A Natural User Interface Game for the Evaluation of Children with Learning Difficulties

Eleni Chatzidaki[1], *Michalis Xenos*[2], *Charikleia Machaira*[3]

[1]Hellenic Open University, Patras, Greece
[2]Computer Engineering and Informatics Department, University of Patras, Greece
[3]Centre for Differential Diagnosis, Diagnosis and Support, Athens, Greece
echatzidaki@eap.gr, xenos@upatras.gr, hara.machaira@gmail.com

Abstract

This paper presents *Kin-LDD* (stands for Kinaesthetic Learning Difficulties Diagnosis), which is a tool that supports the special educators during the assessment process of children's learning difficulties. Children using *Kin-LDD*, instead of participating in a tedious and extensive process, they are playing a game. The tool is using a natural user interface for the children-computer interaction, combining gestures and typical mouse usage. *Kin-LDD* provides a set of activities, by presenting the material in text, images, and sounds. *Kin-LDD* is also available to school teachers and parents, for the early identification of learning disabilities before engaging a special educator, but mostly is a tool for special educators to include the 'fun' factor into the diagnostic process. The tool offers activities for spatial orientation, time orientation and storyboard sequencing and reports a set of key performance indicators, related to each child's performance in these activities, to the special educators helping them towards the diagnosis.

Index Terms: child computer interaction, educational software, gaming interfaces, natural user interface, diagnostic tools, learning difficulties

1. Introduction

In this study, our goal is to introduce 'fun' into a diagnostic process for children that is tedious, extensive and definitely not fun: the process of screening children for the identification of learning difficulties. Towards this goal, we have created *Kin-LDD* (stands for Kinaesthetic Learning Difficulties Diagnosis), a game that uses a natural user interactivity interface, introducing gestures to aid and gamify a part of the screening process. The efficiency of the usage of gestures in this game facilitates the diagnosis by offering a set of key performance indicators (KPIs) to the special educators. The use of the *Kin-LDD* makes the diagnosis more fun for children, while engaging them more actively in the process. Therefore, *Kin-LDD* is a serious game offering a set of activities for children. Although the term 'serious game' is a contradiction, since games are supposed to be fun by definition [1] and educational games are expected to be more 'serious' than the games used only for entertainment, deliberate effort was put to make this game fun for children.

The term 'children with learning difficulties' was introduced by Kirk and Bateman [2] and includes these children who show an evolutionary heterogeneity to their psychological functions, which restricts learning in such way that they need a special educational program [3]. Learning difficulties include common learning disabilities (such as Dyslexia, Dyscalculia, Dysgraphia), auditory and visual processing disorders, and attention disorders (such as the Attention Deficit Hyperactivity Disorder (ADHD)) and are related to emotional, social, behavioural and cognitive development of the children [4].

Children with such learning difficulties often demonstrate reduced capacity of time perception [5] and in some cases difficulties in perceiving space (i.e. to distinguish the right and left), the directions, as well as to calculate distance and speed [6]. Additionally, the use of natural user interfaces that include gestures can stimulate development of motor skills in children [7] and in particular in children with learning difficulties [8]. Utilising such interfaces, children interact more naturally using gestures while body and brain stimulation occurs during play. Although there are examples of games for children with learning difficulties, to the best of our knowledge, this is the first time a game that is using a natural user interface is used in the diagnostic process. In this case the use of the natural user interface not only eases the Children-Computer Interaction (CCI), but also serves as a parameter for the children's performance.

The diagnostic process of the evaluation of learning difficulties is, most of the times, an unpleasant procedure for children. This is mainly because: a) the tasks that children should accomplish are test-based, often using just pen and paper, b) the duration of the whole procedure is extensive and could last up to two hours, and c) the fact that they are examined by a specialist could make children feel quite uncomfortable during the entire process. Furthermore, for children with ADHD, it is difficult to follow the test-based procedure of the assessment. Therefore, the motivation of our work was to exploit the features of a natural user interface in CCI to make the screening process for the identification of learning difficulties more fun for the children.

The rest of the paper is structured as follows: Section 2 presents a short literature review from the fields that the tool is based on, section 3 outlines the approach followed to create *Kin-LDD* and section 4 presents the tool *per se*. Finally, section 5 summarises the main results and discusses limitations and future work.

