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Full Length Research paper

Effects of assistive technology instruction on increasing motivation and capacity of mathematical problem solving in dyscalculia students

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With development in technologies, researchers in special education fields have tried to use technology in the curriculum of dyscalculia students in order to promote their skills in learning efficiently. Present research aims to identify the effect of assistive technology instruction on increasing motivation and capacity of mathematical problem solving in dyscalculia students. Research method is quasi-experimental. 37 students (boys and girls), in age range of 7 to 11 of first to fifth grades, are selected among dyscalculia students of special difficulties learning centers in Tehran. Research instruments were WISC test, motivation measure questionnaire, math exam and "Math Explorer" software. Results show that assistive technology instruction is effective on increasing motivation and capacity of mathematical problem solving (basic addition and subtraction) in dyscalculia students, using Independent samples T-test, Mann-Whitney and One sample sign test. Therefore, assistive technology instruction (computer program instruction; "Math Explorer") is proper for dyscalculia students.

Key words: Learning disabilities, motivation, dyscalculia, assistive technology, "Math Explorer" software, basic addition and subtraction.

INTRODUCTION

In 1966, Clements defined children with learning disabilities as: " children who are median, close to median or higher than median in regard to general intelligence, but have difficulties or special difficulties in learning or behavior. Rate of these difficulties ranges from low to severe. The main difficulty is in perception, language, memory, controlling, attention, dynamic actions and so on and it may result in defect of different gens, disability in metabolism, brain impact or other malady and phenomenon which occur for a long time, affecting growth and completion of central nerve system".

There are different categories of learning disabilities in children, having brain impacts. There are selected terms for them: "special insufficient learning or learning disabilities" (Babapourkheyrodin, 2001). Learning disabilities are divided into three main groups; dyslexia, dysgraphia and dyscalculia. Learning disability in mathematics is dyscalculia. This kind of disorder means disorder in mathematical skills and even most of it. Children given to disorder in mathematics have severe difficulties in perception of space relations field (Naderi, 1995). Dyscalculia students do not remember main facts of numbers and they forget formula and procedures in problem solving easily. They cannot read problems correctly and have challenge in conceptual symbols such as time and directions. They punctuate with pencil and draw cycles posthaste until can calculate via symbols. It seems that they cannot remember computation strategies for problem solving. Therefore, they cannot remember basic mathematics facts automatically (Shepard et al., 1982; Hasselbring et al., 1988). They tend to compute with their fingers and comprehend slowly (Jordan et al., 2005).

Difficulties of students do not end with academic deuce, cost wastage and possibilities, but mathematics programs are responsible in development and popularization of mathematical concepts, creation of motivation, upbringing of creativity power, application and

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bringing of relation in thoughts of students. Nonetheless, it was observed that traditional mathematics education methods cannot be used to teach public students and in particular teaching disabled students in several consecutive years. The methods were tiresome and involved tedious practices. So it is necessary to change communicating method to make learning a pleasurable experience to students.

Teaching disabled students often requires items that differ from what schools produce normally. Most disabled students require contextual changes of subjects, tasks, teaching methods and test. Because of special difficulties of disabled students, it is not sufficient to use one teaching strategy only, but collection and combination of strategies. Mathematics education should include reality experiences and analysis of tasks (Yavari et al, 2006). With development in technologies, researchers in special education fields have tried to use technology in the curriculum of dyscalculia students to promote their skills in learning efficiently (Rastegarpour et al., 2006).

Disabled students cannot remember context learned previously, because their working and long-term memory is weak. Using assistive technology such as software and hardware helps such students to remember prerequisite and needful skills for learning new skills in mathematics (Miller, 2006). Also, with technology, mathematics education can help disabled students make their special features (Symington and Stranger, 2000). Therefore, special technology used for students with special needs is assistive technology.

