Health, 2014, 6, 2236-2244
Published Online September 2014 in SciRes. http://www.scirp.org/journal/health
http://dx.doi.org/10.4236/health.2014.616259

Scientific Research

Investigating Efficacy of "Working Memory Training Software" on Students Working Memory

Mehrnoosh Fahimi[1], Ali Akbar Arjmandnia[2], Jalil Fathabadi[3]

[1]Tehran University, Kish International Campus, Kish Island, Iran
[2]Department of Psychology, Tehran University, Tehran, Iran
[3]Department of Psychology, Shahid Behesti University, Tehran, Iran
Email: mehrnooshfahimi@ut.ac.ir, arjmandnia@ut.ac.ir, j_fathabadi@sbu.ac.ir

Received 10 July 2014; revised 27 August 2014; accepted 13 September 2014

Abstract

The aim of the present study is developing "Working Memory Training Software", and investigating its content validity and the efficacy of this computerized cognitive training on students working memory. This study is in R & D research category, and it is performed in a semi-experimental design. Its data were collected from students of the third grade (30), fourth grade (30), and fifth grade (12) of primary school. After specifying the software content validity by asking expertise opinions, and investigating these opinions through Spearman Test ($r_s = 1$), these children attended in intervention program for 10 sessions. The subtests of working memory in "Tehran-Stanford-Binet Intelligence Scale" and "Wechsler intelligence scale for children" were conducted in all three groups on the pre-test and post-test. After elimination of the pre-test effect, Paired-Samples T-Test on total scores of subtests of working memory in "Tehran-Stanford Binet Intelligence Scale" ($t = 10.869$, $df = 71$, $r = 0.967$ & $P < 0.05$) and in "Wechsler intelligence scale for children" ($t = 16.809$, $df = 71$, $r = 0.983$ & $P < 0.05$) reveals a significant difference in post-test scores. Based on this study the Working Memory Training Software has proper psychometric properties and causes significant improvement in students working memory performance.

Keywords

Computerized Cognitive Training, Content Validity, Working Memory, Working Memory Training Software

1. Introduction

Today educational psychology considers that learning mostly requires efficient use of working memory (WM).

How to cite this paper: Fahimi, M., Arjmandnia, A.A. and Fathabadi, J. (2014) Investigating Efficacy of "Working Memory Training Software" on Students Working Memory. *Health*, **6**, 2236-2244. http://dx.doi.org/10.4236/health.2014.616259

Our working memory has the ability to remember information, and to process or manage information. It also has a fundamental role in a wide range of complex educational activities such as reading comprehension, calculations, and problems associated with words and simple tasks such as transcription from board and orientation [1]. Working memory is the basic of learning and basic cognitive skills that determines our potential for learning. Even according to some experts, it is more important than intelligence quotient [1].

The important component of executive function is working memory [2] that helps human through life, doing tasks, learning, and intellectual activities [3]. Also a wide range of cognitive abilities, especially engaging with information interference and conflict or distraction are influenced by working memory. Therefore cognitive abilities are essential and predict academic achievement in children [2].

Working memory was first introduced by Baddeley and Hitch (1974). They argued that the concept of working memory must be replaced by the concept of short-term memory [4]. According to Baddeley (2001) and Repovs & Baddeley (2006), working memory has four components of the central executive factor including main component, phonological loop, visual-spatial sketchpad, and temporary storage of events [5]. Each of these components can store certain types of information. The task of phonetic circuit is to storeverbal information and the task of visual-spatial sketchpad is to store visual and spatial information. These two subsectors are in direct contact with central executor that is responsible for the task of coordinating cognitive system [6]. Temporary storage of events maintains and integrates information contained in phonological loop, visual-spatial sketchpad, and long term memory [7].

Working memory is a term referring to a high level skill required for attention resource allocation despite interference or distraction [8] and measures simultaneous storage capacity and manipulation of information [9]. This concept, which is related to attention, problem solving and control of impulsivity skills, is closely correlated with fluid intelligence and is a strong indicator of the extent of educational and career success. Because poor working memory is related to weakness in attention skills, it may cause attention deficit hyperactivity disorder (ADHD) and other difficulties in learning [10]. Of course the importance of working memory in learning is not limited to children and it is important for each learning tasks and each age range. Deficits in working memory have negative impacts on various aspects of cognitive processes [1]. Moreover, working memory affects our socialization due to the need to store and retrieve information from our surroundings.