2. Literature review

The work on the design and development of *Kin-LDD* was based on previous works on three fields: a) children with learning difficulties and the diagnostic procedure this tool is assisting in, b) games for children with learning difficulties and what are their specific requirements, characteristics and

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usage for facilitating learning, and c) games that are using a natural user interface, including gestures, to stimulate motor skills and improve learning in children with learning difficulties.

2.1. Children with learning difficulties

Numerous definitions of learning difficulties [9-11] have followed Kirk's [2] definition, and, as Hammill [12] presents, despite there are differences on definitions, there is a consensus that learning difficulties refer to a heterogeneous group of difficulties that are intrinsic to the individual, follow them for their whole life and, although this difficulties may occur concomitantly with other more serious handicapping conditions, they are not the result of those conditions.

The identification of learning disabilities happens usually between the age of 5 to 8 years (mean age 84.2 months) and only a small percentage of these children (12%) are identified by a physician [13], while most cases were identified by parents and teachers during school and confirmed by a special educator. In school, teachers collect data from various resources that include daily observation and assessment of children's' performance. Although the number of children with learning difficulties is around 13% of the worldwide children population [14] and learning difficulties are acknowledged as a serious problem, the identification of such difficulties is not easy. Learning difficulties differ from each other both in terms of their potential causes and in how they are manifested and dealt with in practice. For this reason, it is very difficult to formulate detailed ways of diagnosing and addressing learning difficulties that are applicable for all cases. Each category of learning difficulties requires a distinct method and process of diagnosis and treatment. But even in the case of difficulties falling under the same category, there are differences from person to person.

The diagnosis is made using specific weighted tests [15-19] that compare the child's level of fitness with what is considered normal development for that age, combined with interviews, observation of the child's behaviour and history recording. While in most cases these tests are done on paper, computer-based tests [20-23] are used to mostly automate the test completion and are performed on typical desktop computers using keyboard and mouse.

In this field, *Kin-LDD* offers a tool for the special educator, providing KPIs for important parameters such as the time and spatial orientation and storyboard sequencing, while children are playing a game.

2.2. Games for children with learning difficulties

Kin-LDD is a serious game, since it is a game that "entertainment, enjoyment or fun is not its primary purpose" [24]. Such games have been used extensively for education purposes today for both children and adults [25-28] and make a multibillion market worldwide [29].

The use of technology to assist children with learning difficulties was acknowledged very early [30], as well as that computer-assisted learning can be extremely valuable for children with multiple difficulties [31]. In the literature, several games are used to improve reading and learning skills of children, while some focus on children with learning difficulties. Charlton et al. [32] used a set of games like word puzzles, card and board games in the classroom for children with learning difficulties. Their results showed that children improved their performance on reading when educational games were in effect. Frutos-Pascual et al. [33] used serious games for children and adults with time management and organisational problems. Cassar and Jang [34] investigated the effects of using a game-based instructional approach to improve word recognition and spelling with children diagnosed with reading difficulties and ADHD. *GraphoGame* [35] is a game for children learning to read Finnish, assisting children with dyslexia as well as non-native children that are learning to speak Finnish. *ECHOES* [36] is a project for children with high-functioning autism and Asperger Syndrome that allows children to interact with intelligent virtual characters and socially realistic environments, within a rich, multi-modal 3D environment.

There are not many works using games for the identification of learning difficulties. Theodoropoulos et al. [37] use a game to investigate whether the child's cognitive style is factor that differentiates the way they perceived the learning experience through games. *CoPS* [38] is a computer-based cognitive assessment system that includes eight tests of basic cognitive abilities, including phonological awareness, auditory discrimination, and short-term visual and auditory-verbal memory. *CoPS*, which is a set of computer-based tests, could also be categorised as a game since the tests include animals like rabbits and cartoon characters and while children are interacting with it, they are effectively participating in the test, however, interaction is performed only by using the keyboard and mouse.

In this field, *Kin-LDD* is a serious game that collects indicators that will be used for the diagnosis of learning difficulties, while children play a game.

