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Effectiveness of Cognitive Rehabilitation Program Based on Optimal cognitive burden in self-regulation and academic achievement in children with special learning disorders

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Abstract

Background: The present study aimed to assess the effectiveness of the cognitive rehabilitation program based on optimal cognitive load in self-regulation and academic achievement in children with special learning disorders.

Method: This quasi-experimental applied research was conducted based on a pre-test-post-test control group design with a follow-up period .The statistical population of this study included all children aged 8-10 years with symptoms of special learning disorder who were referred to public learning disorders centers in Tehran in the academic year 2019-2020. To this end, 25 subjects were selected by the available sampling method and randomly assigned to two groups of experimental and control. Data were collected using the Second Learning Disorder Assessment Scale (LDES-R2), McCarney & Armwood (2007), Wechsler Children's Intelligence Scale (WISC-IV), and Novak and Clayton's Self-Regulation Questionnaire (2001).

Results: Based on the results of the multivariate covariance analysis test, the cognitive rehabilitation program affected academic self-regulation, its cognitive, behavioral, and emotional components, as well as academic performance, in students with special learning disorders.

Conclusion: As evidenced by the results of this study, it can be concluded that cognitive rehabilitation program can be used as a suitable method to promote self-regulation and academic performance of students.

Keywords: Achievement, Cognitive load, Cognitive rehabilitation, Self-regulatory

Introduction

Neurodevelopmental disorders are specific learning disorders which result from the interaction between some hereditary and environmental factors that affect the brain's ability to quickly, correctly, and easily understand verbal and nonverbal information. The main characteristic of this disorder is failure to acquire academic skills in reading (difficult, slow, and incorrect reading of words, difficulty spelling and understanding the meaning of words, writing) or mathematics (difficulty learning the concepts and meanings of numbers or calculations). These problems emerge in the early years of education, do not match the child's overall intellectual ability, and last at least six months (1).

The results of a survey of non-clinical samples around the world demonstrated that 5%-15% of school-age children meet the specific learning disorder criteria (2). In addition, recent studies have indicated a significant increase in prevalence estimates in the past decade. For example, Aliagon and Margalit (2018) (3) reported a 17% increase in the prevalence of specific learning disorders for children aged 3-17 years. One of the main characteristics of a specific learning disorder is the continued inability to learn key academic skills starting from the formal academic period (4,5).

Learning disorders can have isolated consequences and affect one's daily activities since memory, reasoning, and the ability to solve problems are difficult in these children. In fact, this disorder can result in some problems in the social, emotional, and educational domains. Since the beginning of the identification of special learning disorder, experts in this area have attempted to provide theories or patterns to explain the etiology of this disorder. One of the valid theorized models for explaining the etiology of learning disorders is deficit learning in neuropsychological mechanisms in these children. Therefore, some researchers consider learning disorder a kind of mild brain injury that is associated with cognitive deficits (6).

One of the cognitive deficits observed in studies is attention, memory, comprehension, and self-regulation deficits, as well as their fundamental neural circuits, in people with learning disabilities (7). Studies illustrated that students with special learning disorders have difficulty in self-regulatory

skills (8). Self-regulation or self-regulated learning (SR) refers to a process in which learners systematically maintain and guide their cognitions, motivations, behaviors, and emotions to achieve their goals (9). People with learning disabilities look at success and failure quite differently from their regular counterparts and do not recognize when or how to use effective strategies to achieve their goals (8).

Many of these students believe that there is no lasting relationship between their behavior and learning outcomes. That is to say, the results of learning are beyond their control (10). Students with learning disabilities are often unprepared to meet academic expectations due to their shortcomings in the field of behavior self-regulation (8). In addition, these students are most likely to experience attention, memory, and motivational problems that hinder learning efforts while these students are cognitively impaired. Although these children are able to learn, they often fall behind in academic achievement, as compared to their peers (1). As a result, these children need special education to be motivated to progress and achieve appropriate academic achievement.

Accordingly, in recent years, researchers have investigated the value of interventions and training that can improve self-regulation processes in students with learning disabilities (11). With the assumption that direct training of cognitive interventions is able to strengthen people's cognitive capacity, more optimal control and efficient regulation on emotions and behaviors are created (12) and develop self-regulation and focused attention in the classroom (13). One of the major shortcomings of people with special learning disorders is cognitive load, which has been less addressed in the conducted studies.

Experts in the field of education and learning are of the belief that cognitive learning involved in learning tasks and activities increases the desired cognitive load, which leads to the development of self-regulation (9). The optimal cognitive load refers to the formation of optimal processing and meaningful learning through the learner's mental effort to understand the content (14). Therefore, Seok & Dacsta (2010) believe that observing the principles of favorable cognitive burden in designing education to help people with learning disabilities assumes more critical importance since memory deficits are much more evident in people with special learning disorders and one of the major challenges posed to these people in educational situations (15).

