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The Effects of Assistive Technology on Increasing Capacity of Mathematical Problem Solving in Dyscalculia Students

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Abstract Learning disability (LD) is common problem in present world. Teachers and parents seek the newest instructional methods always. In this research, LD students in particular dyscalculia students are considered at elementary level. Assistive technology (AT) as assistive tools are designed and constructed to help LD students. One of tools of AT is software. The aim of this study is to introduce and design new mathematical software. Via quasi-experimental method, two basic addition and subtraction operations are taught through mathematical software with its special features for LD students at elementary level. Then findings are analyzed thereby ANOVA and sheffe tests. The results indicated that this technology has effect on the performance of these students and also, it is studied that the effect of using AT (Math Explorer software) on increasing ability of mathematical problem solving for dyscalculia students do not follow gender that is there is not significant difference between favorite performance of girl and boy LD students.

Keywords Learning Disabled Students, Dyscalculia Students, Assistive Technology, Math Explorer, Ability.

1 Introduction

According to the Individuals with Disabilities Education Act (IDEA), define a learning disability as a "disorder in one or more of the basic psychological processes involved in understanding or in using spoken or written language, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell or to do mathematical calculations." The Federal definition further states that learning disabilities include "such conditions as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia." According to the law, learning disabilities do not include learning problems that are primarily the result of visual, hearing, or motor disabilities; mental retardation; or environmental, cultural, or economic disadvantage. Definitions of learning disabilities also vary among states. Learning disabilities (LD) are characterized by a significant difference in the child's achievement in some areas, as compared to his or her overall intelligence [1]. Mathematics gains importance because of the importance of mathematics in humans' life and benefits to scientific life. Mathematics teaching at begins pre-school, primary school and then it continue during a big period. We can explain the aim of mathematics such as this: it gives

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mathematical information abilities for daily life necessaries. And also it teaches solving problem and take up thinking style in a solving problem atmosphere [2,3]. In this study, it is considered dyscalculia students and mathematics issues. Dyscalculia students are one of the kinds of people who have difficult in calculations and numerical memory. Often they use of fingers and other instruments to calculate and solve problems. Students with LD struggle with too rapid pacing of introducing new mathematics concepts, and insufficient examples, explanations, practice, and review in general education classrooms [4]. In fact, teachers are willing to provide additional instructional and adapted materials to facilitate the successful learning of students with LD in their classrooms [5]. For LD students with, technology can offer a variety of individualized mathematics instructions to meet their special learning characteristics and to ensure their successful mathematics achievement in general education settings [6,7]. As the quality and availability of technology has dramatically increased in the past decade, researchers and educators have made efforts to apply technology to the mathematics curriculum for students with LD to enhance their mathematics performance [8,9,10,11,12]. The Technology-Related Assistance for Individuals with Disabilities Act of 1998 (Tech Act) was designed to enhance the availability and quality of assistive technology (AT) devices and services to all individuals and their families throughout the United States [13]. Assistive technology (AT) device means any item, piece of equipment, or product system, whether acquired commercially off the self-modified, or customized, that is used to increase, maintain, or improve the functional capabilities of a child or people with a disability. Assistive technology (AT) includes of software and hardware parts. There are special software that are organized and constructed by researchers for dyscalculia students. In this paper, special and simple software is constructed for elementary dyscalculia students as one tool of assistive technology. "Math Explorer" software is used to teach and learn of two basic operations; addition and subtraction for these students. Finally the performance of dyscalculia (LD) girl and boy students are studied regard to this software separately.

2 Literature

There are many researches about learning disabilities. Since this study is considered in term of technology and dyscalculia students, it is selected several researches about this issue; I) Seo and Woo (2010) indicated that computer-assisted instruction programs would be essential for facilitating the mathematical learning of students with learning disabilities. The results of their research shown that mathematics software with special features and capacities can help to learn for learning disabled students [14], in other study, II) Tezer and Kanbul (2009) argued that computer provides a lot of possibilities for disabled students to improve their mathematical abilities. Mathematics is a numerical system and an abstract concept. It is difficult to get abstract concepts. Computer software is a tool which motivates, gives chance for education one by one and also it concrete some abstract concepts. Regard to teachers' opinions, they indicated that if teachers use these computer technology enough and correct, they will provide a good learning environment for hyperactive and LD students who have learning difficulties and mentally [3], and also III) Lankuits and Kennedy (2002) introduced assistive technology and its features. In this research, they stated literature of this technology and then define and introduce the kinds of special software and hardware for LD students. They argued that AT can promote the cooperation and motivation spirit for LD students [15]. Regard to pervious researches, it clears that AT tools must introduce and apply more and

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more for these students. Also the difference between performance of girl and boy (LD) students is not studied so far.