2.3. Games using gestures for children with learning difficulties

Natural user interaction in games, in a combination with learning context, has been the main focus of multiple studies throughout the recent years, with gestures and body movement being among the key areas of interest [39]. Interactivity using gestures and body movements, provides the means to enhance learning motivation, performance and children's engagement in the educational environment [40]. Gesture-based serious games have many advantages compared to classical methods, such as the physical activity, the feeling of active participation in the learning procedure and the better understanding of the content [41].

Additionally, there has been an increase of studies which use serious games and natural user interfaces in an educational environment for children and students with learning difficulties, allowing them to participate in a more fun and natural learning environment, using hand and body gestures. Works in this area include the use of motion-based interaction for children with autism [42, 43] and for children with disabilities, based on the child's acceptance, motivation, learning styles and performance to enhance the learning procedure [44]. In the study of Hsiao and Chen [45] for preschool children, the development of an interactive game, is proposed, to improve their learning performance and motor skills. Sales et al. [46] present positive findings when children with learning difficulties are taught reading and writing through gesture-based interfaces. In the study of Kourakli et al. [8], children with special educational needs, use a set of games with gesture interactivity to improve their cognitive, motor and academic skills.

Therefore, *Kin-LDD*, by offering a gesture-based interactivity, induces fun in the diagnosis process, while providing KPIs for each child's motor skills.

3. Approach

Our approach focuses on helping special educators to identify children's potential learning difficulties, in a more natural and pleasant environment for children. The tool can also be used by school teachers or parents, before an appointment with a special educator is scheduled, as a means of providing an early warning that a child may need further evaluation. In particular, for Greece, according to the law introduced in 2008 (Law 3699/2008), the assessment of children with special needs takes place at a Centre for Differential Diagnosis, Diagnosis and Support, by a special educator.

In such centres, children are evaluated for their learning difficulties by appointment in a one to one session with a special educator. During a typical diagnostic process, the subject is presented with a series of questionnaires and exercises to undertake using mostly pen and paper. This process is unattractive for children, who feel they are tested against their intelligence and are subsequently stressed, furthermore skewing the test results. This is especially true for children with ADHD, since the fact that they are obliged to sit in a chair for about two hours is inconvenient and frustrating.

Usually before an appointment with a special educator precedes a school teacher's review. Each academic year, school teachers fill in a form detailing each child's behaviour and educational performance and highlighting potential links to learning difficulties. This is a typical practice, since teachers should plan an alternative form of gradual assessment, in combination with traditional methods of evaluation [47]. Therefore, *Kin-LDD* could also be useful to these teachers, using it as a form of confirmation for specific aspects related to learning difficulties, before they urge parents to evaluate their child's learning difficulties by a special educator.

Regarding the *Kin-LDD* methodology, the tool investigates mental skills related to time and spatial orientation and storyboard sequencing, while using physical gesture pattern detection, via a natural user interface, to measure children's motor skills. Mental skills refer to the way the information is being processed, which includes the following steps: a) receiving of the information, b) understanding the information, c) defining the appropriate response, and d) performing the movement [48]. Additionally, motor skills relate to the procedure of an individual, achieving a predefined goal by acting instinctively and making their body do something or follow certain body movements [49, 50]. The development of motor skills plays a key role to the expression of children's learning behaviour [45].

For spatial and time orientation, children with dyslexia or similar learning difficulties, usually have slow visual or acoustic information processing, while many of them have problems dealing with spatial and time orientation, left-right discrimination and directionality [51]. Visual-spatial impairments is also a characteristic of children with nonverbal difficulties which results in a spatial orientation inability and in a difficulty to perceive distances [52]. To examine these parameters, *Kin-LDD* includes activities corresponding to the respective abilities.

Furthermore, the design and development of the tool's activities was based on the questionnaires presented in the previous section, as well as on specific questionnaires in Greek (the "ΛΑΤΩ" questionnaire), which are used by the special educators during the evaluation sessions. It is also based on the assessment form, used by teachers in Greek schools. The first step towards designing and implementing the tool, was to analyse these questionnaires. The content was classified in sub-categories, based on the type of the ability assessed in each questionnaire. The next step was to decide the selection of the categories to be included in the tool. Afterwards, to design the appropriate activities to be developed and design the CCI for the tasks to be presented to the children. Finally, the KPIs were implemented to report on the precision, duration and accuracy of the CCI and to be used as indicators of motor skill performance.