In the last two decades, dramatic advances have been made in the field of cognitive science and the treatment of people who suffer from cognitive impairments. One of the treatments used in recent years to improve cognitive functions is cognitive rehabilitation therapy. Accordingly, cognitive rehabilitation is one of the effective interventions to improve self-regulation and academic performance for students with learning disabilities. Cognitive rehabilitation is one of the interventions used to treat and rehabilitate cognitive disorders, provides health services to strengthen areas of injury, or replace new patterns to compensate for the disorder (16).

In fact, cognitive rehabilitation refers to training based on the findings of cognitive science and strives to improve or promote cognitive deficits in the form of games, all of which point to the principle of brain flexibility (17). The goal of cognitive rehabilitation is not only to improve the structure and function of the body but also to improve activity and participation in areas expressed by the International Center for The Classification of Function, Disorder, and Health (ICF). According to this center, activity and participation focus on one’s functional status and include communication, mobility and dynamism, interpersonal interactions, self-care and learning, and how these areas affect one's ability to function.

Doing assignments and participating in roles are effective in social situations. Therefore, the goal of cognitive rehabilitation is not to improve neuroscience test scores but to achieve better autonomy in daily life. In recent decades, numerous advances have been made regarding the production of cognitive rehabilitation programs, including research (18-19, 7, 12, 20-21, 17, 22). In this regard, in their study, De Bruin & van Merriënboer (2017) (23) indicated that learners will only do more when they receive feedback on the inappropriateness of their performance. These deficiencies open the way for behavior change; accordingly, people can be more immersed in learning processes, the desired cognitive load is promoted, and self-regulation improves.

In their study on cognitive rehabilitation, behavior, cognition, and academic skills in children, Wexler et al. (2016) (24) reported that cognitive rehabilitation program has an immediate impact on cognitive outcomes. In another study, Malhotra et al. (2010) (25) compared cognitive rehabilitation practice techniques and therapeutic exercises for children with learning disabilities, and the results demonstrated that both approaches improved students' academic performance. Malhotra, Rajendra, Sharma, and Singh (2009) investigated the impact of cognitive retraining on children with learning disabilities, and the results pointed out that this program led to the modification of cognitive deficits in these children with learning and their improved academic achievement (26).

However, one of the most important objectives of interventions is to improve executive functions in the field of transition (i.e., improving learners’ performance, not only in the tasks that have been taught (close transfer) and new tasks that have not been part of the training (teleworking)). Although studies in this field have pointed to the improvement

of executive functions and working memory in trained tasks, effectiveness has not been reported regarding the transition to tasks that were not part of education.

For example, based on the results of some studies (Swanson et al., 2020; Dahlin, 2011; Turrell, Lindoist, Bergman) (7, 21, 17) in the field of executive functions, performance improvement has been detected in the tasks that have been trained. Nonetheless, in similar tasks that were not part of the trained tasks, no improvement has been observed and the transfer of education has failed. However, the educational transfer is of particular importance in people with special learning disabilities since the main purpose of interventions in these people is to transfer the learned skills for content management, which is the main challenge for these students (27).

Experts in the field of education and learning believe that learners' cognitive involvement in learning tasks and activities increases the desired cognitive load, while the promotion of executive functions leads to the transfer of education in new tasks (teleworking) (22). Optimal cognitive load refers to the formation of optimal processing and meaningful learning through the learner's mental effort to understand the content (14). Seok & Dacsta (2010) believe that observing the principles of optimal cognitive load in designing education to help people with learning disabilities is more important since memory deficits are much more evident in people with special learning disabilities and one of the major challenges of these people in educational situations (15).

Previously conducted studies indicated that optimal cognitive load plays a special role in learning and acquiring organized schemas. Moreover, there is a paucity of research on the application of desirable cognitive load principles in cognitive rehabilitation. In addition, cognitive rehabilitation is an efficient method for improving cognitive and educational functions. Due to the aforementioned issues and the relatively high prevalence of this disorder in daily life and academic performance, research in this field seems necessary. In addition, students drive great pleasure out of computer programs which motivate them to get involved in education more enthusiastically since they consider learning an interesting game.

In this research, rehabilitation program based on computer-based education was considered to attribute students' motivation and willingness to increase training. Therefore, the restorative cognitive rehabilitation approach based on optimal cognitive load theory (with emphasis on strengthening students' cognitive infrastructure skills) has not been used in previous studies .Therefore, reconstructive cognitive rehabilitation intervention based on optimal cognitive load using schema-based techniques can be used to enhance the performance of students with special learning disabilities and provide a suitable platform for future studies in the field of cognitive rehabilitation. In light of the aforementioned issues, the present study aimed to assess the effectiveness of optimal cognitive load-bases rehabilitation program in self-regulation and academic achievement of children with specific learning disorders.