Since 1990, the beginning of special instruction for disabled students, professional teams discover technology with the name, assistive technology for teaching disabled students. Assistive technology is defined as any instrument, segment of equipment and producing system for increasing retention and growth of performance capacity of disabled students. In fact, assistive technology is a system used to relief and recover learning disabilities and related disabilities. This kind of technology removes disabilities of these students and increase communication between teachers and students (Berhman, 1995). Fields of assistive technology include strategies that are famous such as: Special Access Technology, Adaptive Technology, Augmentative Technology, Special Education Technology and computer instruction. Teaching method using assistive technology and computer program instruction makes disabled students to remember a particular content of information at a time. Segregating of teaching content into small parts and then dividing these small part into tiny teaching details are necessary mathematics skills in helping the memory of disabled students (Seo and woo, 2010).

Literature Review

Among the widespread mass of researches done on the effect of assistive technology instruction on increasing motivation and capacity of mathematical problem solving in dyscalculia student, three groups are more considered: I) research done via National center for technology innovation and center of implementing technology in education titled, "Help for young learners: how to choose AT" (2006). In addition to the introduction of assistive technology, it does not only highlight the usefulness of this kind of technology for teaching disabled students, but also shows that this technology makes students independent and can give self-confidence to them. In this research, six principles are important in using this technology: before using assistive technology, the weakness and strength disabled students should be measured; II) other research done by Deubel (2006) titled "Addressing the needs of students with disabilities in math". In addition to introduction and grouping of students with learning disabilities, he introduced special software and hardware for such students. For instance, "Do-It" software is designed in American university and also, he has provided collections of activities for learning disabled students.

He used this software for students who have disabilities such as dynamic disabilities, dyslexia, dysgraphia and mathematical problem. Finally, he used affective assistive technology on promoting motivation and capacities of such students and III) research done by Seo and woo (2010) titled "The identification, implementation and evaluation of critical user interface design features of computer-assisted instruction program in mathematics for students with learning disabilities". With study of questionnaires and tests, they considered effective usage of computers on teaching disabled students in mathematics. In fact, there are shortage of researches on the basic features of computer-assisted instruction mathematics program for teaching disabled students and also basis of their deep analysis of mathematical performance and biological features.

Therefore, it is not clear how designed instruction programs with computer assisted disabled students in respect to efficiency of mathematics education and subsequently their mathematics learning achievement. Previous researches did not consider computer and assistive technology and did not introduce it to such students; and also motivation rate of dyscalculia students was low because they did not use special instruction. Also, since addition and subtraction operations are basic principles of mathematical learning and motivation, and since disabled students often have weakness in these two operations, even to fifth grade, it is necessary to use new strategy of instruction. With this description, the importance of computer and using of assistive technology such as software instruction in learning-teaching process of these students are needed for increasing their learning, motivation and centralization.

Hypothesis

(I)Using of assistive technology ("Math Explorer" software) is effective on increasing capacity of mathematical problem solving in dyscalculia student.

(II)Using of assistive technology ("Math Explorer" software) is effective on increasing motivation of mathematical problem solving in dyscalculia student.

METHODOLOGY

Method of research is quasi-experimental. In this research, experiment group is dyscalculia students who have learned through assistive technology ("Math Explorer" computer program instruction) and control group is dyscalculia students who have learned without assistive technology ("Math Explorer" computer instruction program); through teacher-centered instruction. Also, independent variable is assistive technology instruction ("Math Explorer" computer program) and dependent variable is motivation and capacity of problem solving (mark's students). At first, pretests are done to identify their capacity level and disability in basic addition and subtraction in addition to identifying of specialists in special learning difficulties center in two groups; and posttests are done after both instruction through "Math Explorer" program in experiment group and teacher-center instruction in control group. Also, questionnaire is implemented by researcher for every dyscalculia student after presenting software.

Participants

Statistical social is all disabled students (dyscalculia) in special learning difficulties centers in Tehran who were equal to 157 students. 37 learning disabled (dyscalculia) students (21 boys and 16 girls in age range of 7 to 11) are selected through random simple sampling of statistical social. These students have difficulty in basic addition and subtraction and their learning disabilities and dyscalculia are proved through WISC test, math exam and in respect to opinion of specialists in these centers. It necessary to cite that these students have no difficulty in conception and computation of numbers of ten.

Instruments

In this research is used and applied WISC test, motivation measure questionnaire, math test and also "Math Explorer" software.