Therefore, *Kin-LDD* is a tool for special educators helping them to: a) reduce the duration of the diagnostic process, b) track the duration of each activity, c) store the results of the process for post-processing, and d) make a part of the process more exciting and attractive for children. Additionally, *Kin-LDD* could be used by parents and school teachers, to aid in evaluating their children's learning skills.

4. The *Kin-LDD*

The name *Kin-LDD* is selected to imply the use of kinaesthetic interactivity offered to the children through Kinect hardware, while LDD stands for 'Learning Difficulties Diagnosis', which is the scope of the tool. Microsoft Kinect is used for the implementation of gesture recognition. Kinect [53] is a motion sensing device, which includes an RGB camera, a depth infrared sensor and a multi-array microphone and its functionality includes capturing of hand gestures, body movements and voice commands.

The game is segregated into two modules. The first module consists of spatial orientation activities and the second, time orientation tasks, which also includes storyboard sequencing and categorisation based on time. All the activities in both modules are presented by text, images and sound. The natural interactivity is achieved by the 'selection' and 'move' gestures. The children can select an object by placing their hand on it and holding it for a while. The moving (drag and drop) of an object is achieved by closing their hand and releasing it, on the new position.

At the end of each module, *Kin-LDD* provides a positive feedback "*Congratulations! You have completed successfully the session!*" to each child, regardless of the success or failure of each activity. The aim of this positive feedback is to reduce the sense of being under assessment and to sustain the child's positive state of mind for the activities that will follow.

4.1. Spatial orientation

During the interactivity in spatial orientation module, the children are asked to select objects from each activity screen. The task they should fulfil is displayed as a text, as well as sound, since a narrator reads the instruction on each screen of the game. Also, when the user hovers over the speaker icon, the current activity instructions sound file is replayed. The spatial orientation directions are: a) right, b) left, c) up, d) down (or under), e) in front of, f) behind, g) in the middle, h) between, i) inside, k) outside, and l) next to. Totally, eighteen

activities are included in this module. Figure 1 is a screen from the activity 'in front of'.

Figure 1: *Select the flower in front of the girl*

4.2. Time orientation

The time orientation module of the game is composed of activities that clearly express the past, present and the future time in the available screens. More specific, the groups of the activities are: a) stories with sequence of events (storyboard sequencing), b) activities concerning a clear distinction of chronological order, c) activities with categorisations based on time, and d) activities concerning the age. A total of ten (more complex than the ones of the first module) activities are included in this module.

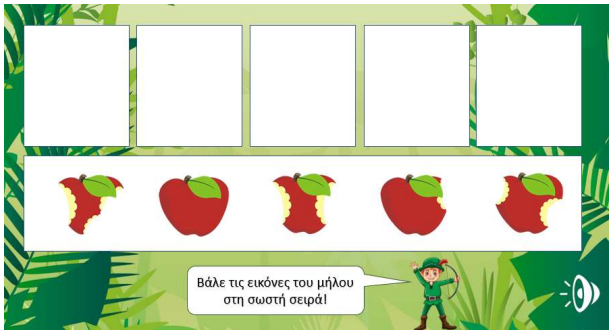

Figure 2: *The apple*

To complete each task, the children are asked to either put images in the correct order, or categorize the images, or place the images in the correct position. An example of time orientation tasks is presented in the Figure 2, where the user should place the apple objects in the correct order based on how an apple looks like before it is bitten, during and after. This activity, is part of the group of activities concerning a clear distinction of chronological order. The activity in Figure 3 presents the story of a boy growing up. To complete this task, the children must order the pictures of the boy starting from younger to older.

4.3. Key Performance Indicators

During the CCI in the game, KPIs are stored to help the special educator in the retro-respective analysis of each child's interaction.

For the activities where 'selection' is the expected children action, the KPIs include: a) the duration of each task (the time begins counting from the appearance of the first screen, until the selection has been completed, regardless of the result), b) the count of the correct and incorrect choices for each activity, c) the precision of each selection, and d) the number of the selection attempts (how many times did the child attempted to select an object unsuccessfully in each activity).

