talent to show other kinds of visual and spatial abilities such as composing puzzles and the capability to accomplish spatial, perceptual and mix match assignments.

Experts believe that children with autism can understand through visual means. According to Kamaruzaman and Azahari (2014), Munoz-Soto *et al.* (2016) and Kamaruzaman, Nor, and Azahari (2016) some children with autism may easily learn and remember information that is presented in a visual format. The major advantage of using infographic supports is that they could be used everywhere and anytime to process information. In developing a design application architecture that is more practical and usable, it is vital to look closely into user modelling. It is believed that works about usability and user characteristics help shape how the end user interacts with the application system (Zhang, Carey, Te'eni, & Tremaine, 2004). Kamaruzaman *et al*. (2013) believe that the existing framework should incorporate the counting principles outlined by Gallistel and Gelman (1992) as a basis.

RESEARCH DESIGN DEVELOPMENT

Five main phases are implied in developing the autistic education application design model. The earliest stage comprises children with autism's issues of learning how to count, objectives, possibility, and lifelong learning environment. The following stage forms the outline of the design application which includes creating the mood board, storyboard, and prototype model. This model will also look into certain elements and aspects of children with autism's user interface, dynamic visual, and contents. The third phase

focuses on building the contents and materials based on the earlier phases. Next, the experiment stage comprises testing and analysing the prototype with children with autism. Autism experts believe that in ensuring the success of the investigation, the instructor, mentor, and parents will need to run the application with the children with autism in their natural atmosphere. A distance observation session was used and these children's behaviour were recorded and alnalysed (Gallistel & Gelman, 1992). It is also believed that the natural atmosphere plays a dynamic role in determining the children's capacity to produce discerning responses. Any issues and matters that arise during this phase will be identified and documented. The final stage comprises of compiling data and feedback from the instructor, mentor, and parents of participating children with autism about the numeracy design learning application.

USER INTERFACE DESIGN APPLICATION FOR CHILDREN WITH AUTISM

The Content Application

The numeracy interface design learning application was designed according to the needs of children with autism (M. Kamaruzaman & Zainol, 2012).The numeracy learning application consists of basic numbering information, number recognition, and drag and drop and drag and match numbering games. The languages used in this numeracy learning application are English and Malay (Bahasa Malaysia) as they are the most common languages used by children with autism in Malaysia. The contents of this application were divided into two parts: learning to count and numbering exercises. All the segments' contents were adapted and aligned with the Integrated Curriculum for Learning Disabilities issued by Ministry of Education Malaysia.

The Development of the Basic Counting Application

According to Gallistel and Gelman (1992), designing assistive learning systems for children with autism should anticipate existing limitations. The first stage is the analysis phase, where the main purpose was to consider all factors that are related to the project and how to produce a desirable result.

The investigation involved several children with autism. To comprehend the needs of the children with autism, and to identify the issues and purpose for the application, interviews were held with the instructor, mentor, and parents at the onset of the project. Since the goal of the investigation was to develop a prototype that focuses on the method of learning how to count, information gathered in the analysis phase was used to develop a hypothetical design of the application. The primary design of the application needs to emphasise the practicality and usability of the application with testing being the key objective. A mood board and a storyboard were created to identify the interface design of the application. The visual layout has been delicately thought out to ensure that the overall application is pleasurable and easy to use. Aspects such as the children with autism's skill and ability to use the assistive learning technology such as a tablet, Smartphone, and computer were taken into consideration. Dynamic visual elements such as audio, video, animation, text, and graphics were included in the design to enrich the application.

Numeracy Skills Learning Application Experiment with Autism Children

A total of 15 children with autism from the Klang Valley, Selangor, Malaysia had participated in this research. They were selected by the Education Planning and Research Division (EPRD), Ministry of Education (MOE) Malaysia in collaboration with Selangor Education Department due to the specific area of research in Special Education. Two primary schools with integrated special education programmes (PPKI) in Selangor, Malaysia participated in the study. All children with autism were protected by agreements with their school principal to ensure that the protocol in research ethics has been followed accordingly (REC: 600-IRMI (5/1/6)).

Testing of the prototype was conducted in the participants' natural surroundings and environment as it is important to make them feel 'natural and relaxed' (Hood Mohamad Salleh, 2012). The experiment was led and guided by the children's respective teachers and instructors who had been briefed on the structure as well as the configuration of the application, its user interface, looks and feels, and most importantly its practicality and usability for children with autism's self-development in understanding basic numeracy by using the assistive learning technology.