Since working memory is important at any age range, its deficiency can cause learning and even occupational problems [11]. Working memory capacity significantly increases during childhood [12] and has a distinct change in each age range [6]. Generally, memory range increases rapidly from 6 to 9 years old and then gradually grows until about age 12 [13], then it reaches to its peak and remains constant during adulthood to about age 20 [1]. Also working memory unlike IQ is not associated with parental education level and socioeconomic status. Equal opportunity to strengthen working memory can be provided for children, regardless of past or environmental effects [1]. Therefore, working memory performance can be improved with cognitive training.

Today cognitive practices are presented by psychologists both traditional cognitive rehabilitation and computer. Cognition is defined as the ability to pay attention, receive, and understand information in order to integrate and maintain them in line with effective relationship. Thus, cognitive re-habilitation is a set of methods with interventional strategies in order to rehabilitate clients and aims to reduce the cognitive deficits [14]. In general, the objective of cognitive and behavioral rehabilitation is to increase one's ability to process and interpret information and to improve all aspects of life [15].

Literally, "rehabilitation" is derived from the Latin word "re-habilis", in which "re" refers to one's previous ability and is any action to restore person's missed ability [16]. Traditional cognitive rehabilitation programs are offered individually and in group by a trained person according to the needs of clients in each cognitive capability [17]. Many traditional cognitive rehabilitation programs require face to face communication and are expensive as well [18]. In contrast, computer technology has extensively progressed and made it possible to create training programs focused on cognitive development of children via computer [19].

On the other hand, although the boundary between playing and learning is not always clear and in theories such as Piaget's theory playing is not synonymous with learning [20], there has been strong evidence confirming the link between different types of play and mental development [21]. Access to play devices is one of the strongest predictors of mental development even in the neonatal period [20]. As the main activity of childhood is to play [21], there is no doubt playing can facilitate learning [20]. Playing can enhance verbal skills, social skills, and awareness of feelings and emotions, it also results in self-culture, and it can develop the ability to use complex information and to organize them in a child by creating the ability to subjective review of a situation happened in past for the child [21]. According to Piaget, symbolic or imaginative play that emerges during the second year of a child's life can become an important learning experience [20].

Abilities of a child can be promoted through purposeful games [22]. Games not only affect cognitive development, but also affect physical development, social development and emotional development of children. In addition, games besides entertainment are a great tool to facilitate and motivate learning [23]. Games such as puzzles, matching words and forms, and chess have roles in improving working memory [24]. In several studies, the relationship between motivation and cognitive activities with purposeful has been reviewed [25]-[28].

Today, children have much tendency to play computer games. Computer-based trainings is one of the modern methods of instruction that facilitates teaching and learning using computer-based technologies and has been widely welcomed because of the many benefits compared to traditional training [29]. Learning through computer games can be classified as "active learning". In active learning, the emphasis is on learner's normal contemplation and activity in learning [30] and learner is responsible for learning and understanding the material [31]. In training through computer games, play process acts as a facilitator of learning. Today, active participation of learner in learning process is emphasized rather than learning experience [32].

Computer games besides entertainment can be a great tool to facilitate and motivate learning. It seems that using games is the best way to incorporate meaningful learning and entertainment [23]. Computer and video games provide children the opportunity to do stressful assignments, teach them how to deal with the assignments is a creative manner [33], make learning fun and enjoyable, and encourage students to participate in educational activities by creating a sense of competition [34]. Motivation in learning with computer participation affects learning activities and knowledge acquisition [35], can teach self-assessment to children, and enhance attention and concentration. The use of computer-based interventions and computer games can even improve children's cognitive skills [36].

Much research has been conducted worldwide concerning the impact of computerized cognitive training on working memory of children. Today, research on working memory and ways to enhance its capacity is one of the most important issues in the field of psychology [11].

Brain Ware Safari, a computerized cognitive training, was conducted on 40 children of the first to fourth grade of primary school with a learning disability for 12 weeks. The children were divided in to one control and one experimental group. Children in the experimental group during 12 weeks of intervention dedicated 5 days week for 30 minutes to computerized cognitive training. Pre-test and post-test data showed that subjects of experimental group compared to control group improved significantly in all assessed skills.

