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The Instructional Thematic Game for Children with Mild Mental Retardation: For Enhancement of Left-Right Recognition Skill

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ABSTRACT

Children with mild mental retardation had several difficulties with interaction, remembering information, problem-solving, physic-motoric, learning problem, etc. Therefore, we proposed a novel framework to increase their learning skill using instructional thematic game rehabilitation framework based on Kinect sensor as the solution. Basically, the framework had three components. First, intellectual functions, which implied to the competencies reached through the game by the student. Second, instructional thematic game model, which was the concept to learn everything from the real single topic of the subject by associating to the abstract objects. Three, computer sensor device, which was the equipment as the bridge between the children and the program application. This research covered enhancement of right and left-hand recognition. We adopted Single Subject Research to evaluate the effectiveness of the system and to explore each of the individual's progress. This process was divided into 2 steps. Namely, baseline stage and treatment stage. Apparently, from our finding, such framework gave the student an enhanced learning skill covering left-right recognition skill, decreasing the level of disturbance, and improving the level of learning independence.

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1. INTRODUCTION

Mental retardation has significant intrusion or limitation in intellectual function and adaptive behavior. One category of them is mild mental retardation (MMR), which has an attribute of the intellectual function or IQ value in the range 50 – 70 and also has several difficulties with interaction, interpersonal, remembering information, problem-solving, physic-motoric, etc. [1-3]. Although MMR makes children undergo difficulty to increase their knowledge and skill, they are classified as educable students with the term of education area. Thus with appropriate supports and approaches, individuals with MMR can usually live successfully in the community [3], [4].

The children with MMR need full attention, supervision, guidance, and assistance. One of the ways in supporting them is to provide the assistive technology system, which can give them easiness in improving their difficulties. Some researchers have conducted research to facilitate them with the game application to improve their motivation and cognitive behavior [5-8]. Others have enhanced the research in the cognitive

and learning the skill through combining kinesthetic and games, by providing some equipment as a media to learn from. These media can improve their skill [9-12] but they have not provided the way how to improve their learning skill based on the instructional thematic game. Consequently, the main purpose of this paper is to improve their learning skill through rehabilitation based on the instructional thematic game (ITG). It gives the important role for them to indulge in the immersive learning in various activities and also is oriented to encourage the children with MMR at the age of 8-12 years old.

2. ITG REHABILITATION FRAMEWORK

The learning skills are a generic heuristic that enables mastery of specific domains or skills. Three important aspects related to its definition are the skills are specific domain and knowledge-rich, the skills describe an integrated transaction between the person and the environment, and the skills are developed by practice [13]. In addition, the learning skills are often broken down into the skills of thinking and problem-solving, information and communication, and interpersonal and self-management [14]. Improving the learning skills for the children with MMR will become one of the solutions to their difficulties. Based on the previous research, how the way to enhance learning skill is by making exercising [15-18]. Therefore, we propose the framework formed in the assistive technology system to help them increase their learning skill in easy, simple and fun ways. This research paper covers learning skill enhancement with the topic on mastering the concept of right and left-hand based on the ITG rehabilitation framework defined as the structure of rehabilitation for the children with MMR. It has three supporting components, namely, computer sensor devices, the instructional thematic game, and intellectual function as shown in Figure 1.