3 Hypothesis

The effect of using AT (Math Explorer software) on increasing ability of mathematical problem solving for dyscalculia students follow gender.

4 Method

Regard to conditions and implications of this research, it is used of quasi-experimental method. When students stand under control of researchers and they won't indicate real behavior then researchers have used of quasi-experimental method. In this method, researchers selected two groups as control and experiment groups randomly. In this control group, it is used of traditional teaching and also, it is applied modern method (using mathematical software; Math Explorer as one of the AT's tools) in experiment groups. Finally the effects of independent variables will be identify. Of course control and experiment groups are divided to two subgroups; girl and boy groups.

4.1 Participants

In this study, all LD students of Iranian centers of Learning disabilities in Tehran that equal to 157 LD students are selected as statistical population. Regard to random simple sampling method, LD students (dyscalculia) are chosen at elementary level. These students have difficulties in the fields of writing, reading and mathematics in particular basic concepts. 16-18 boys and 12-15 girls are selected as participants at first to fifth grades. These students have difficulties in basic mathematical concepts even at fifth grade.

4.2 Instrumentations

There are several instrumentations in this research such as WISC test for determining intelligence level, clinical public questionnaire to identify of public conditions of students individually, researcher-constructed test and also "Math Explorer" software for studying performance of students.

4.2.1 WISC test

For primary implication of this research, it needs that used of Wechsler test (WISC). This test has two parts; verbal and practical sections. Validity rate of this test is proved with Cronbach's alpha; 80, 82. Findings of this test indicated that general intelligent of participants equal 92-93%. This value shows that intelligence level of these students is "median". Also this test has proved learning disabilities of participants.

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4.2.2 Clinical public questionnaire

Narderi and Saif-Naraghi (1995) were written questionnaire entitled "clinical public questionnaire" [16]. This questionnaire has validity and reliability that equal to 90%. Findings and responses of this questionnaire indicated that participants have several difficulties such as genetic, mindful, memorial problems. Also participants were hyperactive. They have not enough focus.

4.2.3 Researcher-constructed test

Researcher-constructed test was implemented as math exam with big font and points. This exam was designed base on teacher's opinions in learning disability centers. Its validity of this exam is studied with 84% rate. This exam has 5 question that include of numerical and verbal sections. General mark of these exams was 10. These questions were designed so that disability and performance of these students indicated exactly for both sections; pretest and posttests.

4.2.4 "Math Explorer" software

Regard to this matter that "Math Explorer" software is designed and constructed by Woo and Seo (2009) in Korea, this technology is designed by researchers (2011) for two basic simple operations; addition and subtraction. This software is designed under experts and teachers in learning disability centers of Iran. This software has seven procedures that include of title, welcome, educational goal, teaching modeling, guidance practice, various practices and exams. In both section; addition and subtraction, there are four teaching pages such as a guidance practice page, random various pages with different practices and exam pages. All section follow four main cognition steps such as reading, finding, drawing and computing. Each cognitive steps have three meta-cognitive methods; do it, ask it and check it. This software has special effects, colors and icons. Also whole text of this software are written via B Morvaride font (for having big fonts and points). Positive and negative feedbacks exist in this software. All steps have special features such as highlighting parts and emphasizing numbers. There is ruler that helps to these students in computation phase. In all parts, "Explorer Fish" states and indicates phases step by steps. This technology as one of tools of AT helps to participants who have not long-term memory, motivation, mathematical ability and even they cannot write and read properly. This software can promote the computation ability through fantastic ruler and they can find main parts in problems. This technology increases attention rate for hyperactivity students.