Based on the distance observation and teachers' feedback, most of the participating children were found to be fond of and had enjoyed using the application. As a learning tool, the application will provide support for leaning basic numbers for children with autism both within and outside the classroom beyond normal classroom instructions. Table 2, shows the different outcomes.

Table 2: Numeracy Result Experimentation towards Children with Autism Learning Development

No of Children with Autism	Age	Numeracy Skill Learning Application									
		Ability to understand basic numeracy skill	Cognitive Level					Children with Autism Response Psychomotor Level	Psychomotor Level		
			Slow	Poor	Modest	Good	Excellent		Low	Medium	High
1	7	*Yes*	√					Blur	√		
2	6	*Yes*		√				Confuse	√		
3	8	*Yes*	√					Low	√		
4	7	*Yes*		√				Uncertain	√		
5	6	*Yes*			√			Skepticism		√	
6	6	*Yes*			√			Severe		√	
7	7	*Yes*			√			Enjoy		√	
8	6	*Yes*				√		Connect		√	
9	8	*Yes*					√	Determine			√
10	7	*Yes*				√		Enthusiastic			√
11	8	*Yes*				√		Hyper			√
12	7	*Yes*				√		Inspire			√
13	9	*Yes*					√	*Intense*			√
14	6	*Yes*					√	Passionate			√
15	8	*Yes*					√	*Extreme*			√

Note: Age reflects participant's age at the time of the experiment.

Numeracy Learning Design Application Screenshots

Figure 1 until Figure 4, are print screens on several existing activities in the numeracy learning skill design application.

Figure 1: Main page of Numeracy Learning Design Application Screen

Figure 2: Example of number one in basic numeracy learning skill screen page

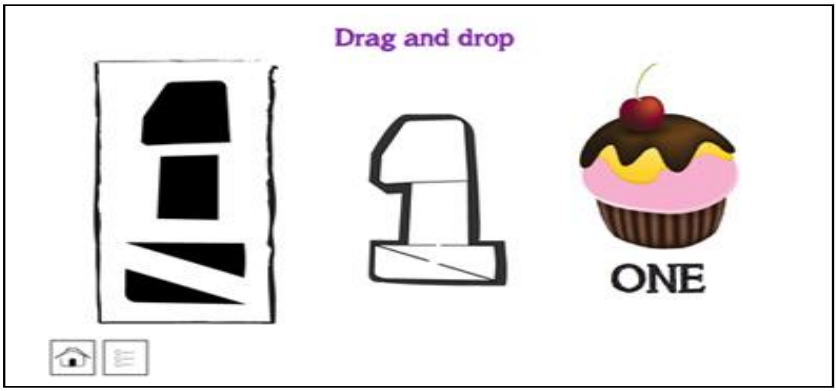

Figure 3: Example of Drag and Drop on Number One in Numeracy Learning Skill Application Screen Page

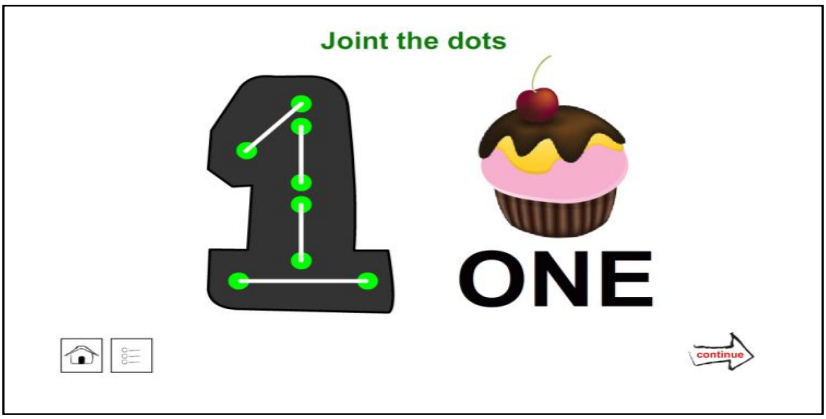

Figure 4: Example of Joining the Dots on Number One in Numeracy Learning Skill Application Screen Page

FINDINGS

It is relevant to note that results of the experiment indicated that children with autism were attracted by the application. The attraction had led them to eventually spend more time on the numeracy application; practising and doing exercises while exploring their idealistic conceptions beyond the logical perception as well as to attain their learning interests and achieve self-independence.

CONCLUSION

As the population of children with autism increases it becomes more pressing for parents and educators to have better understanding of their special needs, notably in the area of learning and self-independence. This research provides support for understanding such needs. Results from the study show that almost all of the teachers and instructors who had participated agree that using assistive learning technology will enhance and enrich children with autism's state of mind and inspire them to acquire new knowledge independently.