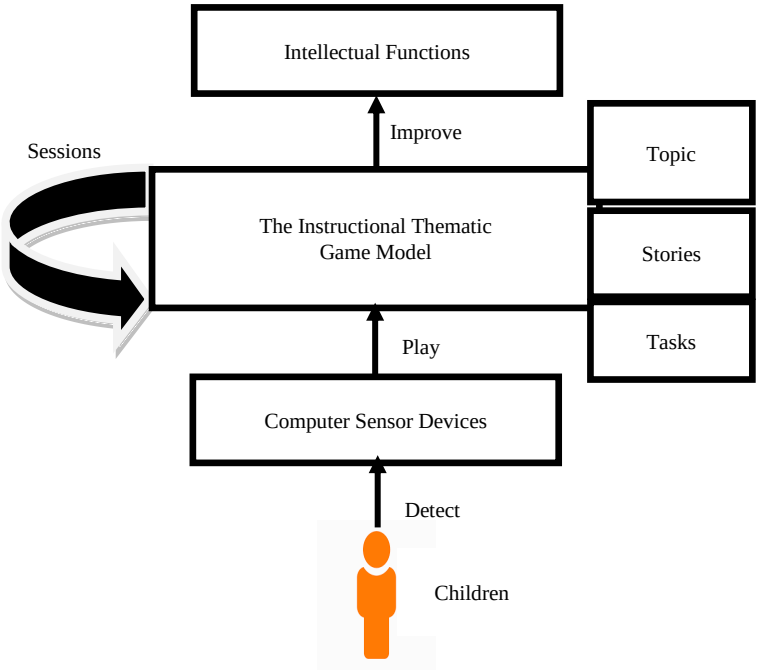


Figure 1. ITG Rehabilitation Framework

2.1. Computer Sensor Devices

The learning process can be fitted due to the condition which enhances the learning skill of the children in kinesthetic ways. The children will enjoy the game digitally aimed to improve their learning base on the particular topic due to the instructional design at the school. The children with MMR may not be able to hold a console of the game devices to play the game. It will risk for them. Therefore, we put the sensor such as Kinect to displace the console devices to detect their motions. In addition, we can explore their potential through interaction with the game application. It will also be processed and recorded as the entry item by the sensor, then it sends the signal to the computer, then finally it reflects on the children's application through the screen as shown in Figure 2.

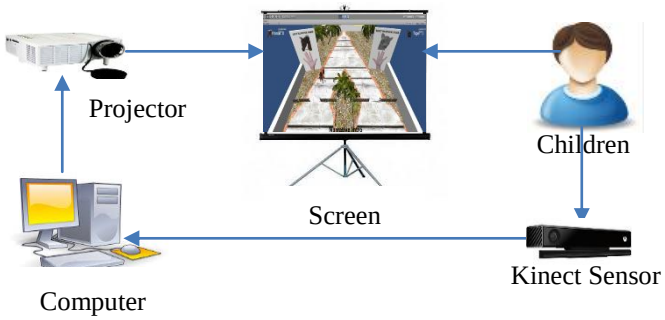


Figure 2. Architecture System

2.2. The Instructional Thematic Game Model

The instructional thematic game provides a rule of thumb for the children. It facilitates the opportunities for them to learn everything from the real object by associating to the other abstract subject without ignoring the meaning of each subject of the lesson [19]. This component comes up as the solution for the children with MMR who are not able to recognize something in the abstract. They do not know the meaning of the abstract subject such as mathematics, science, interaction, problem solving, etc. Therefore, they will only know something appearing in front of them visibly or in the concrete existence. This model is divided into three components. First, the topic means as the material given to the children, which relates to the concept of right and left-hand. Second, the stories represent the scenario undertaken on the game. Three, the task is the transformation of the children's functions in order to be more definitive in the activities form and also as the activity scenario to play for the children in front of Kinect. The stories and the task are discussed in detail in the following Table 1.

2.3. The Intellectual Functions

The intellectual functions are the most important component because it implies whether their competencies reach through the game. This component is revealed from the children with MMR difficulties. In this paper, the children's functions covering their diverse limitations are interacting, remembering the information and problem-solving. Those functions are the referenced criteria which must be increased. Each of children's functions is discussed in detail in the following Table 1.

Table 1. Intellectual Achievement

No	The Children Functions	The Children Task on Game	Game Stories/ Scenarios
1	Children learning (insights)	The Children watch and learn the video as a narrative introduction of the game (a demonstration mode).	It is set on Video Mode: The animal appears to the starting point randomly one by one. It leaves the starting point to its cage by themselves. While there is an installed poster on each of the left and right side. The poster using a different side of hand associated with different animal is showed largely on each of side.
2	Interaction	The children raise one of their hands to lead the certain animal to each of the different cages. For instance, the right hand is for the horse and the left hand is for the tiger.	The animal appearing on the starting point will go to its cage after detecting the raised hand. Either correct or not it will go through.
3	Remembering on information	The children recall their memory or remind the animal associated with each of their hands.	The animal coming up on the starting point will be alternately turn one to each other. For instance, if the first time, the animal appearing on the starting point is a horse, and then the subsequent animal appearing might be a tiger or the same type of the animal at the first stage, since it is set randomly.
4	Problem Solving/ Exercise to take a good Judge	The children can determine and analyze which hand should be raised if the next animal appears on the application screen.	