"Jungle Memory" is also a brain training program (2011). This weekly program using number of games has been produced and utilized to strengthen working memory [1]. Many studies have been done on this computerized application in United States, Canada, Singapore, Brazil, China, Hong Kong, Australia and New Zealand. Alloway observed progress in students' grades, working memory, and IQ after running "Jungle Memory" for 9 weeks. This group was significantly different from the control group. The software also was run for a group of children with dyslexia disorder in Scotland in 2010 and 2011, and significant progress was achieved in their working memory. At a conference in Scotland in 2010 the results of this software were presented in improving working memory and language and math scores for children with autistic spectrum disorder after training 4 times a week for 8 weeks.

Cogmed is another computer program made for attention problems caused by working memory deficits. This cognitive computer program consists of computer games that according to research in Singapore, the Netherlands and Canada enhance working memory [37].

Moreover, Coglab is also another computer training program developed to enhance attention, perception, sensory memory, short-term memory, neurocognition, working memory, memory processes, Meta memory, and imagery. Several studies have been done on this computer program as well.

According to what was said, although educational psychology considers that learning requires efficient use of working memory and many studies have been conducted on the relationship between working memory and learning and academic achievement in Iran and academic achievement in Iran [38]-[42] and other countries [43]-[47], so far no computer training program for this issue has not been made in Iran.

This study seeks to strengthen the capacity of working memory through developing a proper Iranian Version of purposeful computer games, and has provided the first computer training program to strengthen working memory in Iran so that an appropriate intervention would promote working memory capacity of children efficiently.

2. Methods

This study is in R & D research category. The population included 72 students of the third grade (30), fourth grade (30), and fifth grade (12) of primary school selected by accessible sampling method from Tehran and Kish schools. After specifying content validity of "Working Memory Training Software" Software in this study, subtests of working memory in "Tehran-Stanford-Binet Intelligence Scale" and "Wechsler intelligence scale for children" were conducted as pre-test through Spearman Test. Subsequently, the software was conducted for 10 sessions to verify its effectiveness to strengthen working memory in children. After elimination of the pre-test effect, subtests of working memory in "Tehran-Stanford Binet Intelligence Scale" and in "Wechsler intelligence scale for children" were conducted as post-tests.

3. Research Tool

3.1. Researcher Made Scale to Examine Content Validity of the Software

To determine content validity, software was provided for two experts. Data from judgment of both experts tabulated independently using a four-point scale ranged from "irrelevant" to "extremely relevant". Then, using Spearman correlation coefficient [48], agreement between these two was obtained, this ratio indicates the extent to which the tool reflects the target.

3.2. Subtests of Working Memory in Tehran-Stanford Binet Intelligence Scale

The new version of Tehran-Stanford Binet Intelligence Scale in 2008 by Afrooz and Kamkari with a detailed review of the fifth edition of Stanford Binet Intelligence Scales was developed in 2003 [49]. Tehran-Stanford Binet Intelligence Scale has 10 subtests, 2 of which are related to IQ measure of working memory. Today this view that was introduced by Baddeley (1986) is known as key component of intelligence in school learning [49]. In this test, a class of memory process that stores a variety of information in long-term memory and reviews, saves, or transfers the information is known as working memory [49]. Verbal working memory subtest continues from level 2 to 6. In level 2 and 3 simple sentences and in level 4, 5, and 6 compound sentences are raised. To remember the last word in the sentences start from level 4 and continues to level 6 [49]. Nonverbal working memory subtest continues from level 1 to 6. In the first level, delayed and dismiss neural responses were noted. In level two, three, four, five and six, the process of hitting green cubes is followed. In level 2, a maximum of two cubes and in level 3, a maximum of 3 cubes are hit. This number increased to 5 in level 4, to 7 in level 5, and to 8 in level 6 and complications with emphasis on the cubes can be raised in yellow and red rows [49]. Finally, using the total scaled scores of two subtests of verbal and nonverbal working memory, subject's working memory IQ is identified.

3.3. Subtests of Working Memory in Wechsler Intelligence Scale

Wechsler intelligence scale for children during a research project commissioned by the Department of Education of Chaharmahal and Bakhtiari and under supervision of Isfahan University was conducted on more than 900 subjects after translation and adaptation in 16 regions of the province. Normal tables with a review of 872 answer sheets were prepared by Abedi *et al.* [50]. Subtests of working memory in Intelligence Scale and Kessler Scale are: 1) digit span, 2) sequence of letters and numbers.