In the activities where 'drag and drop' is the expected children action, the KPIs include: a) the total duration of the task (the time begins counting from the appearance of the screen, until the last object has been placed on the target area), b) the time needed for the drag-and-drop action for each object of the activity, and c) in the case the children drag and drop the objects in incorrect order, the count of the wrong objects in the sequence at the end of the scene. All the above KPIs are stored in a file, which the special educator can access and process for further analysis.

Figure 3: *Growing up*

5. Conclusion, limitations and future work

This paper presents *Kin-LDD*, a game for children, which is also a tool for special educators helping them to collect data for spatial, time and storytelling issues related to learning difficulties. The game uses a natural user interactivity interface, introducing gestures to gamify the screening process for learning difficulties. The use of *Kin-LDD* makes the diagnostic process more fun for the children, while engaging them more actively in the process.

A limitation of this work is that children with multiple problems that include reading, vision and kinetic difficulties might have problems using the game. Another limitation is that, although teachers and parents can use *Kin-LDD* to collect data, the analysis of the key performance indicators related to each child's performance in the game activities, requires a special educator.

Future work includes reporting on qualitative and quantitative results from the use of *Kin-LDD*, which is a lengthy process, due to the special nature of the diagnostic process. This process will produce a data set from the children's activity results, which could be further analysed automatically. Internationalisation of the tool, by adding activities in more languages (currently there is only available in Greek) is another future goal.

6. References

[1] J. Breuer, and G. Bente, "Why so serious? On the relation of serious games and learning," *Journal for Computer Game Culture,* vol. 4 (1), pp. 7-24, 2010.

[2] S. A. Kirk, and B. Bateman, "Diagnosis and remediation of learning disabilities," *Exceptional Children,* vol. 29, no. 2, pp. 73-78, 1962.

[3] S. A. Kirk, "Specific learning disabilities," *Journal of Clinical Child & Adolescent Psychology,* vol. 6, no. 3, pp. 23-26, 1977.