2.4. Program Application

The design of the game is oriented to give the concept of the right and left hand associated with the specific animal respectively. We assign that the right hand represents a horse and the other represents tiger. On the application, the animal randomly appears one by one on the game display. Then, the children stands up in front of the Kinect sensor to have interaction by raising one of their hands to lead such animal to the correct cage. If it is correct, their hand meets the determined animal and they will get a point. On the other

side, since the object comes up and leaves on the game display one to each other, it can make the children remember and remind again the information relating to the material associated with the animal. In addition, they have to solve the problem by determining which of their hand should be used in order to make the animal goes to the correct cage. The design of the game application interface is divided into 2 modes. Namely, the demonstration mode and the application mode.

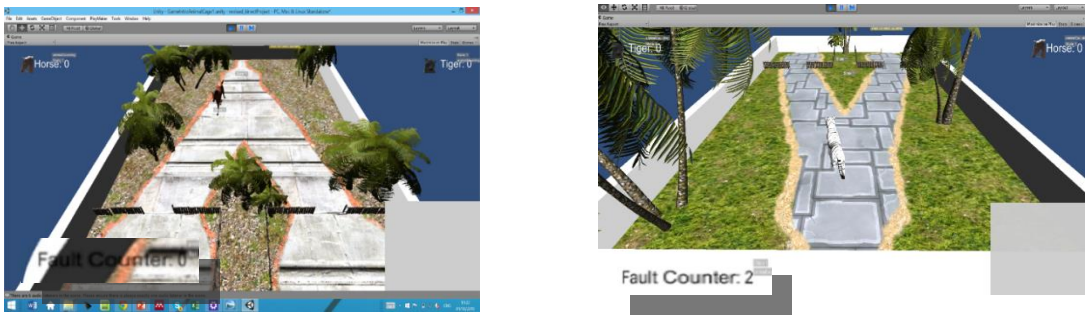
2.4.1. Demonstration Mode

The main purpose of this mode is to give an introduction material related how to play the game and also to reinforce their understanding. In this mode, we first provide the narrative introduction that they can recognize the animal moving automatically from the starting point to each of its cages. The animal appears one by one randomly at the starting point, both of the animals have different cage to make sure that those animals will not fight together in the same cages. The cage is signed by the specific part of the hand and a picture of the animal over each of a poster.

2.4.2. Application Mode

After the children learn from the narrative introduction about the game, then they play the game. In this part, there are 2 different application programs that must be gone through. Each of them has 2 different animals, tiger and horse. These animals come up at starting point one by one randomly. When one of the animals appears at the starting point, the children should lead the animal into the cage by raising their suitable hand as interaction with the animal. The game application program is started by the front side of the application interface as shown in figure 4a. And then, it is followed by the rear side of the application interface as shown in Figure 4(b).

The result of the game application depends on the value of the corrected interaction. When the children do the game application, they have to raise their hand. The application system will record and show on the correct and incorrected-raising hand respectively on the application game display as shown in Figure 4. Each of the value will be calculated to determine whether the children complete the game or not. If the value of the corrected item is more than the standard value which have been fixed in advance, the children succeed to complete the game. Otherwise, the children should repeat the game again from an earlier stage of application.



a. The front side of the application mode b. The rear side of the application mode

Figure 4. (a) The front side of the application mode, (b) The rear side of the application mode

3. RESEARCH METHOD

3.1. Participant

The process of rehabilitation activities was followed by 5 children as the participants who had MMR. They came from 2 different areas of the school, one was from rural and the other was from urban school. The children were 10 years old in average and also they were on the 3rd level of the class in the primary school of special education.

3.2. Research Procedure

The method used in this research was a single subject research [20-21]. This process was divided into 2 steps, namely, the baseline stage and the treatment stage as shown in the Figure 5. The baseline stage was aimed to recognize the participant condition at the earlier stage. This stage had 2 activities, those were

discussing with the teacher and pre-identification. And the other was the treatment stage, which was oriented to do treatment to the participant. This stage also had 2 activities, narrative introduction and game play.