In order perform to forward digit span, subject repeats numbers in the same way read aloud by the examiner. For backward digit span the subject repeats numbers inverted, but in this case the numbers are also read out aloud y the examiner [50]. Digit span includes two components that are implemented separately, that means each component is implemented regardless of subject's score for the other component [50]. The maximum score for forward implement is 16, it is 16 for backward, and it is 32 in total [50]. Then, according to tables of benchmark scores and subjects' age, benchmark scores are achieved. Sequence of letters and numbers that is another subtest of working memory in Wechsler Intelligence Scale wants the subject to repeat numbers by ascending order and alphabets by alphabetic order [50]. Each question consists of three attempts. For 6 - 7-year-old children, recognition questions are used in order to be clear that they know counting and alphabet. If participant fails in recognition questions, arithmetic subtest is done [50]. However, in this study arithmetic subtest was not necessary due to age group of subjects.

3.4. "Working Memory Training Software"

The computer program used in this study as an intervention has been produced by the researcher to provide computer cognitive exercises to strengthen working memory in children."Working Memory Training Software" consists of two games in order to strengthen working memory. After developing initial stories of the games, "story board" was used to prepare image. "Story board" or illustrated screenplay is a bridge between a written screenplay and images world of visual media. The best way for visual expression of each action is story [51]. Initial illustration of story board was finalized by "Coral Draw" graphic software. "Coral Draw" software is a vector graphic editor application that is commonly used for drawing and less for editing images. With preparation of images by general-purpose, high-level, object-oriental, and interpreter programming language of Python, coding began. In order to register subject's information, a file called statics was embedded and its information could be converted into "xlsx" format. This file format is related to the database of "Excel". "Microsoft Office Excel" software is software suitable for charting and statistical analysis of data. Finally, after audio recording using "Cubase" recording software, which is one of the most important digital music composition software, volume was adjusted and music and audio files were added to the game.

In general, in these two games it has been attempted to employ verbal working memory (auditory working memory) and visual-spatial working memory. Remembering and following long instructions successfully, remembering long sentences that encompass content, and remembering sentences with complex grammatical structures are activities that cover verbal/auditory working memory [1], which are used in both games. Also, activities such as using images to remember and selecting largeness or smallness according to need that involve visual-spatial working memory [1] have been included in both games.

3.5. Flower Game

In flower game, the main character of story is going to plant a flower for his/her grandmother to give her as a gift. First, the game introduces plant and planting equipment to the child. The introduction of planting equipment is either verbal, written, or as picture. Thus, it targets visual memory and auditory memory. It also results in picture and pattern sense. The child is then expected to choose a suitable pot with respect to plant seen in the previous plan. In next stage, the child should have a correct function to plant the flower using prior knowledge among planting equipment. However, the child is given some instructions about proper function of planting during the game. Therefore, the subject is expected to choose correct options by recalling the planting equipment and the mentioned notes. Overall, in flower game right choice and problem solving with recalling previous data will be reviewed within six questions.

3.6. Cake Game

In this game the main character is going to help his/her father bake a cake for his/her mother's birthday. After choosing cake recipe paying attention to the details of image by the subject, cake recipe for four people is presented in written form and verbal form. Then, the child is expected to choose sweet ingredients from the list that has been appeared as a picture. Subsequently, the child is expected to select a right place to make cake. Moreover, since in the beginning of the story the child is told that the cake recipe is for 4 people but there are 8 people, he/she should choose the amount of ingredients as well. In this game, which is more difficult than flower game, the child is expected to answer to 12 questions by recalling previous data and to make the right choice.

4. Results

Demographic data from this study indicate that 41.7% of subjects were in the third grade, 41.7% if subjects were in the fourth grade, and 16.7% of them were in the fifth grade of primary school. The mean age of the subjects was 9.82. 50% of subjects were girls and 50% of them were boys.

Table 1 indicates descriptive results of pre-test and post-test scores of working memory by grade.

Spearman test ($r_s = 1$) considers cake game as 100% reflecting the target. Content validity of flower game ($r_s = 1$) is also appropriate. Finally, content validity of working memory training software was appropriately evaluated according to coefficient of above test ($r_s = 1$).