Method

This quasi-experimental applied research was conducted based on a pre-test-post-test control group design with a follow-up period. The statistical population of the present study included all children aged 10-8 years with symptoms of special learning disorder who were referred to the state learning disorders centers in Tehran in the academic year 2019-2020. To this end, the sample size was estimated at 25 subjects based on Cohen's proposed method (1988) (12). They were selected using the available sampling method according to inclusion and exclusion criteria and randomly assigned to two groups of experimental who received Barclay's parental education (n=12) and control who received no intervention (n=13) (13).

The inclusion criteria were as follows: having normal intelligence based on the score obtained in the intelligence test, the age range of 8-10 years, having at least one component of the diagnostic criteria of special learning disorder lasting at least six months, and willingness to participate in the study. On the other hand, the exclusion criteria entailed the presence of any obvious psychological disorder (e.g., hyperactivity and autism), physical diseases, such as vision and hearing problems, which are predisposing factors for academic problems. It is worth noting that the inclusion and exclusion criteria were evaluated by a clinical specialist. In this study, the following scales were used for data collection. The present study was approved by the ethics committee of Kharazmi University (ID IR.KHU.REC.1398.058).

Second Edition Learning Disorder Assessment Scale (LDES-R2)

This scale which was designed by McCarney and Artaud (2007) (28) was used in the present study to sift students with special learning disabilities. This scale consisted of 108 items that are rated on a 4-point Likert scale ranging from 0 (unsuitable for age in terms of development) to 3 (most of the time or always). This scale encompasses seven subscales of listening, thinking, speaking, reading, writing, dictation, and mathematical calculations. The test takes approximately 20 min to complete and information can be obtained from one of the sources aware of students' characteristics, including parents, classroom teachers, therapists, and other school staff who have the necessary information about the child. The standardization of this scale for the sample group of 4473 students aged 6-18 years from the first grade

of primary to the third grade of high school using demographic variables of gender, residence, race, geographic region, and occupation of parents indicates its high and acceptable psychometric properties. The reliability of this scale has been reported between 0.60 and 0.70 using the test-retest method for all subscales. Inter-rater reliability for all subscales in different age groups has been reported between 0.68 to 0.83. This scale was translated in Iran by Hassan Abadi and Khaksar (2017 quoted by Parhoon et al., 2018) (2018), implemented based on adaptive Persian language structure in the form of a doctoral thesis for 350 students with learning disorders in 10 clinics in Tehran province. Psychometric characteristics of this tool indicate that it has the necessary sensitivity and validity in the field of diagnosing students with learning disorders in Iran.

Wechsler Intelligence Scale for Children- Fourth Edition (WISC-IV)

In this study, the fourth edition of Wechsler Intelligence Scale was used to measure children's intelligence. This scale was developed in 2003 to measure children's intelligence aged 6-16 years. This questionnaire encompasses 16 subscales, 10 of which (designing cubes, similarities, digits, visual concepts, cryptography, vocabulary, letter and number sequencing, visual reasoning, comprehension, and symbolization) are the main subscales and the rest (image completion, calligraphy, general information, arithmetic, and verbal reasoning) are complementary subscales. This test provides four index scores, including (comprehension of verbal content, practical reasoning, working memory, processing speed, and intelligence in general). Sadeghi et al. (2011) (30) have standardized this scale in research. In their research, the correlation of this scale with the revised third edition scale and Wexler (1974) and Raven's Advancing Matrices (1938) in related sections was high and significant.

Self-regulatory scale

This 12-item scale was designed by Novak and Clayton (2001) to assess children's self-regulation ability. The items are rated on a 4-point Likert scale ranging from 1 (never) to 4 (always). This scale has three dimensions: emotional (items 1-5), cognitive (items 6-8), and behavioral (items 9-12). In the research by Novak and Clayton (2001), the results of exploratory factor analysis showed three dimensions of emotional, cognitive, and behavioral in this questionnaire. The coefficients of factors for this questionnaire were obtained at 0.95, 0.96, and 0.94 for three dimensions of cognitive, emotional, and behavioral, respectively. The content validity of this tool was confirmed by two experts in developmental psychology and educational psychology. The convergent validity of the scale was reported to be 0.56 by correlating its total score with the Behavioral Rating Inventory of Executive Function (BRIEF) (Novak & Clayton, 2001). Moreover, the reliability of this instrument was obtained at 0.71 using Cronbach's alpha for the whole scale, and the results of exploratory factor analysis illustrated a favorable fit for the three-factor model. Factor coefficients for emotional, cognitive, and behavioral self-regulation factors were calculated at 0.61, 0.54, and 0.88, respectively (31).