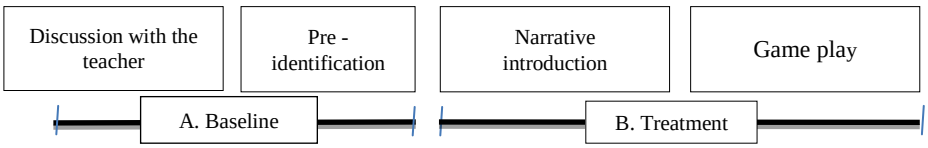


Figure 5. Single Subject Research Procedure

a) Procedure of baseline stage was following:

1. *Discussion with the teacher*. This step was done to have an information in detail about the children who would have rehabilitation. On the other side, the teacher was involved in taking care of the children with MMR through the application to make the student feel relieved at the first time they played.
2. *Pre-identification*. This process was done to recognize the condition of the participant before the game started (Preliminary Description) by giving some questions to the participant. The goal of the questions was to identify the participant's understanding in the concept of right and left hand. We provided all 9 question items. It was divided into 2 classifications. The first category had the truly same 5 questions, which related to the main question about the right and left-hand concept and was aimed to emphasize consistency of the children in answering the question because the answer only had 2 conditions, that was left or right hand. The second category had 4 items with the open question and aimed to determine their ability to mention their daily activity, such as parent's name, the animal's name near to their environment, favorite animal, and their class level.

b) Procedure on the treatment stage

1. *The narrative introduction*. This step was oriented to give the knowledge related to the left and right-hand concept associated with the different animal respectively and the way how to play the game. They watched the narrative introduction displayed before the game started.
2. *The game play*. This step provided the game for the children to play by themselves after the introduction stage. It was oriented to implement the right and left-hand concept. In this stage, the result of the game was recorded through the application system. In addition, there were some rules of the game to make the participant had a maximum result in playing the game. First, the room condition must be conducive to conduct the game. There was no one else who could hamper the participant's concentration because it was easily broken, then they would not want to learn. Second, we put a white strip line to make them stayed in the right position in front of the device. Finally, the period to play the game was conducted in 3 sessions.

3.3. Measurement Variables

In order to measure their learning skill improvement, we used the following valuables:

1. *Mastering the material*, the indicator was the children were able to master the concept of right and left hand. The gain would be achieved by a comparison of the data before and after the children played the game. Which is to say the data resulted before the game started was retrieved by doing pre-identification by questioning the children related to the material and the data resulted after the game finished was retrieved by the program application.
2. *The disturbance level*, this indicator was signed by the children doing any other activities out of the ordering such as they paid attention to the other object, run around the area of the game, moved their leg or others, etc. Those activities could be counted as the disturbing level and hamper their learning [22]. Otherwise, the ordering activity was only just raising the left and right hand, so they could focus to play the game. If the level of disturbances would be going down since the game started until the game completed. That mean, they had an improvement in their learning,
3. *The independence level*, this area was signed by the children who could complete the game during all the sessions independently. As the indicator, the children run the game by themselves or it might be assisted by their teacher. In order to make it simple in classifying the children's independence, we made the conversion values for the level of independence. The following criteria were aimed to recognize the independence of the children.
   a. 0 = value for the children who do not pay attention or have an interest in conducting the game.

b. 1 = value for the children who have the desire to complete the game but they still need full assistances from the teacher.
c. 2 = value for the children who have the desire to complete the game but they need a few assistances from the teacher.
d. 3 = value for that student who have the desire to complete the game fully by themselves.

4. RESULTS AND ANALYSIS

The data resulted from all the activities were shown in Table 2. It would be processed according to each of the measurement level criteria. Those data represented the learning skill started from disturbance level, capability level, and mastering the material. We would like to confirm that the result is appropriate to some of the values. Those are first, the contents of software are age appropriate. Second, this educational software is able to reach educational goals and is used as a tool educational entertainment. Third, these programs promote independent learning [15].