This research is a progressive work on basic numeracy learning application which is a part of a comprehensive numeracy learning design application. As soon as the comprehensive numeracy learning design application is ready, it will be tested again to establish the practicality and usability of the model. It is also relevant to note that it is possible to use the application in psychoanalysis to enhance children with autism's independence, lifelong learning, and quality of life.

ACKNOWLEDGEMENT

This research was approved by the local Research Ethics Committee, Universiti Teknologi MARA (UiTM) and Ministry of Education, Malaysia. This project was funded by UiTM under the LESTARI grant scheme. The authors also would like to thank Faculty of Art & Design, UiTM and Research Management Centre, UiTM for the administrative support.

REFERENCES

Alankus, G., & Kelleher, C. (2012, May). *Reducing compensatory motions in video games for stroke rehabilitation*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Ausin, Texas.

Association, A. P. (2000). *Diagnostic criteria from dsm-iv-tr:* American Psychiatric Pub.

Ayres, K. M., Mechling, L., & Sansosti, F. J. (2013). The use of mobile technologies to assist with life skills/independence of students with moderate/severe intellectual disability and/or autism spectrum disorders: Considerations for the future of school psychology. *Psychology in the Schools*, *50*(3), 259-271. DOI: 10.1002/pits.21673.

Carmo, J. C., Souza, C., Gonçalves, F., Pinho, S., Filipe, C. N., & Lachmann, T. (2016). Effects of categorical representation on visuospatial working memory in autism spectrum disorder. *Journal of Clinical and Experimental Neuropsychology*, *39*(2), 1-11. http://dx.doi.org/10.1080/13803395.2016.1207754.

Carnahan, C., Musti-Rao, S., & Bailey, J. (2009). Promoting active engagement in small group learning experiences for students with autism and significant learning needs. *Education and Treatment of Children*, *32*(1), 37-61. DOI: 10.1353/etc.0.0047.

Cohen, M. J., & Sloan, D. L. (2007). *Visual Supports for People with Autism: A Guide for Parents and Professionals*. United States of America: Woodbine House.

Edgin, J. O., & Pennington, B. F. (2005). Spatial cognition in autism spectrum disorders: Superior, impaired, or just intact? *Journal of Autism and Developmental Disorders, 35*(6), 729-745. DOI: 10.1007/s10803-005-0020-y

Gallistel, C. R., & Gelman, R. (1992). Preverbal and verbal counting and computation. *Cognition*, *44*(1), 43-74. https://doi.org/10.1016/0010-0277(92)90050-R.

Grandin, T. (2011). T*he Way I See It: A Personal Look At Autism & Asperger's.* Unite States of America: Future Horizons.

Grandin, T., & Panek, R. (2013). *The Autistic Brain: Thinking Across the Spectrum*. New York: Houghton Mifflin Harcourt.

Hasnah Toran, S. B., Fadliana Chiri. (2013). S*iri Pendidikan Autisme*: *Pengajaran Berstruktur.*Bangi: UKM Press.

Hood Mohamad Salleh, H., Zaharatul Sophia Mohamed Amir Abas& Aishah Mohamed Yusoff. (2012). *Do You Know Autism?* Bangi: UKM Press.

Ingvarsson, E. T., & Hollobaugh, T. (2010). Acquisition of intraverbal behavior: Teaching children with autism to mand for answers to questions. *Journal of Applied Behavior Analysis*, *43*(1), 1-17. doi: 10.1901/jaba.2010.43-1.

Kamaruzaman, M., & Zainol, I. (2012, December). *Behavior response among secondary school students development towards mobile learning application*. Paper presented at the 2012 IEEE Colloquium on Humanities, Science and Engineering (CHUSER, Sabah. doi: 10.1109/CHUSER.2012.6504381.

Kamaruzaman, M. F., Rahman, S.H.A., Abdullah, K.Z., Anwar, R. (2013, April). *Conceptual framework study of basic counting skills based dynamic visual architecture towards autistic children's development*. Paper presented at the 2013 IEEE Business Engineering and Industrial Applications Colloquium (BEIAC), Langkawi. doi:10.1109/BEIAC.2013.6560108.

Kamaruzaman, M. F., Azahari, M.H.H. (2014, September). *Form design development study on autistic counting skill learning application*. Paper presented at the 2014 International Conference on Computer, Communications, and Control Technology (I4CT), Langkawi. Doi: 10.1104/14CT.2014.6914148.

Kamaruzaman, M. F., Nor, H.M., Azahari, M.H.H. (2016). Using touchscreen technology to support basic numeracy learning process for high functioning children with autism. *Turkish Online Journal of Educational Technology*, *2016(*July) pp. 632-639.