Cognitive Rehabilitation Program

The cognitive rehabilitation program of executive functions based on cognitive load (Cable et al., 2020) is an application software program which focuses on cognitive abilities based on executive functions. The assignments of this software are designed based on five principles of optimal cognitive load enhancement (multimedia principle, guided learning principle, principle of thinking and meditation, privatization principle, and urgent feedback principle) (Moreno & Meyer, 2010) (32). Each of the tasks designed in this software has several difficulty levels that are set in a hierarchical manner from simple to difficult. Assignments start from the simplest level and the criterion for passing through one step and the next step is the provision of the correct answer to at least 75% of the stimuli presented at each stage and in case of responsivity, that step will be repeated.

The program is provided by the therapist whose presence is mandatory. Based on the obtained results, the minimum and maximum relative coefficients of content validity index (CVI) for each material or component of the program were 0.8 and 1, respectively, and the minimum and maximum content validity ratios (CVR) for each material or component of the program was obtained at 0.7 and 1, respectively. Therefore, the cognitive rehabilitation program based on the desired cognitive load had acceptable validity for educational application and clinical use. The cognitive rehabilitation program was performed individually for 18 30 minute-sessions three sessions a week. A summary of the assignments of this cognitive rehabilitation program is provided in Table 1.

Content

First session: Meeting with participants and familiarizing them with the training program and providing information about special learning disorder for parents and explaining cognitive impairments caused by this disorder, expression of the cognitive rehabilitation program, and program objectives

Second session: Familiarity of parents with the characteristics of children with learning disabilities and providing strategies to improve the deficiencies of these people, Providing explanations for child-parent interaction

Third session: Summing up the rehabilitation program for parents, providing additional explanations and feedback from parents in order to strengthen parent-child interaction, and completing parent-specific questionnaires

Fourth session: Making students familiar with executive functioning skills, describing executive functions for children, and teaching strategies to deal with executive problems, working memory, inhibition, and updating

Fifth Session: Enhancing executive functions (working memory, updating, and inhibition), reviewing the previous session, teaching working memory tasks (task 1, first step), inhibition (task 1, first step)

Sixth session: a review of previous session assignments, training of working memory tasks (task

11th session: reviewing the assignments of the previous session, training of working memory tasks (task 2, third step); inhibition (task 2, steps 4 and 5); update (task 2, first step)

12th session: a review of previous session assignments, training of working memory tasks (task 2, steps 4 and 5); inhibition (task 3, first step); update (task 2, step 2)

13th session: a review of previous session assignments, training of working memory tasks (task 3, first step); inhibition (task 3, second and third step); update (task 2, steps 3 and 4)

14th session: reviewing the assignments of the previous session, training of working memory tasks (task 3, step 2 and 3); inhibition (task 3, step 4); update (task 2, steps 5 and 6)

15th session: a review of previous session assignments, training of working memory tasks (task 3, step 4 and 5); inhibition (task 3, step 5); update (task 3, first step)

16th session: a review of previous session assignments, training of working memory tasks (all three tasks), inhibition (task 3, step 6); update (task 3, steps 2 and 3)

17th session: reviewing the assignments of the previous session, training of working memory tasks (assignment, step), updating (task 3, step 4 and 5)

18th session: reviewing the assignments of the previous session, preparation for the termination of treatment

Research Methodology

In order to implement the rehabilitation program, to obtain the necessary legal permissions, the researchers referred to the Department of Exceptional Education of Alborz Province, as well as the education departments of Hashtgerd and Nazarabad, as well as the schools and learning disorder centers affiliated to the ministry of Education. In this regard, after justifying and convincing the relevant authorities, a briefing was established to inform and justify families regarding

1, second step), inhibition (task 1, second and third step)

Seventh session: reviewing the assignments of the previous session, training update assignments (task 1, first step), inhibition (task 1, step 4)

Eighth session: a review of the tasks performed in the previous session, training of working memory tasks (task 1, third step), inhibition (task 1, step 5), update (task 1, step 2)

Ninth session: reviewing the assignments of the previous session, training of working memory tasks (task 1, step 4, and 5); inhibition (task 2, first step); update (task 1, step 3)

10th session: a review of previous session assignments, training of working memory tasks (task 2, first and second step); inhibition (task 2, second and third step); update (task 1, steps 4 and 5)

the importance of this study and gain their consent for participation in the study. After inviting the first people whose children had special learning disabilities, they detailed about this disorder, especially the characteristics of children with this disorder who had problems in different areas of education despite having moderate or higher than average intelligence.