Table 2. Data of participant

1	Name	:	D			L			V			A			M				
2	Age	:	9			9			11			10			11				
3	Class level	:	3			3			3			3			3				
4	Syndrome	:	MMR			MMR			MMR			MMR			MMR				
5	Pre Identification:	:																	
	1 Do you know which one of your right hand or left hand?	:	X			V			X			V			V				
	2 Do you know your parent name?	:	x			V			v			v			v				
	3 Do you know which one of your right hand or left hand?	:	X			V			X			X			V				
	4 Do you know the animal name around you?	:	1 AN			2 ANs			1 AN			Many ANs			Many ANs				
	5 Do you know which one of your right hand or left hand?	:	X			V			X			V			V				
	6 Do you know your favorite animal?	:	x			V			v			v			v				
	7 Do you know which one of your right hand or left hand?	:	V			X			V			V			X				
	8 Do you know your class level?	:	x			V			x			x			x				
	9 Do you know which one of your right hand or left hand?	:	X			X			X			X			V				
	Total Pre- Identification		1			3			1			3			4				
6	Session	:	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		
7	Post-identification	:	3	3	5	1	2	4	3	3	4	3	3	3	4	5	3		
8	Independence level	:	2	2	3	1	2	3	1	2	3	2	3	3	1	3	3		
9	Disturbance level	:	2	2	1	0	0	0	2	1	1	3	2	2	2	1	1		

Note:
MMR = Mild Mental Retardation
AN = Animal's name
Many ANs = More Than 3 AN
X (Incorrect answer) and V (correct answer) related to the right and left-hand concept
x (Incorrect answer) and v (correct answer) had no relation to the right and left-hand concept

4.1. Mastering the Material

This area was oriented to measure the children's learning skill. Therefore, the data used were related to the children's correct answer of the right and left-hand concept as the specific skills. Based on Figure 6, the participant initialled D had a good result with increasing 100% since she showed maximum correct answer at the end of the session. The other participant initialled L and V had a progress respectively 20%, and 60%. In addition, the progress trend since the first till the last session, for participant D, L, and V had undergone an increasing correct value. Except, the one initialled A, he had the same value between pre and post-identification, and also the other participant with initial M who had a downgrade at the end of the session but actually had a good trend since the first and second sessions. Even in the second part of the practice, he showed a perfect value with 0 mistakes but at the last session, his value was smaller rather than the previous session. As the analysis, he might be a bit nervous in doing the practice.

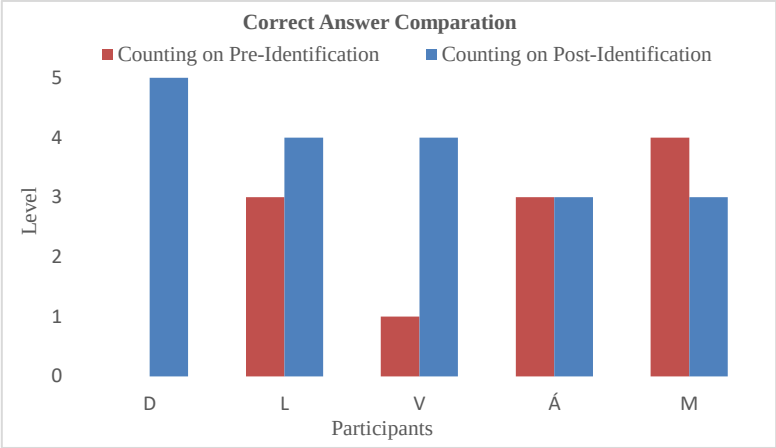


Figure 6. Correct Answer Comparison

4.2. Disturbances Level

This area was leveraged by the children intrusions. All these activities were counted to know the disturbance level. Otherwise, the activity just in the order was only raising their left or right hand. The data from Table 2 relating to disturbance level had converted into the chart in Figure 7. Based on it, which the disturbance trend graph for all the participant was getting down. In the earlier stage most of them had a bigger value of disturbance level. But after several sessions, the result was getting better. Some of them at the starting phase had done some unnecessary deeds such as they played around whole the corner of the game area, played on some of the computer devices, revolved around the devices sensor, etc. But after having another session they could reduce that unnecessary deed, even they could complete the game almost with no disturbances, like what had shown for the participant with initialled L. So, they could learn the concept with less disturbances.