In order to evaluate the research hypothesis, paired t-test was used. After intervention and elimination of the pre-test effect, paired-samples t-test on total scores of subtests of working memory in "Tehran-Stanford Binet

Intelligence Scale" (t = −10.869, df = 71, r = 0.967 & P < 0.05) and in "Wechsler intelligence scale for children" (t = −16.809, df = 71, r = 0.983 & P < 0.05) reveals a significant difference in post-test scores (**Table 2**).

5. Discussion and Conclusion

In order to investigate the hypothesis that working memory training affects students' working memory performance, after software content validity paired t-test was used. The results showed that according to Spearman correlation coefficient ($r_s = 1$) content validity is good, *i.e.* components of tool cover content well [48]. When the content validity is high, it can be used with more confidence [52]. Therefore, with 100% confidence this software can be used to enhance working memory.

Mean score of working memory test after interference of "working memory training software" was significantly different. After intervention and elimination of the pre-test effect, paired-samples t-test on total scores of subtests of working memory in "Tehran-Stanford Binet Intelligence Scale" (t = −10.869, df = 71, r = 0.967 & P < 0.05) and in "Wechsler intelligence scale for children" (t = −16.809, df = 71, r = 0.983 & P < 0.05) reveals a significant difference in post-test scores. Therefore, after intervention students' working memory performance improved. According to above results and proper correlation coefficient between scores of pretest and posttest after elimination of intervention effect, answer was given to the hypothesis. It was supported, so working memory training affects students' working memory capacity. The result of the study was consistent with previous studies (e.g. Jungle Memory, Cogmed, Coglab, and Brain Ware Safari).

Selecting equal numbers of boys and girls in each grade was a limitation of the study. This limitation reduces the ability to generalize findings to gender of subjects. Another limitation was the use of computer equipment in

Table 1. Descriptive findings of working memory test.

Minimum	Minimum	Standard deviation	Mean	Step	Scale	Group
132	65	15.837	96.83	Pre-test	Tehran-Stanford-Binet Intelligence Scale	The third grade
132	77	12.579	103.60	Post-test		
129	75	12.37	104.70	Pre-test	Wechsler intelligence	
131	80	11.84	110.06	Post-test		
135	74	17.56	101.86	Pre-test	Tehran-Stanford-Binet Intelligence Scale	The fourth grade
138	80	15.30	106.00	Post-test		
136	83	14.50	106.50	Pre-test	Wechsler intelligence	
138	89	12.77	111.86	Post-test		
129	77	16.61	101.58	Pre-test	Tehran- Stanford-Binet Intelligence Scale	The fifth grade
129	83	14.09	107.83	Post-test		
129	92	13.09	108.16	Pre-test	Wechsler intelligence	
129	92	12.86	111.83	Post-test		

Table 2. Paired t-test in Tehran-Stanford Binet Intelligence Scale and Wechsler intelligence scale for children.

Significant coefficient	Degrees of freedom	t	Mean deviation error	Standard deviation	Mean		
0.001	71	−10.869	0.560	4.749	−6.083	Pretest Scores of Working Memory in Tehran-Stanford Binet Intelligence Scale-Posttest Scores of Working Memory in Tehran-Stanford Binet	paired
0.001	71	−16.809	0.320	2.566	−5.083	Pretest Scores of Working Memory in Wechsler-Posttest Scores of Working Memory in Wechsler	-

schools. As a result, the study was conducted slowly. The next restriction is a research limitation. The study was performed in a semi-experimental design. It was not possible to realize random assignment of subjects the same as experimental studies.

It is recommended to obtain validity of the intervention program, "Working Memory Training Software", using random samples and considering the larger sample size. Another recommendation is to investigate effectiveness of "Working Memory Training Software" on academic performance of children. The researchers are also suggested to perform this intervention for special groups such as children with learning difficulties.

Time impact on the intervention effectiveness has not been evaluated. If a research is able to evaluate the intervention effectiveness after the intervention period at different intervals, long term effectiveness of this treatment modality will be determined.

Studying effectiveness of this intervention for both verbal working memory and visual-spatial working memory can obtain intervention disadvantages for better effectiveness on all aspects of working memory.

Researchers can develop advanced versions of computerized cognitive training programs under net command and thereby they can perform the intervention at homes through the Internet and reduce costs.