Thereafter, the rehabilitation program and its benefits were discussed and parents' satisfaction was obtained to participate in the research process. Following that, after reviewing parents' reports, teacher's reports, and finally learning disorder assessment scale (LDES) questionnaire, 33 students with diagnostic criteria in standard intelligence test (Wechsler or Stanford Bine) were selected and randomly assigned to two groups of experimental and control. Subsequently, the experimental group received the rehabilitation program for eight weeks (each session lasted 40 min), while the control group did not receive any educational programs. The self-regulatory scale was then administered to both groups and the average was used after receiving the training program.

One month later, follow-up tests were performed for both experimental and control groups. In each session, 10 min before the commencement of training, the previous session was reviewed and 30 min of sessions were devoted to new exercises. In each session, students were busy with rehabilitation assignments, and the researcher and two research assistants also guided and supervised their activities at the same time. Moreover, through initial training to research assistants, using implementation instructions and random monitoring of some training sessions during work, it was attempted to use confounding factors, such as the effect of pre-test and measurement tools, to control and apply the same principles for implementing interventions and pre and post-test.

All rehabilitation sessions were conducted between 8:00 and 10:00 a.m in a quiet room in

centers for learning disorders and administered by the researcher. It is noteworthy that the students who were weaker in education and slower to learn received more help. At the end of each session, the students and their parents were given feedback on students' progression in that session. Furthermore, the ethical considerations of the present research included placing the control group on the waiting list, obtaining informed consent from the participants in the research and withdrawing from participating in each stage of the research, and the fact that the subjects were promised that their information would remain confidential.

Results

Table 2. Mean and standard deviation of pre-test and post-test scores in self-regulatory variables and academic performance separately

Variable	group	Pre-test		Post-test		Follow up	
		mean	Standard deviation	mean	Standard deviation	mean	Standard deviation
Academic Self-Regulation	experiment	20.17	4.09	33.5	2.94	36.50	5.62
	control	20.62	4.23	19.54	3.04	20.85	3.36
Academic Performance	experiment	28.5	2.94	36.75	2.66	35.83	2.88
	control	28.30	2.56	28.23	1.96	27.38	2/36

As illustrated in this table, the mean scores of self-regulation and academic performance in the experimental group increased in the post-test and follow-up stages, as compared to those in the control group. In addition, a multivariate covariance analysis test was used to analyze the data. This test has assumptions to evaluate the normality of the data using Kolmogorov-Smirnov and Shapiro Wilk tests. The results of this test demonstrated that the significance level of all four scales and their components in experimental and control groups was greater than the significance level (0.05) required to reject the zero assumption (P>0.05). Therefore, our zero assumption regarding the distribution of dependent variable scores in both self-regulatory variables (and emotional, cognitive, and behavioral components) and academic performance was confirmed. Moreover, the box test was used to investigate the default homogeneity of the variance-covariance matrix. The results of the box test showed that the significance level of this test was not statistically significant and the default homogeneity of variances for these variables was established (P>0.05).

Levene's test was used to assess the homogeneity of the variances for the variables in the two groups. The results of this test demonstrated that the significance level of the test values in both self-regulatory variables (and emotional, cognitive, and behavioral components) and academic performance was not statistically significant, and the default homogeneity of variances for these variables was established (P>0.05). In addition, the other assumption is the homogeneity of regression line slopes in group interaction and pre-test in the two groups. The results of this test suggested that the significant level of interaction between the group and the pre-test in self-regulatory variables (and emotional, cognitive, and behavioral components) and academic achievement was not significant (P>0.05). Therefore, it can be stated that this assumption was established after ensuring the establishment of multivariate covariance analysis assumptions to determine the effectiveness of rehabilitation program in self-regulatory variables and academic performance. This method was used to analyze the data and the results are presented in the table below.

Sources of Change	Wilks' lambda	F value	Degree of Freedom1	Degree of Freedom2	Meaningful level	Ata Square	exponent
Progress pre-test	0.0013	14.01	10	1	0.068	0.987	0.536
Self-regulatory pre-test	0.099	1.664	10	1	0.435	0.901	0.127
Group	0.072	104.37	10	1	0.01	0.998	0.995

Furthermore, among the tests of Pillai's trace, Wilks' lambda, Hoteling's trace, and Roy's largest root, the Wilks' lambda was used. As displayed in Table 2, the group effect is significant for the scores of variables (F10,1=104.37, P<0.001, η2=0.995). This indicates that there are differences between the averages, pointing to the effectiveness of rehabilitation program on self-regulation and academic performance. In addition, the effect size of 0.998 indicates that rehabilitation has a strong effect on children with special learning disorders. Moreover, the results of the multivariate covariance analysis test on temporal components are depicted in the table below.