5 Collecting data

In first phase, pretest is performed. When knowledge level of participants is known then one of the tools of AT; "Math Explorer" software is implemented for experiment group for two month nearly and individually. Control group has taught under traditional teaching. Finally posttest is performed on both groups and then data are collected.

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6 Data analysis

After collecting data method, it is used of descriptive and deductive statistics. In descriptive section studied the mean and std.deviation for both groups. In addition it is used of One-Sample Kolmogorov-Smirnov test, Test of Homogeneity of Variances, ANOVA and Scheffe test at level of 0.05.

7 Findings

As it is shown in Table 1, the means of experiment group's posttests among girl and boy (LD) students are same nearly for addition operation. Also for subtraction operation, the means of experiment group's posttests among girl and boy (LD) students have not any significant difference. In addition this section indicates that mean of experiment group's posttest is more than control group's posttest for girl and boy groups separately.

Table 1 Descriptive statistic of control and experiment groups

Basic Addition-Boy group	**N**	**Mean**	**Std**
Pretest control	۵	3.2	1.78
Posttest control	5	4.4	0.89
Pretest experiment	11	3.82	1.88
Posttest experiment	11	8.64	1.96
Basic Addition-Girl group	**N**	**Mean**	**Std**
Pretest control	5	4	1.41
Posttest control	5	4.8	1.09
Pretest experiment	10	3	2.35
Posttest experiment	10	8.2	2.04
Basic Subtraction-Boy group	**N**	**Mean**	**Std**
Pretest control	5	2.8	1.09
Posttest control	5	3.6	1.67
Pretest experiment	13	3.23	1.53
Posttest experiment	13	8.37	1.71
Basic Subtraction- Girl group	**N**	**Mean**	**Std**
Pretest control	5	3.6	2.19
Posttest control	5	4.8	1.78
Pretest experiment	7	3.71	2.43
Posttest experiment	7	8.57	2.5

In Figures 1 and 2, the means of experiment groups' posttests are same between girl and boy groups nearly.

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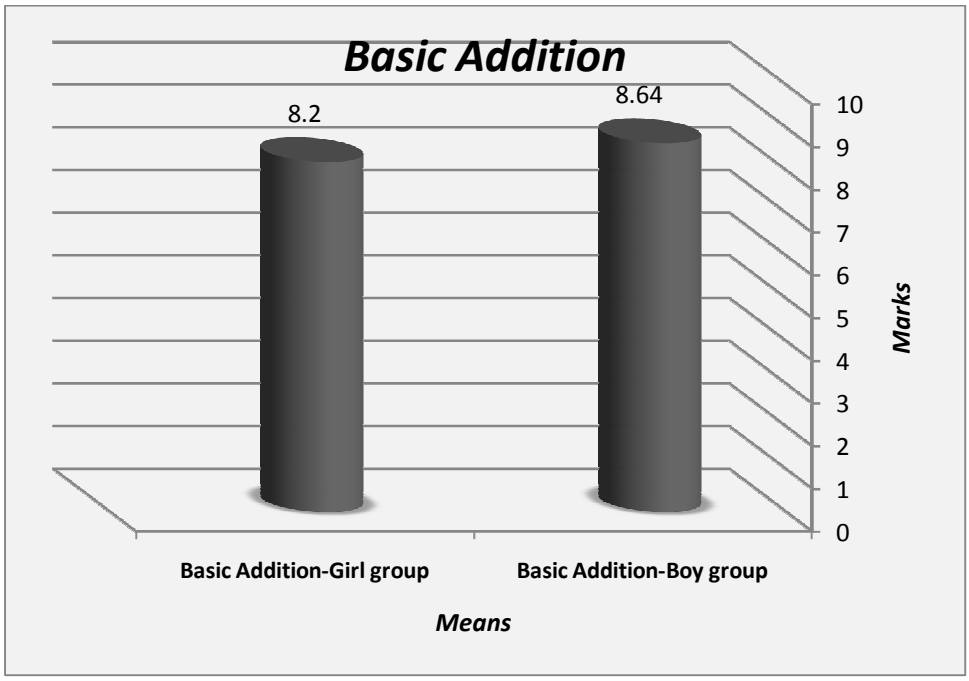