Finally, according to the needs of children to such computer programs due to the need to improve cognitive function, schools and officials are recommended to include working memory training programs in school curricula according to grade level, and also to include "Working Memory Training Software" in recreation program of student at schools.

References

[1] Arjmandnia, A. and ShokoohiYekta, M. (2012) Improving Working Memory. Teymoorzadeh Press—Tayyeb Publications, Tehran.

[2] Morales, J., Calvo, A. and Bialystok, E. (2013) Working Memory Development in Monolingual and Bilingual Children. *Journal of Experimental Child Psychology*, **114**, 187-202. http://dx.doi.org/10.1016/j.jecp.2012.09.002

[3] Barkley, R.A. (1998) Attention-Deficit Hyperactive Disorder: A Handbook for Diagnosis and Treatment. 2nd Edition, Guilford, New York, 303-306.

[4] Eysenck, M. and Kin, M. (2009) Cognitive Psychology (Memory). Translated by: Zare, H., Aeezh Publications, Tehran.

[5] Eysenck, M. and Kin, M. (2010) Memory Cognitive Psychology (New Edition). Translated by: Zare, H., Nahrovanian, P. and Abdollahzadeh, H. (2013), Aeezh Publications, Tehran.

[6] Alloway, T.P. and Gathercole, S.E. (2006) How Does Working Memory Work in the Classroom? *Educational Research and Reviews*, **1**, 134-139.

[7] Radmehr, F., Elmolhodaei, H. and Daneshamooz, S. (2011) Review of Individual Differences and Cognitive Approaches in Relation to Working Memory and Mathematical Problem Solving Performance of Learners. *The First National Conference of the Cognitive Science Results on Education*, 23 November 2011.

[8] Baddeley, A.D. (1996) Exploring the Central Executive. *Quarterly Journal of Experimental Psychology Section A*: *Human Experimental Psychology*, **49A**, 5-28. http://dx.doi.org/10.1080/713755608

[9] Baddeley, A. (2000) The Episodic Buffer: A New Component of Working Memory? *Trends in Cognitive Sciences*, **4**, 417-423. http://dx.doi.org/10.1016/S1364-6613(00)01538-2

[10] Shipstead, Z., Hicks, K.L. and Engle, R.W. (2012) Cogmed Working Memory Training: Does the Evidence Support the Claims? *Journal of Applied Research in Memory and Cognition*, **1**, 185-193. http://dx.doi.org/10.1016/j.jarmac.2012.06.003

[11] Dehn, M.J. (2008) Working Memory and Academic Learning. Wiley, Hoboken.

[12] Alloway, T.P. and Alloway, R.G. (2013) Working Memory: The Connected Intelligence. Psychology Press, New York.

[13] Gathercole, S.E. (1999) Cognitive Approaches to the Development of Short-Term Memory. *Trends in Cognitive Sciences*, **3**, 410-419. http://dx.doi.org/10.1016/S1364-6613(99)01388-1

[14] Clare, L. and Woods, R.T. (2001) A Role of Cognitive Rehabilitation in Dementia Care. In: Clare, L. and Woods, R.T., Eds., *Cognitive Rehabilitation in Dementia*, Psychology Press, New York, 193-196.

[15] Sholberg, M.M. and Mateer, C.A. (2001) Cognitive Rehabilitation: An Integrative Neuropsychological Approach. The Guilford Press, New York.

[16] Barret, A.M. and Gonzalez-Roth, L.J. (2002) Theoretical Basis for Psychological Intervention. In: Slinger, P.J., Ed., *Neuropsychological Intervention*, the Guilford Press, New York, 17-37.

[17] Dunlosky, J., Kubat-Silman, A. and Hertzog, C. (2003) Training Monitoring Skills Improves Older Adults' Self-Paced Associative Learning. *Psychology and Aging*, **18**, 340-345. http://dx.doi.org/10.1037/0882-7974.18.2.340

[18] Wadley, V.G., Benz, R.L., Ball, K.K., Roenker, D.L., Edwards, J.D. and Vance, D.E. (2006) Development and Evaluation of Home-Based Speed-of-Processing Training for Older Adults. *Archives of Physical Medicine and Rehabilitation*, **87**, 757-763. http://dx.doi.org/10.1016/j.apmr.2006.02.027

[19] Sandford, J.A. (2003) Cognitive Training and Computers: An Innovative Approach. In: Fine, A.H. and Kotkin, R.A., Eds., *Therapist's Guide to Learning and Attention Disorders*, Academic Press, London, 421-441. http://dx.doi.org/10.1016/B978-012256430-7/50016-8

[20] Hughes Fergus, P. (1999) Game's Psychology: "Children, Game and Growth". Translated by Ganji, K. (2013), Roshd Publications, Tehran.