Table 3. Results of Multivariate Covariance Analysis of Cognitive Rehabilitation Effectiveness in Self-Regulatory Components

Source of changes	Total Squares	Wilks' lambda	Degree of Freedom1	Degree of Freedom2	Meaningful level	Ata square	exponent
Emotional	0.507	5.82	3	18	0.006	0.493	0.896
Cognitive	0.418	8.34	3	18	0.001	0.582	0.975
Behavioral	0.513	5.69	3	18	0.006	0.484	0.889
group	0.077	71.39	3	18	0.001	0.923	1

As displayed in Table 3, the group effect is significant for the scores of variables (F18,3=71.937, P<0.001, η2=0.923,) pointing to differences between the mean scores the effects of rehabilitation on self-regulatory components. Furthermore, the effect size of 0.923 signifies that rehabilitation has a strong effect on temporal components in children with special learning disabilities. Furthermore, in order to investigate the persistence of cognitive rehabilitation effectiveness based on optimal cognitive load in self-regulation (and emotional, cognitive, and behavioral components) and academic achievement of children with special learning disorders, multivariate repeated measurement variance analysis with an intergroup variable (mixed-change model) was used. The results of this test illustrated that the effect of cognitive rehabilitation based on the optimal cognitive load on self-regulation and academic achievement of children with special learning disorders was stable over time.

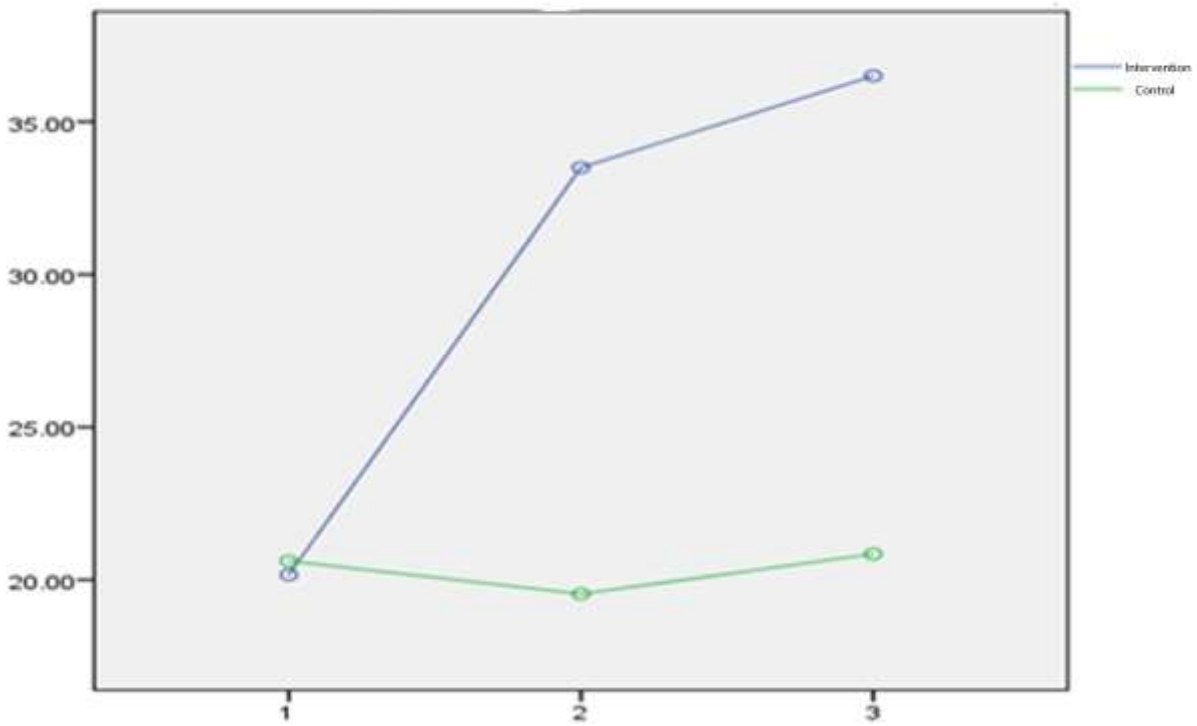

Figure 1. Trend Analysis of Changes in Behavioral Self-Regulatory Scores in Groups