Fig. 1 The means of experiment groups' posttests in basic addition

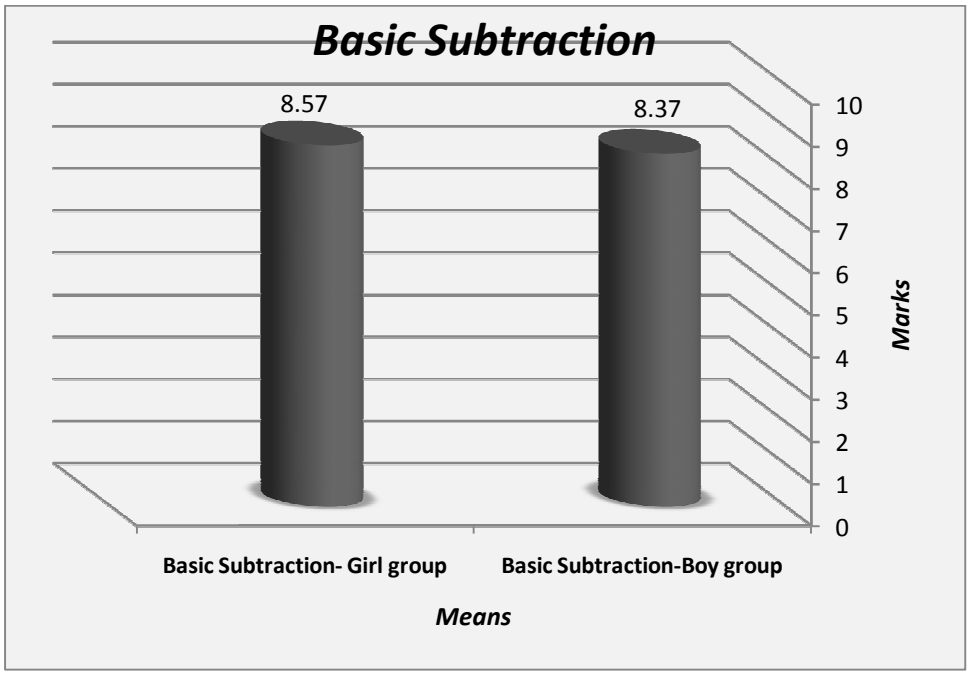

Fig. 2 The means of experiment groups' posttests in basic subtraction

The first, findings of One-Sample Kolmogorov-Smirnov test and Test of Homogeneity of Variances indicated that data was normal and has homogeneity at level 0.05 ($P>0.05$). Therefore it can use of One-Way ANOVA and then Scheffe test for pretests and posttests. The results of One-Way ANOVA for pretests has shown that there are not significant differences among pretests for boy and girl students ($P>0.05$) in Table 2.

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Table 2 The results of ANOVA for pretests

Pretest-Addition	Sum of Squares	df	Mean Square	F	Sig
Between Groups	5.3	3	1.76	0.44	0.72
Within Groups	106.43	27	3.94		
Total	111.74	30			
Pretest-Subtraction	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig**
Between Groups	2.93	3	0.97	0.28	0.83
Within Groups	87.73	26	3.37		
Total	90.66	29			

In Table 3, posttests of boy and girl students are studied in control and experiment groups. The findings indicate that there are significant differences among groups of girl and boys ($P<0.05$). Therefore it obvious that "Math Explorer" software has effect on the performance among posttests of control and experiment groups for both basic operations.

Table 3 The results of ANOVA for posttests

Posttest-Addition	Sum of Squares	df	Mean Square	F	Sig
Between Groups	100.69	3	33.56	10.77	0.000
Within Groups	84.14	27	3.11		
Total	184.83	30			
Posttest-Subtraction	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig**
Between Groups	124.17	3	41.39	11.11	0.000
Within Groups	96.79	26	3.72		
Total	220.96	29			

The results of Scheffe test has proved that there are significant differences among experiment groups' posttests ($P<0.05$). Therefore it concluded that Math Explorer software has effect on the performance of boy and girl students separately in addition operation. But there is not significant difference between experiment group's posttest of girl and boy ($P>0.05$) for addition operation.