[21] Singer, D.J. and Singer, J.L. (2001) Fostering Creativity by the Help of Simulate Games. Translated by Hamid Alizadeh, & Alireza Roohi (2012), Javaneh Roshd Publications, Tehran.

[22] Avery, R.E., Smillie, L.D. and de Fockert, J.W. (2013) The Role of Working Memory in Achievement Goal Pursuit. *Acta Psychologica*, **144**, 361-372. http://dx.doi.org/10.1016/j.actpsy.2013.07.012

[23] Akkerman, S., Admiraal, W. and Huizenga, J. (2009) Storification in History Education: A Mobile Game in and about Medieval Amsterdam. *Computers & Education*, **52**, 449-459. http://dx.doi.org/10.1016/j.compedu.2008.09.014

[24] Steele-Johnson, D., Heintz, P. and Miller, C.E. (2008) Examining Situationally Induced State Goal Orientation Effects on Task Perceptions, Performance, and Satisfaction: A Two-Dimensional Conceptualization. *Journal of Applied Social Psychology*, **38**, 334-365. http://dx.doi.org/10.1111/j.1559-1816.2008.00308.x

[25] Gable, P.A. and Harmon-Jones, E. (2008) Approach-Motivated Positive Affect Reduces Breadth of Attention. *Psychological Science*, **19**, 476-482. http://dx.doi.org/10.1111/j.1467-9280.2008.02112.x

[26] Gasper, K. (2004) Do You See What I See? Affect and Visual Information Processing. *Cognition and Emotion*, **18**, 405-421. http://dx.doi.org/10.1080/02699930341000068

[27] Gray, J.R. (2001) Emotional Modulation of Cognitive Control: Approach-Withdrawal States Double-Dissociate Spatial from Verbal Two-Back Task Performance. *Journal of Experimental Psychology*, **130**, 436-452. http://dx.doi.org/10.1037/0096-3445.130.3.436

[28] Phillips, L.H., Bull, R., Adams, E. and Fraser, L. (2002) Positive Mood and Executive Function: Evidence from Stroop and Fluency Tasks. *Emotion*, **2**, 12-22. http://dx.doi.org/10.1037/1528-3542.2.1.12

[29] Hosseinzadeh Shahri, M. and Zangane Nezhad, N. (2013) Evaluation of the Effectiveness of e-Learning Systems. *Journal of Human Resource Management of Imam Hossein University*, **5**, 173-196.

[30] Biabangard, E. (2009) Educational Psychology: Psychology of Teaching and Learning. Virayesh Publications, Tehran.

[31] Seif, A. (2011) Modern Educational Psychology: Learning and Teaching Psychology. 6th Edition, Print 51, Doran Publications, Tehran.

[32] Ao, M.-C. (2006) The Effect of the Use of Self-Regulation Learning Strategies on College Students' Performance and Satisfaction in Physical Education. A Thesis Submitted in Partial Fulfillment of the Requirements of Degree Doctor of Education, Australian Catholic University.

[33] Admiraal, W., Huizenga, J., Akkerman, S. and ten Dam, G. (2011) The Concept of Flow in Collaborative Game-Based Learning. *Computers in Human Behavior*, **27**, 1185-1194. http://dx.doi.org/10.1016/j.chb.2010.12.013

[34] DeLeeuw, K. and Mayer, R. (2011) Cognitive Consequences of Making Computer-Based Learning Activities More Game-Like. *Computers in Human Behavior*, **27**, 2011-2016. http://dx.doi.org/10.1016/j.chb.2011.05.008

[35] Schoor, C. and Bannert, M. (2011) Motivation in a Computer-Supported Collaborative Learning Scenario and Its Impact on Learning Activities and Knowledge Acquisition. *Learning and Instruction*, **21**, 560-573. http://dx.doi.org/10.1016/j.learninstruc.2010.11.002

[36] Veenman, M.V.J., Bavelaar, L., De Wolf, L. and Van Haaren, M.G.P. (2014) The On-Line Assessment of Metacognitive Skills in a Computerized Learning Environment. *Learning and Individual Differences*, **29**, 123-130. http://dx.doi.org/10.1016/j.lindif.2013.01.003

[37] Ralph, K. (2013) COGMED Research Claims & Evidence. Cogmed Working Memory Training, Pearson Clinical Assessment, Australia and New Zealand.