WISC Test

WISC test (intelligence test; Wechsler test) was reviewed in two verbal and practical parts in 1989. Its reliability and validity is proved by two researchers (2000) in Iran in three verbal, practical parts and general with Cronbach' alpha; 88, 83 and 90 percent, respectively. Validity of three parts in this test is proved by researcher (2011) with Cronbach' alpha; 80, 82 and 88 percent respectively. Results show that general intelligence marks of these participations equal to 93 percent, generally. This mark is "median level" in respect to intelligence scale ranking and these students did not lack brain and proved their learning disabilities. Also, all participations got marks lower than standard marks in small tests of WISC test (mathematics, perception, numerical memory and cryptography tests).

Motivation Measure Questionnaire

This questionnaire of 20 questions is provided and listed by Crowther et al (2004) and Nielsen et al. (2000). Its context reliability and validity was proved in 2000 and 2004; its validity was proved with Cronbach's alpha as 90 percent. And it had five Likert scale; "strongly disagree, disagree, neutral, agree, strongly agree". In 2011, 10 questions are implemented out of 20 in regard to specialist's mathematics education and also in regard to its necessary timing in implication. This questionnaire is implemented to every dyscalculia students after presenting "Math Explorer" software. Researcher asked every question to student in regard to three scales; "disagree, neutral, agree". This questionnaire has three sections. First section included public characteristic; gender, age and grade and second section included five questions about efficiency rate of software in mathematical problem solving and third section included final five questions about structural rate of software. Its context reliability is proved by specialist's mathematics education and learning disabilities and its validity is proved by researcher (2011) with Cronbakh's alpha; 85 percent.

Math Exam

Math exam was constructed by the researchers and published with great font. The questions consisted of the basic of mathematics teachers' opinions, then, this exam had acceptable context reliability. Validity of exam was estimated with split-half test and its value equal to Cronbakh's alpha; 84 percent in pretests and posttests. The three first questions were numerical questions in pretests and posttests of basic addition and subtraction. Two final questions were word problem solving questions in pretests of basic addition and subtraction. In the final question posttest's basic addition and subtraction, the question is designed to identify all fields of numerical, word problem solving computation. In this question they were asked to state short story in two operations. Students stated short story and final answer.

"Math Explorer" Software

Math Explorer software was registered by Woo and Seo (2009) in Korea. This software is constructed by researcher (2011) under ".net frame work 4 " in two parts of basic addition and subtraction and with exerted changes in it. After emphasis of researchers and specialists in learning disabilities and in respect to special education's opinions, this software is performed in Iran. In ever part, there are seven procedures in first part. These seven procedures include title, welcome, instructional goal, instructional modeling, guided practice, independent practices and testing. In two parts (addition and subtraction), there are four instruction pages; a guided practice page, random various pages, laden independent practices and three testing pages.

Among instructional modeling pages and guided practice page, there is one persuasion page. In this software, there are four cognitive steps: reading, finding, drawing and computing that constitute the content of procedures of instructional modeling. In every cognitive step, it performs three meta-cognitive stated via "Math Explorer" fish. These steps included: 1) do activity, 2) ask activity and 3) check activity. Also, in all pages, direction buttons such as home, exit, back and next are stood by jellyfish, ashcan with shovel, nix and crab, respectively with grant dimension in bottom of pages for more focus of students on context. In all pages, narrator fish exists in bottom of pages except reading step versatility that states necessary preambles to student.

In addition, all words and numbers are shown with grant dimension and with B Morvaride font and with black blue (for better recognizing than background color (light blue)) until dyslexia students can read it. In this software, operation buttons related to instructional modeling and testing pages are sited in left direction with white, so that students can focus in the center. In this software, there are two positive and negative feedbacks (continuum and not continuum). In all over pages, there is a sentence that makes closed relation to math. This kind of feedback is positive continuum and in persuasion page, there is positive and not continuum feedback. Also, in all pages related to independent practices, there are negative and positive continuum feedbacks.