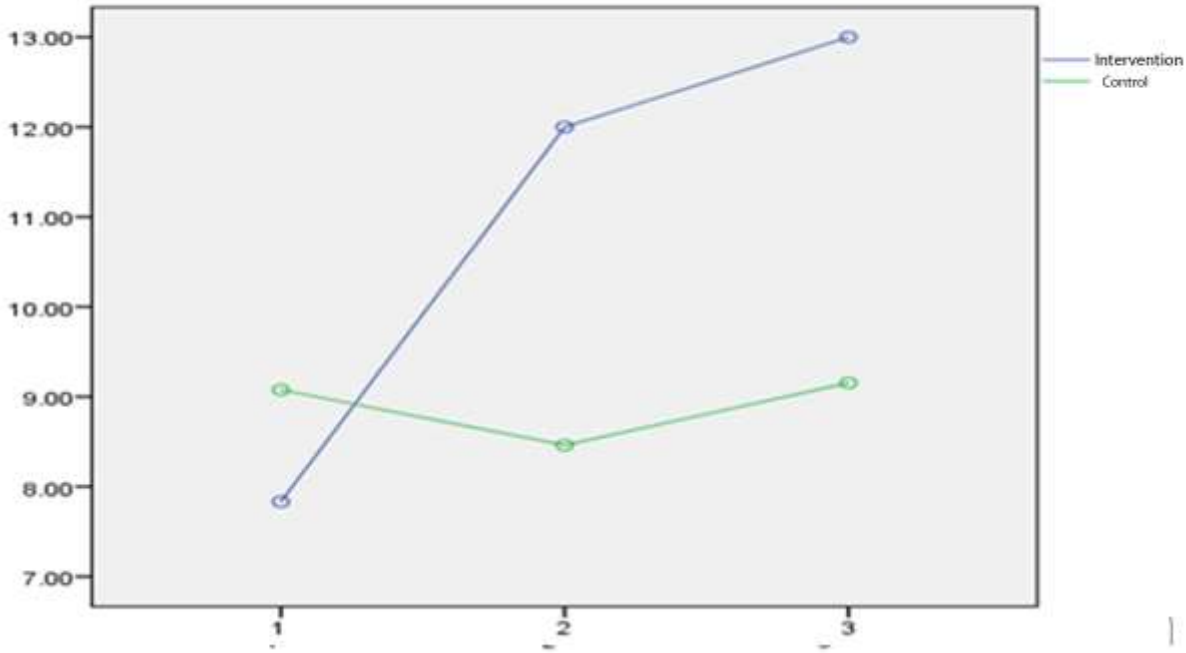

Figure 2. Trend Analysis of Changes in Cognitive Self-Regulatory Scores in Groups

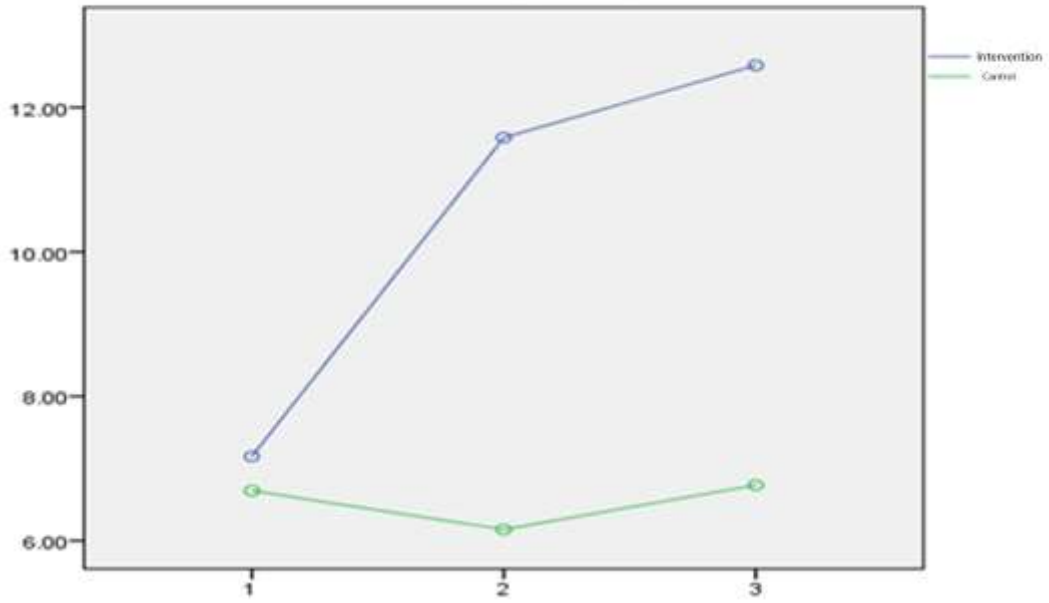

Figure 3. Trend Analysis of Changes in Emotional Self-Regulatory Scores in Groups