[4] W. N. Bender, and M. E. Wall, “Social-emotional development of students with learning disabilities,” *Learning Disability Quarterly,* vol. 17, no. 4, pp. 323-341, 1994.
[5] A. Smith, E. Taylor, J. Warner Rogers, S. Newman, and K. Rubia, “Evidence for a pure time perception deficit in children with ADHD,” *Journal of Child Psychology and Psychiatry,* vol. 43, no. 4, pp. 529-542, 2002.
[6] P. Satz, and R. Morris, “Learning disability subtypes: A review,” *Neuropsychological and cognitive processes in reading*, pp. 109-141, 1981.
[7] A. I. Wang, and J. G. Ibanez, “Learning recycling from playing a kinect game,” *Department of Computer Science and Technology, Norwegian University of Science and Technology, Trondheim*, 2014.
[8] M. Kourakli, I. Altanis, S. Retalis, M. Boloudakis, D. Zbainos, and K. Antonopoulou, “Towards the improvement of the cognitive, motoric and academic skills of students with special educational needs using Kinect learning games,” *International Journal of Child-Computer Interaction,* vol. 11, pp. 28-39, 2017.
[9] B. Bateman, “An educator's view of a diagnostic approach to learning disorders,” *Learning disorders,* vol. 1, pp. 219-239, 1965.
[10] C. E. Kass, and H. R. Myklebust, “Learning disability: An educational definition,” *Journal of Learning disabilities,* vol. 2, no. 7, pp. 377-379, 1969.
[11] L. B. Silver, “A review of the federal government's Interagency Committee on Learning Disabilities report to the US Congress,” *Learning Disabilities Focus*, 1988.
[12] D. D. Hammill, “On defining learning disabilities: An emerging consensus,” *Journal of learning disabilities,* vol. 23, no. 2, pp. 74-84, 1990.
[13] J. S. Palfrey, J. D. Singer, D. K. Walker, and J. A. Butler, “Early identification of children's special needs: A study in five metropolitan communities,” *The Journal of Pediatrics,* vol. 111, no. 5, pp. 651-659, 1987.
[14] T. D. Snyder, C. de Brey, and S. A. Dillow, “Digest of Education Statistics 2014, NCES 2016-006,” *National Center for Education Statistics*, 2016.
[15] D. D. Hammill, *DTLA-4: Detroit Tests of Learning Aptitude*: Pro-ed, 1998.
[16] B. Van de Rijt, J. Van Luit, and A. Pennings, “The construction of the Utrecht early mathematical competence scales,” *Educational and Psychological Measurement,* vol. 59, no. 2, pp. 289-309, 1999.
[17] M. Shinn, and M. Shinn, “AIMSweb training workbook: Administration and scoring of reading curriculum-based measurement (R-CBM) for use in general outcome measurement,” *Eden Prairie, MN: Edformation*, 2002.
[18] F. B. Wood, D. F. Hill, M. S. Meyer, and D. L. Flowers, “Predictive assessment of reading,” *Annals of Dyslexia,* vol. 55, no. 2, pp. 193-216, 2005.
[19] D. Wechsler, "Wechsler intelligence scale for children–Fifth edition (WISC-V): Technical and interpretive manual," Bloomington, MN: Pearson Clinical Assessment, 2014.
[20] C. Singleton, J. Horne, and K. Thomas, “Computerised baseline assessment of literacy,” *Journal of Research in Reading,* vol. 22, no. 1, pp. 67-80, 1999.
[21] A. Protopapas, C. Skaloumbakas, and P. Bali, “Validation of unsupervised computer-based screening for reading disability in the Greek elementary Grades 3 and 4,” *Learning Disabilities: A Contemporary Journal,* vol. 6, no. 1, pp. 45-69, 2008.
[22] A. Protopapas, and C. Skaloumbakas, “Traditional and computer-based screening and diagnosis of reading disabilities in Greek,” *Journal of Learning Disabilities,* vol. 40, no. 1, pp. 15-36, 2007.
[23] D. R. Michael, and S. L. Chen, *Serious games: Games that educate, train, and inform*: Muska & Lipman/Premier-Trade, 2005.
[24] R. Van Eck, “Digital Game-Based Learning: It's Not Just the Digital Natives Who Are Restless,” *EDUCAUSE Review,* vol. 41, no. 2, pp. 16, 2006.
[25] H. Kelly, K. Howell, E. Glinert, L. Holding, C. Swain, A. Burrowbridge, and M. Roper, “How to build serious games,” *Commun. ACM,* vol. 50, no. 7, pp. 44-49, 2007.
[26] D. Djaouti, J. Alvarez, J.-P. Jessel, and O. Rampnoux, "Origins of Serious Games," *Serious Games and Edutainment Applications*, M. Ma, A. Oikonomou and L. C. Jain, eds., pp. 25-43, London: Springer London, 2011.
[27] A. De Gloria, F. Bellotti, and R. Berta, “Serious Games for education and training,” *International Journal of Serious Games,* vol. 1, no. 1, 2014.
[28] F. Laamarti, M. Eid, and A. E. Saddik, “An overview of serious games,” *Int. J. Comput. Games Technol.,* vol. 2014, pp. 11-11, 2014.
[29] J. Alvarez, V. Alvarez, D. Djaouti, and L. Michaud, “Serious Games: Training & Teaching-Healthcare-Defence & security-Information & Communication,” *IDATE, France*, 2010.
[30] P. L. Hutinger, “State of Practice: How Assistive Technologies Are Used in Educational Programs of Children with Multiple Disabilities. A Final Report for the Project: Effective Use of Technology To Meet Educational Goals of Children with Disabilities,” 1994.
[31] J. Copley, and J. Ziviani, “Barriers to the use of assistive technology for children with multiple disabilities,” *Occupational Therapy International,* vol. 11, no. 4, pp. 229-243, 2004.
[32] B. Charlton, R. L. Williams, and T. McLaughlin, “Educational Games: A Technique to Accelerate the Acquisition of Reading Skills of Children with Learning Disabilities,” *International Journal of Special Education,* vol. 20, no. 2, pp. 66-72, 2005.
[33] M. Frutos-Pascual, B. G. Zapirain, and A. M. Zorrilla, “Adaptive tele-therapies based on serious games for health for people with time-management and organisational problems: preliminary results,” *International journal of environmental research and public health,* vol. 11, no. 1, pp. 749-772, 2014.
[34] A. G. Cassar, and E. E. Jang, “Investigating the effects of a game-based approach in teaching word recognition and spelling to students with reading disabilities and attention deficits,” *Australian Journal of Learning Difficulties,* vol. 15, no. 2, pp. 193-211, 2010.
[35] M. Ronimus, J. Kujala, A. Tolvanen, and H. Lyytinen, “Children's engagement during digital game-based learning of reading: The effects of time, rewards, and challenge,” *Computers & Education,* vol. 71, pp. 237-246, 2014.
[36] K. Porayska-Pomsta, C. Frauenberger, H. Pain, G. Rajendran, T. Smith, R. Menzies, M. E. Foster, A. Alcorn, S. Wass, and S. Bernadini, “Developing technology for autism: an interdisciplinary approach,”