In this software use highlighting method for finding key cases in word problem solving and "ruler" strategy for receiving answer easily that stands in bottom of page in grant dimension and orange with grant font and to nether ten numbers with great distance among numbers. In new strategy, after travelling of cognitive steps, "Math Explorer" fish wants to do necessity jumps in regard to distance among numbers on ruler to answer with persuasion. These jumps are right direction in addition and left direction in subtraction. In final, prime and final numbers (final answer) are shown on ruler. Fish states two addition or subtraction which has similar answers to previous problem. Using of "ruler" strategy with special features has advantages; using of this strategy for students who have such problems (disabilities) in perception of left and right direction, in curve drawing, incorrect computation using their fingers, weak memory in remembering prime and final numbers in addition and subtraction, in focus on problem-solving, motoring and writing skills and even students who have no motivation; with using of jumps on ruler, they are sure to receive answer. In guided practice, other problem with above strategies (using of ruler and highlighting key cases in word problem) is stated. In independent practice pages, students face three addition or subtraction randomly every time they enter this page. This part has the highest capacity in software. In the bottom of any addition or subtraction, place which is sited to student, type self-answer in it and under this place, there is yellow box that if student types correct answer, software shows "bravo, you say correctly" and if student types incorrect answer first time, then, software shows "endeavor, you can" and in final, if student types incorrect answer two times, software shows correct answer automatically. These pages have advantages such as removing the possibility of surface memorizing; students who are dysgraphia or motoring agnosia; and because of these reasons, they retire to write and practice. In these pages, they can remove their disabilities with only typing number and with using of mouse. Also, a number of practices do not compute in independent pages. In final pages, testing step is that students solve numerical and word problem without ruler.

Collecting Data

Math exam is performed as pretest after sample selecting and their appointment to control and experiment groups. In next step, assistive technology instruction ("Math Explorer" software) is performed in 6 weeks and for any

Table 1. Descriptive statistic of students' marks in control and experiment groups.

Basic Addition	**N**	**Mean**	**Std**
Pretest Control	10	3.6	1.57
Posttest Control	10	4.6	0.96
Pretest Experiment	21	3.43	2.11
Posttest Experiment	21	8.43	1.96
Basic Subtraction	**N**	**Mean**	**Std**
Pretest Control	10	3.2	1.68
Posttest Control	10	4.4	1.57
Pretest Experiment	20	3.4	1.84
Posttest Experiment	20	8.4	1.95

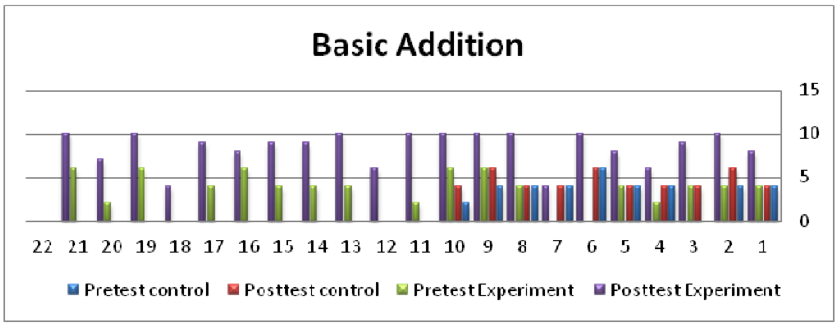

Figure 1. Marks of control and experiment groups in basic addition.

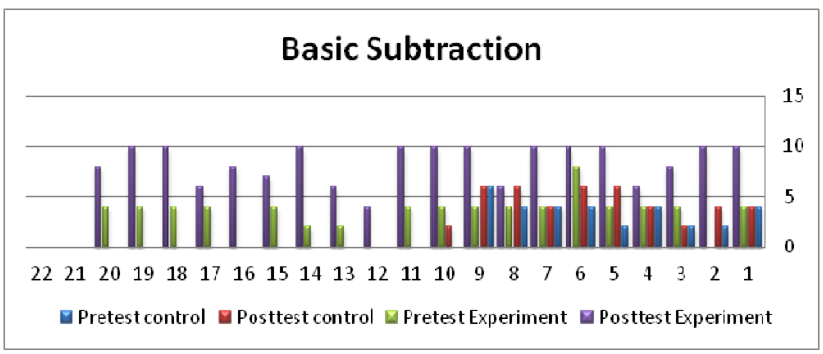

Figure 2. Marks of control and experiment groups in basic subtraction.

students, 4 sessions of 20 to 30 minutes individually. "Ruler" strategy with same features and also, "finding key cases" in problem solving repeat and practice via students with helping parents in home. Finally, math exam is performed as posttest on control and experiment groups and motivation measure questionnaire is asked to every student after presenting software individually. Then data are analyzed.