Table 4 The results of Scheffe test for basic addition operation

Variable I	Variable J	Mean Difference (I-J)	Std. Error	Sig	95% Confidence Interval	
					Lower Bound	Upper Bound
Control-Posttest Girl	Posttest-Experiment-Girl	-3.4	0.96	0.01	-6.2	-0.52
	Posttest -Control-Boy	0.4	1.11	0.98	0.52	3.73
	Posttest-Experiment-Boy	-3.83	0.95	0.005	-6.6	-1
Experiment-Posttest Girl	Posttest-Control-Girl	3.4	0.96	0.01	0.52	6.2
	Posttest -Control-Boy	3.8	0.96	0.006	0.92	6.68
	Posttest-Experiment-Boy	-0.43	0.77	0.95	-2.7	1.86
Control-Posttest Boy	Posttest-Control-Girl	-0.4	1.11	0.98	-3.7	2.9
	Posttest- Experiment-Girl	-3.8	0.96	0.006	-6.6	-0.9
	Posttest-Experiment-Boy	-0.43	0.95	0.002	-7	-1.4
Experiment-Posttest Boy	Posttest-Control-Girl	3.83	0.95	0.005	1	6.6
	Posttest- Experiment-Girl	0.43	0.77	0.95	-1.8	2.7
	Posttest- Control-Boy	4.23	0.95	0.002	1.47	7

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As it clears in Table 5, findings of Scheffe test has indicated that there are significant differences among experiment groups' posttests ($P<0.05$) for subtraction operation. Then it can concluded that Math Explorer software has effect on the performance of boy and girl students separately for subtraction operation. Yet there is not significant difference between experiment group's posttest of girl and boy ($P>0.05$) for subtraction operation.

Table 5 The results of Scheffe test for basic subtraction operation

Variable I	Variable J	Mean Difference (I-J)	Std. Error	Sig	95% Confidence Interval	
					Lower Bound	Upper Bound
Control-Posttest Girl	Posttest-Experiment-Girl	-0.37	1.13	0.02	-7.1	-0.4
	Posttest -Control-Boy	1.2	1.22	0.8	-2.4	4.8
	Posttest-Experiment-Boy	-3.58	1.01	0.01	-6.6	-0.5
Experiment-Posttest Girl	Posttest-Control-Girl	3.77	1.13	0.02	0.4	7.1
	Posttest -Control-Boy	4.97	1.13	0.000	1.6	8.3
	Posttest-Experiment-Boy	0.18	0.9	0.99	-2.5	2.8
Control-Posttest Boy	Posttest-Control-Girl	-1.2	1.22	0.8	-4.8	2.4
	Posttest- Experiment-Girl	-4.97	1.13	0.000	-8.3	-1.6
	Posttest-Experiment-Boy	-4.78	1.01	0.000	-7.8	-1.7
Experiment-Posttest Boy	Posttest-Control-Girl	3.58	1.01	0.01	0.55	6.6
	Posttest- Experiment-Girl	-0.18	0.9	0.99	-2.8	2.5
	Posttest- Control-Boy	4.78	1.01	0.000	1.75	7.8

8 Conclusion

In present study, it is tried that indicated the effects of AT and it is used of mathematical software entitled "Math Explorer" for LD students in particular dyscalculia students. In this software, special items and icons is applied with special situation and color for learning basic operations such as addition and subtraction. The findings indicated that this software can effect on the mathematical performance of students and it seems that AT can apply at learning disability centers in Iran. There are many reasons of this improvement such as; 1) students are interested to solve of various problems, 2) students felt that do not need to help of teachers and parants, 3) hyperactivity students have more focus on screens of this software, 4) these students did not use of fingers or drawing figures to compute, so on. Also this research argued that there is not any difference between performance and abilitiy of girl and boy (LD) students for mathematical problem solving via software. Regard to these reasons, AT can apply at home even or other places. Teachers or instructors of learning disability centers can use of AT for all LD students. With this act, LD students can promote their abilities and talents for self-academic courses. Researchers suggest that teachers of LD students must use and develop AT for all academic courses. Also, other researchers can built and design developed AT tools in two parts; software and hardware in Iranian learning disability centers. This research is limited to elementary level and math textbooks and also two basic operation; addition and subtraction operations.

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