Kim, H., & Cameron, C. E. (2016). Implications of Visuospatial Skills and Executive Functions for Learning Mathematics: Evidence From Children With Autism and Williams Syndrome. *AERA Open*, *2*(4), doi:10.1177/2332858416675124.

Mukerji, C., Mottron, L., & McPartland, J. C. (2013). *Enhanced Perceptual Functioning Encyclopedia of Autism Spectrum Disorders*. New York: Springer. doi:10.1007/978-1-4409-1698-3.

Munoz-Soto, R., Becerra, C., Noël, R., Barcelos, T., Villarroel, R., Kreisel, S., & Camblor, M. (2016, October). *Proyect@ matemáticas: A learning object for supporting the practitioners in autism spectrum disorders*. Paper presented at the 2016 XI Latin American Conference on Learning Objects and Technology (LACLO). San Carlos, Costa Rica. DOI: 10.1109/LACLO.2016.7751760.

Muñoz, R., Barcelos, T., Noël, R., & Kreisel, S. (2012). D*evelopment of software that supports the improvement of the empathy in children with autism spectrum disorder*. Paper presented at the 2012 31st International Conference of the Chilean Computer Science Society. Valparaiso, Chile. DOI: 10.1109/SCCC.2012.33.

Schaeffer, B., Eggleston, V. H., & Scott, J. L. (1974). Number development in young children. *Cognitive Psychology, 6*(3), 357-379. https://doi.org/10.1016/0010-0285(74)90017-6.

Pellicano, E. (2010). Individual differences in executive function and central coherence predict developmental changes in theory of mind in autism. *Developmental psychology*, *46*(2), 530. doi: 10.1037/a0018287.

Pellicano, E., Maybery, M., Durkin, K., & Maley, A. (2006). Multiple cognitive capabilities/deficits in children with an autism spectrum disorder:" Weak" central coherence and its relationship to theory of mind and executive control. *Development and psychopathology*, *18*(1), 77. DOI:10.1017/S0954579406060056.

Rani N.M., Rahman S.H.A., Kamaruzaman M.F. (2015) Color Cognition Framework for Autistic Children Development. In: Hassan O., Abidin S., Anwar R., Kamaruzaman M. (eds) Proceedings of the International Symposium on Research of Arts, Design and Humanities (ISRADH 2014). Singapore: Springer. https://doi.org/10.1007/978-981-287-530-3_47.

Rani N.M., Yusoff M.F., Azman F.Z.R., Kamaruzaman M.F. (2015) The Role of Digital Educational Game Design Learning Environment: An Empirical Study. In: Hassan O., Abidin S., Anwar R., Kamaruzaman M. (eds) *Proceedings of the International Symposium on Research of Arts, Design and Humanities* (ISRADH 2014). Singapore: Springer. https://doi.org/10.1007/978-981-287-530-3_14.

Rani N. M, Zainol I.H., Kamaruzaman M.F. (2015) Empirical Study on Game-Based Learning Phenomenon Through Mobile Design Technology. In: Hassan O., Abidin S., Legino R., Anwar R., Kamaruzaman M. (eds) I*nternational Colloquium of Art and Design Education Research* (i-CADER 2014). Singapore: Springer. https://doi.org/10.1007/978-981-287-332-3_20

Rice, C. E., Baio, J., Van Naarden Braun, K., Doernberg, N., Meaney, F. J., & Kirby, R. S. (2007). A public health collaboration for the surveillance of autism spectrum disorders. *Paediatric and perinatal epidemiology*, *21*(2), 179-190. DOI:10.1111/j.1365-3016.2007.00801.x

Torii, I., Ohtani, K., Niwa, T., Yamamoto, A., & Ishii, N. (2012, January). *Augmentative and alternative communication with digital assistant for autistic children*. Paper presented at the 2012 IEEE International Conference on Emerging Signal Processing Applications. Las Vegas. DOI: 10.1109/ESPA.2012.6152448.

Wehmeyer, M. L., Shogren, K. A., Palmer, S. B., Williams-Diehm, K. L., Little, T., & Boulton, A.(2012). Impact of the Self-Determined Learning Model of Instruction on Self-Determination: A Randomized-Trial Control Group Study. *Exceptional Children*, *78*(2), 135–153.

Zhang, P., Carey, J., Te'eni, D., & Tremaine, M. (2004, August). *Integrating human-computer interaction development into SDLC: A methodology*. 10th Americas Conference on Information Systems, AMCIS 2004, New York, NY, USA.