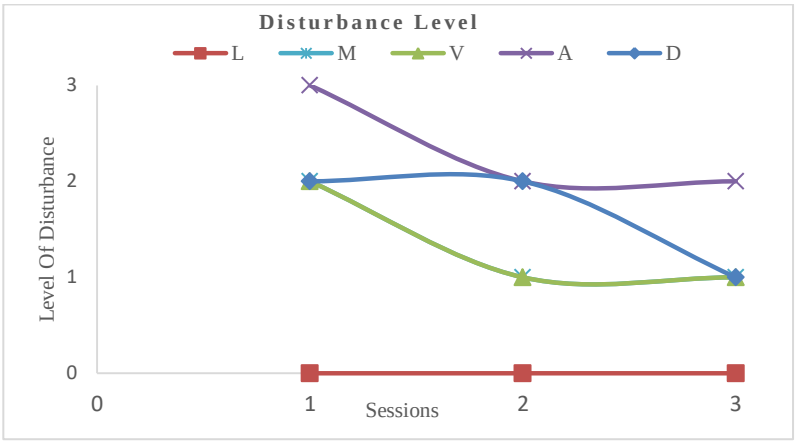


Figure 7. Disturbance Chart

4.3. Independence Level

This area showed the independence ability of the children to complete the game. As the indicator, a participant could play the game by him/herself or it might be assisted by the teacher. Y axis was representing the level of the children in doing the game, it had ranged from 0 – 3 and X-axis was representing a period in conducting the game. The data showed in the Table 2 which had been converted into the graph.

Based on Figure 8, on the first session all the children need full assistance from the teacher. But on the second part of the session they started to do much better in doing the game with a little assistance and the subsequent session particularly session 3 in average they could do by themselves without assistance from the teacher anymore. Therefore, in general, all participant had a significant progress in game operation, their

potential ability would be improved if they could be positioned in the suitable treatment. It can show us that they can do better to have independence learning.

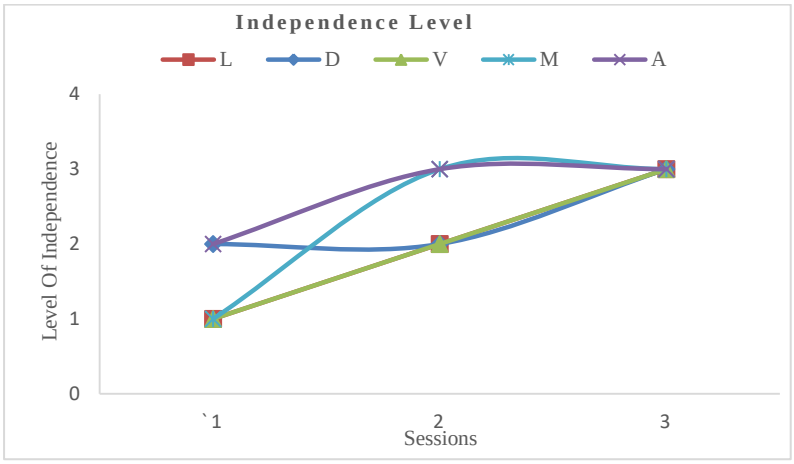


Figure 8. Capability Chart

5. CONCLUSION

The children with MMR had been treated by the ITG rehabilitation to encourage them to learn. As the result, they could recognize the right and left-hand side. It was proved by the value of correct answer that they had undertaken, most of them has much progress in learning skill. In addition, the other variable such as disturbance level and independence level can support them in the way they learn to achieve the learning skill. For instance, in independence level, they can undertake the game application by themselves, even though in the earlier of practicing process they need assistance fully from the teacher. In disturbance level, they can eliminate the disturbance over the session they go through. For future work, we are going to handle another variable of an intellectual function using speech detection. It will be implied to another concept of material with the different way of detection. It would try to improve their speech articulation through voice detection.

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REFERENCES

[1] H.J. Grossman, *et al*., "AAMD: Classification in Mental Retardation", *American Association on Mental Deficiency*, Washington, DC 20009, 1982.
[2] R.K. Deuel, "Mental retardation: definition, classification, and systems of supports (10th ed)", *Journal of Pediatric Neurology*, vol. 29, no. 1, p. 80, 2003.
[3] American Psychiatric Association, "Diagnostic and Statistical Manual of Mental Disorders", *In Arlington*, 2013.
[4] O.J. Seay, "Evaluating Mental Retardation For Forensic Purposes", *Appl. Psychol. Crim. Justice*, vol. 2, no. 3, pp. 52–81, 2006.
[5] C. Beavis, S. Muspratt, and R. Thompson, "'Computer games can get your brain working': student experience and perceptions of digital games in the classroom", *Learn. Media Technol.*, pp. 1–22, 2014.
[6] S. Mami, M. Karami and K. Ghatari, Z. Bahrami, "The Effectiveness of Cognitive Behaviour Game Therapy on Developing Social Skills in Mentally Retarded Children", *Indian J. Fundam. Appl. Life Sci. ISSN*, vol. 4, pp. 1581–1584, 2014.
[7] A. Agarwal and Y.P.A.L. Singh, "Computer Gaming For Children With Mental Retardation", *Spectr. A J. Multidiscip. Res.*, vol. 1, no. 8, 2012.
[8] R. Garris, R. Ahlers, and J. E. Driskell, "Games, Motivation, and Learning: A Research and Practice Model", *Simul. Gaming*, vol. 33, no. 4, pp. 441–467, 2002.