Personal and Ubiquitous Computing, vol. 16, no. 2, pp. 117-127, 2012.

[37] A. Theodoropoulos, A. Antoniou, and G. Lepouras, "How Do Different Cognitive Styles Affect Learning Programming? Insights from a Game-Based Approach in Greek Schools," *Trans. Comput. Educ.,* vol. 17, no. 1, pp. 1-25, 2016.

[38] C. Singleton, K. Thomas, and J. Horne, "Computer-based cognitive assessment and the development of reading," *Journal of Research in Reading,* vol. 23, no. 2, pp. 158-180, 2000.

[39] K.-W. Chen, F.-C. Hsu, Y.-Z. Hsieh, and C.-H. Chou, "To design an interactive learning system for child by integrating blocks with Kinect." pp. 20-22.

[40] W.-J. Lee, C.-W. Huang, C.-J. Wu, S.-T. Huang, and G.-D. Chen, "The effects of using embodied interactions to improve learning performance." pp. 557-559.

[41] N. A. R. Ayala, E. G. Mendívil, P. Salinas, and H. Rios, "Kinesthetic Learning Applied to Mathematics Using Kinect," *Procedia Computer Science,* vol. 25, pp. 131-135, 2013.

[42] F. Garzotto, M. Valoriani, and L. Bartoli, "Touchless motion-based interaction for therapy of autistic children," *Virtual, Augmented Reality and Serious Games for Healthcare 1*, pp. 471-494: Springer, 2014.

[43] E. Boutsika, "Kinect in Education: A Proposal for Children with Autism," *Procedia Computer Science,* vol. 27, pp. 123-129, 2014.

[44] M. Too, P. Ong, S. Lau, R. Chang, and K. Sim, "Kinect-based framework for enhanced learning of disabled students." pp. 1-4.

[45] H.-S. Hsiao, and J.-C. Chen, "Using a gesture interactive game-based learning approach to improve preschool children's learning performance and motor skills," *Computers & Education,* vol. 95, pp. 151-162, 2016.

[46] E. S. S. E. B. Sales, D. M. Cavalcante, L. B. Marques, and D. S. das Graças, "A Game for Teaching Children With disability in Reading and Writing in Portuguese using Voice Recognition and Kinect Sensor," IEEE, 2011.

[47] J. G. Elliott, and E. L. Grigorenko, *The dyslexia debate*: Cambridge University Press, 2014.

[48] M. L. Fleming, *Instructional message design: Principles from the behavioral and cognitive sciences*: Educational Technology, 1993.

[49] A. W. Burton, and D. E. Miller, *Movement skill assessment*: Human Kinetics, 1998.

[50] R. A. Magill, and D. I. Anderson, *Motor learning and control: Concepts and applications*: McGraw-Hill New York, 2007.

[51] R. I. Nicolson, and A. J. Fawcett, "Automaticity: A new framework for dyslexia research?," *Cognition,* vol. 35, no. 2, pp. 159-182, 1990.

[52] D. J. Johnson, and H. R. Myklebust, "Learning Disabilities; Educational Principles and Practices," *Foundations of Language,* vol. 8, no. 1, pp. 138-139, 1972.

[53] H.-m. J. Hsu, "The potential of Kinect in education," *International Journal of Information and Education Technology,* vol. 1, no. 5, pp. 365, 2011.