Data Analysis

Descriptive statistical methods were used such as mean, Std. deviation for describing cases and for testing hypothesis. We used One-Sample Kolmogorov-Smirnov test, Leven's test, Independent Samples T-test, Mann-Whitney test and One Sample sign test.

RESULTS

Results of hypothesis (I)

In Table 1, the highest mark is related to Posttest Experiment group (M=8.43) in basic addition and the highest mark is related to Posttest Experiment group (M=8.4) in basic subtraction.

In Figures 1 and 2, the means of marks of experiment group are more than control group in both operations. In Table 2 related to One-Sample Kolmogorov-Smirnov test,

Table 2. Normality of students' marks in control and experiment groups.

Basic Addition	Pretest control	Posttest control	Pretest Experiment	Posttest Experiment
N	10	10	21	21
Z	1.26	1.36	1.25	1.07
Sig	0.08	0.04	0.08	0.2
Basic Subtraction	**Pretest control**	**Posttest control**	**Pretest Experiment**	**Posttest Experiment**
N	20	20	10	10
Z	1.5	1.68	0.77	0.89
Sig	0.02	0.007	0.58	**0.4**

Table 3. Results of pretest's Independent samples T-test in basic addition.

Basic Addition	Leven's Test for Equality of Variances		T-test for Equality of Means				
	F	Sig	t	df	sig	Mean difference	Std.Error difference
Equal variances assumed	2.28	0.14	0.22	29	0.82	0.17	0.75
Equal variances not assumed			0.25	23.27	0.8	0.17	0.67

Table 4. Results of pretest's Mann-Whitney test in basic subtraction.

Basic Subtraction	Pretest's Control and Experiment groups
Mean Rank's pretest Control	14.75
Mean Rank's pretest Experiment	15.88
Mann-Whitney U	92.5
Z	-0.38
Sig	0.7

students' marks in two groups are studied in regard to normality. In regard to results, posttest in control group is not normal (P<0.05) in basic addition, pretest and posttest in control group are not normal (P<0.05) in basic subtraction in meaningful level of 0.05.

In regard to results of Leven's test for equality of variances in Table 3, variances of control and experiment groups are equal (F=2.28, P>0.05). Results of T- test show that there are no meaningful difference between the marks of mean of pretest control and experiment groups (T=0.22, P>0.05) in basic addition. Also, in Table 4, results of Mann-Whitney test show that there are no meaningful difference between marks of mean of pretest control and experiment groups (Z= -0.38, P>0.05) in basic subtraction in meaningful level of 0.05.

In Table 5, results of Mann-Whitney test show that there are meaningful difference between mean's marks of posttest control and experiment groups (T= -3.86, -3.93 and P<0.05) in both basic addition and subtraction in meaningful level of 0.05. Also, mean rank posttest experiment group is higher than control group in both basic addition and subtraction.

Results of hypothesis (II)

In regard to Table 6, most students who participated in the questionnaire were 8 to 9 years and in first and second elementary grade. Also, numbers of boy and girl of dyscalculia students were equal to 16 and 11 people, respectively.

For testing hypothesis (II), normality of questions is studied through One-Sample Kolmogorov-Smirnov test. Results of this test show that data of this questionnaire are not normal.

As shown in Table 8, all questions values are bigger than 0.05 except question 5 using One Sample Sign test in meaningful level of five percent. Therefore, Most

Table 5. Results of posttest's Mann-Whitney test in basic addition and subtraction.