[38] Arjmandnia, A. and Seif Naraqi, M. (2009) The Effect of Mental Rehearsal Strategy on Working Memory Performance of Dyslexic Students. *Journal of Behavioral Sciences*, **3**, 173-178.

[39] Mir Mahdi, R., Alizadeh, H. and Seif Naraqi, M. (2009) Impact of Executive Functions on Math and Reading Performance of Elementary Students with Specific Learning Disabilities. *Research in the Field of Exceptional Children*, **9**, 1-12.

[40] Asadzadeh, H. (2008) Investigating the Relationship between Working Memory Capacity and Academic Performance among Students in the Third Grade of Junior High School in Tehran. *Quarterly Journal of Education*, **97**, 53-69.

[41] Abedi, A. and AqaBabaee, S. (2010) Effectiveness of Working Memory Training on Improving Academic Performance of Children with Mathematics Learning Disability. *Journal of Clinical Psychology*, **2**, 73-81.

[42] Molawi, H. and MirzayeNazer, M. (2002) Comparison of Short-Term Memory, Long-Term Memory, and Working Memory in Normal and Disabled Students in Reading in Students of Third Grade of Primary School in Mashhad (Cognitive Validity of Wechsler Memory Scale). *Journal of Knowledge & Research in Applied Psychology*, **11-12**, 29-44.

[43] Hornung, C., Brunner, M., Reuter, R. and Martin, R. (2011) Children's Working Memory: Its Structure and Relationship to Fluid Intelligence. *Intelligence*, **39**, 210-221. http://dx.doi.org/10.1016/j.intell.2011.03.002

[44] Nevo, E. and Breznitz, Z. (2013) The Development of Working Memory from Kindergarten to First Grade in Children with Different Decoding Skills. *Journal of Experimental Child Psychology*, **114**, 217-228. http://dx.doi.org/10.1016/j.jecp.2012.09.004

[45] Alloway, T.P., Bibile, V. and Lau, G. (2011) Computerized Working Memory Training: Can It Lead to Gains in Cognitive Skills in Students? *Computers in Human Behavior*, **29**, 632-638. http://dx.doi.org/10.1016/j.chb.2012.10.023

[46] Toll, S.W.M. and Van Luit, J.E.H. (2013) The Development of Early Numeracy Ability in Kindergartners with Limited Working Memory Skills. *Learning and Individual Differences*, **25**, 45-54. http://dx.doi.org/10.1016/j.lindif.2013.03.006

[47] Gibson, B.S., Gondoli, D.M., Johnson, A.C., Steeger, C.M. and Morrissey, R.A. (2012) The Future Promise of Cogmed Working Memory Training. *Journal of Applied Research in Memory and Cognition*, **1**, 214-216. http://dx.doi.org/10.1016/j.jarmac.2012.07.003

[48] Hooman, H. (2010) Educational and Psychological Measurement, Test and Questionnaire Preparation Technique. 6th Edition, Peik Farhand Publications, Tehran.

[49] Kamkari, K. (1390) The Practical Guide to the New Version of Tehran-Stanford-Binet Intelligence. Madaresse Karamad Publishing, Tehran.

[50] Wechsler, D. (2009) Implementation and Scoring Guide for the Wechsler Intelligence Scale for Children. Translated by Mohammad Reza Abedi, Ahmad Sadeghi and Mohammad Rabiei, Sina Cognitive Behavioral Sciences Research Institute, Tehran.

[51] Fernandez, I. (2005) Creating Animations with Macromedia Flash. Translated by Babak Ehterami & Shahram Shabani, Danesh Negar Publications, Tehran.

[52] Shokoohi Yekta, M. and Parand, A. (2009) Theoretical Principles of Evaluation and Application of Psychological and Educational Tests Including Tests of Intelligence, Academic Achievement and Character. 2nd Edition, Teymoorzadeh Press-Tayyeb Publications, Tehran.