[9] M.A.R.D. González-Ortega, F.J. Díaz-Pernas, M. Martínez-Zarzuela, "A Kinect-based system for cognitive rehabilitation exercises monitoring", *Comput. Methods Programs Biomed.*, vol. 113, no. 2, pp. 620–631, 2013.
[10] V.I. Kozyavkin, O.O. Kachmar, V.E. Markelov, V.V Melnychuk, and B.O. Kachmar, "Web-based home rehabilitation gaming system for balance training Patient", in *Proc. 9th Intl Conf. Disability, Virtual Reality & Associated Technologies*, pp. 10–12, 2012.
[11] S.T. Chen, Y.G.L. Huang, and I.T. Chiang, "Using somatosensory video games to promote quality of life for the elderly with disabilities", *Proc. 2012 4th IEEE Int. Conf. Digit. Game Intell. Toy Enhanc. Learn. Digit.* 2012, pp. 258–262, 2012.
[12] D. Kuswardhana and S. Hasegawa, "Improving Concentration Through Picture Selecting Game Based on Kinect Sensor for Student with Intellectual Deficiencies", in *2015 International Conference on Information, Communication Technology and System*, pp. 3–6, 2015.
[13] R.E. Boyatzis, and D.A. Kolb, "From learning styles to learning skills: the executive skills profile", *Journal of Managerial Psychology*, Vol. 10 Iss: 5, pp.3 – 17, 1995.
[14] Higgins S, Baumfield V, Hall E, "Learning skills and the development of learning capabilities", Report. In: *Research Evidence in Education Library*. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London. 2007.
[15] A. Dandashi, A., Saad, S., Karkar, A.G., Barhoumi, Z., Al-Jaam, J., & El Saddik, "Enhancing the Cognitive and Learning Skills of Children with Intellectual Disability through Physical Activity and Edutainment Games", *Int. J. Distrib. Sens. Networks*, vol. 2015, pp. 1–11, 2013.
[16] W.E. Mueller and G.H. Massiha, "An Interactive Game to Enhance Student Understanding of Materials Management", *International Journal of Evaluation and Research in Education (IJERE).* Vol. 1, No. 2, pp. 45-50, 2012.
[17] D. Kuswardhana and S. Hasegawa, "Animal Thematic Game Based on Kinect Sensor for Mental Retardation Rehabilitation", in *Proceedings of the 23rd International Conference on Computers in Education. China: Asia-Pacific Society for Computers in Education Animal*, pp. 509–514, 2015.
[18] J.A. Abubakar, A.A. Mutalib, D. Permadi,"Design and Development of Curious Jojo©: A Go-Green 3D Game on Android", *TELKOMNIKA Indonesian Journal of Electrical Engineering*. Vol. 11, No. 6, pp. 3123-3129, 2013.
[19] D. Kuswardhana & S. Hasegawa, "A Conceptual Model of Instructional Thematic Game for Children with Intellectual Deficiencies", *Human-Computer Interaction International 2016 - Posters' Extended Abstracts (Part II). Communication in Computer and Information Science*. Vol. 618, pp. 243–248, 2016.
[20] S. Zhan and K.J. Ottenbacher, "Single subject research designs for disability research", *Disabil. Rehabil.*, vol. 23, no. 1, pp. 1–8, 2001.
[21] J.A. Campbell, "Single-Subject Designs for Treatment Planning and Evaluation", *Adm. Policy Ment. Health*, vol. 19, no. 5, pp. 335–343, 1992.
[22] H. Kellerman & A. Burry, "Handbook of Psychodiagnostic Testing (4th Edition)". Springer. 2007

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