Basic Addition	**Posttest's Control and Experiment groups**
Mean Rank's posttest Control	7.1
Mean Rank's posttest Experiment	20.24
Mann-Whitney U	16
Z	-3.86
sig	0.000
Basic Subtraction	**Posttest's Control and Experiment groups**
Mean Rank's posttest Control	6.9
Mean Rank's posttest Experiment	19.8
Mann-Whitney U	14
Z	-3.93
sig	0.000

Table 6. Descriptive statistic of students' opinions.

Questionnaire	**N**	**Mean**	**Std**
Gender	27	1.41	0.5
Age	27	8.81	1.3
Grade	27	2.37	1.24

Table 7. Normality of students' opinion.

	Q 1	**Q 2**	**Q 3**	**Q 4**	**Q 5**	**Q 6**	**Q 7**	**Q 8**	**Q 9**	**Q 10**
N	27	27	27	27	27	27	27	27	27	27
Z	2.8	2.8	2.7	2.7	2.7	1.8	2.6	2.7	2.6	2.7
Sig	.000	.000	.000	.000	.000	.002	.000	.000	.000	.000

Table 8. Results of students' opinions.

Median of Sign test = 1 versus > 1						
	N	**Below**	**Equal**	**Upper**	**P**	**Median**
Q 1	**27**	**0**	**25**	**2**	**0.7**	**1**
Q 2	**27**	**0**	**23**	**4**	**0.06**	**1**
Q 3	**27**	**0**	**25**	**2**	**0.25**	**1**
Q 4	**27**	**0**	**24**	**3**	**0.12**	**1**
Q 5	**27**	**0**	**16**	**11**	**0.000**	**1**
Q 6	**27**	**0**	**24**	**3**	**0.12**	**1**
Q 7	**27**	**0**	**25**	**2**	**0.25**	**1**
Q 8	**27**	**0**	**25**	**2**	**0.25**	**1**
Q 9	**27**	**0**	**26**	**1**	**0.06**	**1**
Q 10	**27**	**0**	**26**	**1**	**0.06**	**1**

dyscalculia students respond to "agree" scale in regard to median 1.

DISSCUSION

In this research, in regard to hypothesis, it can be concluded that means difference of mark's experiment group is more meaningful than control group after implementing "Math Explorer" software for elementary learning disabled (dyscalculia) students in basic addition and subtraction. And in respect to result, it is concluded that assistive technology instruction is effective on increasing capacity of mathematical problem solving in dyscalculia student. Dyscalculia students need cases which differ from what schools use normally. Most of such students need to change context, tasks, instructional methods and testing. Also, individual needs and allocating of context and instruction are essential for such students.

Communicating practices can be increased by using impressive materials such as "Math Explorer" software that enable increase in learning, focusing and speeding in dyscalculia students. Using of "ruler" strategy in this software is made to increase focus and speed and also, reinforcement of dynamic-sensory skills in answering. Brain capacity increases cognition, memory and dynamic designing and promote dominating and learning in whole academic scopes.

In both final sections of questionnaire which emphasize efficiency and structure of respected software, most dyscalculia students believe that assistive technology instruction is effective on increasing motivation and mathematical problem solving. Using of technology in special instruction in regard to its postive results increases self-confidance and self-conception of dyscalculia students, followed by increase in motivation. Advocates of camputer program instruction believe that this activity will integrate instruction of learners. Also, students are active and individual in learning through assistive technology instruction. In fact, since "Math Explorer" software made such students to act excellently in instruction through picture, voice, motion and animation, thereby increasing their motivation, shows that they were interested to observe and apply this software instead of traditional instruction; and they yearn to use "ruler" strategy and act thoughtful in both basic addition and subtraction. Because these students can prove their learning process without sarcasm, we suggest that 1) present and instruct all mathematics contexts in "Math Explorer" software through new strategy, 2) provide and introduce new strategy in all contexts for learning easily, using computer program instruction adequately with same usual instruction methods. Restrictions of this research include lack of suitable space, location and time in special difficulties learning center for implementing computer program instruction and few number of dyscalculia students, such that researchers were force to present in center all the time and days. And this research is restrict to first and second grade students and related to basic addition and subtraction.

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