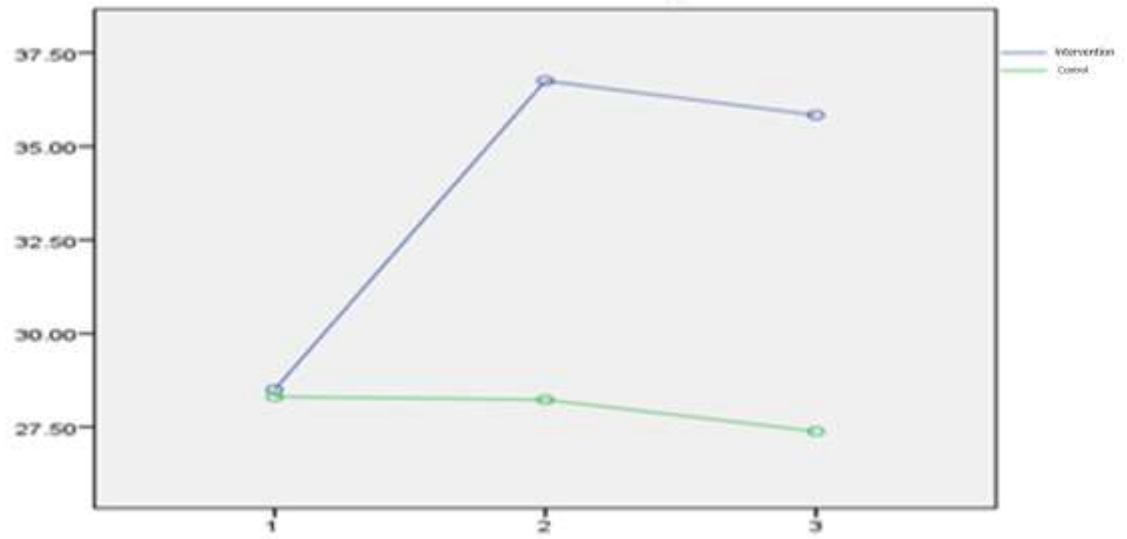

Figure 4. Trend Analysis of Changes in General Self-Regulatory Scores in Groups

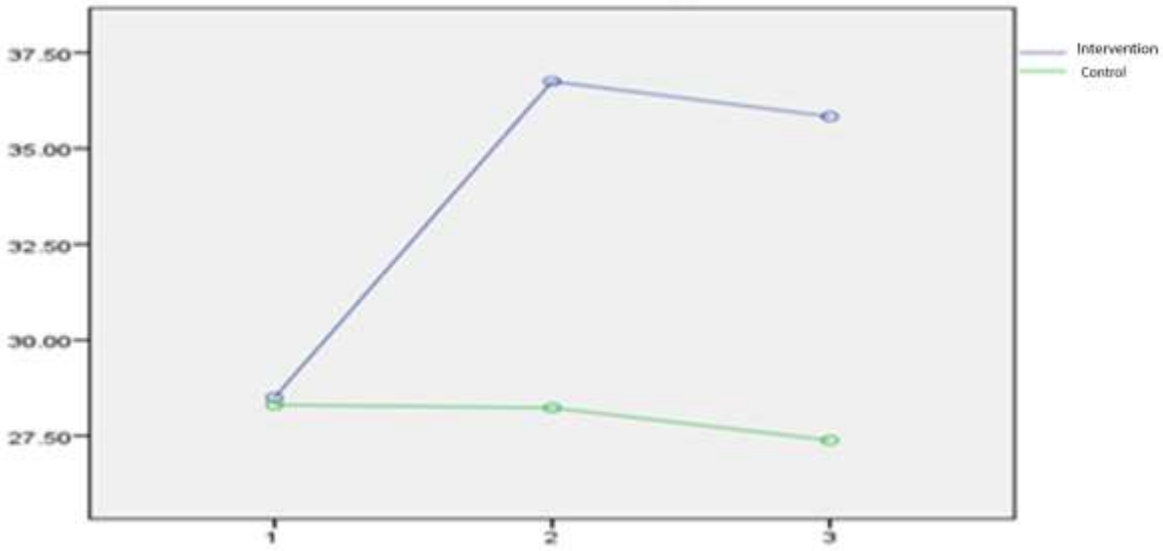

Figure 5. Trend Analysis of Changes in Academic Achievement Scores in Groups

In the Figure 1,2,3,4,5, changes in self-regulatory scores and its components are reported by group. Step 1 is the pre-test, step 2 is the post-test, and step 3 is the follow-up. As illustrated, there is a significant improvement in the scores of the experimental group after the test and in the follow-up of relative retention of the scores. Furthermore, changes in academic achievement scores were reported by the As shown, the scores of the experimental group have grown significantly compared to the post-test.

Discussion and Conclusion

The present study aimed to assess the effectiveness of cognitive rehabilitation program based on optimal cognitive load in self-regulation and academic achievement in children with special learning disorders. The obtained results pointed out that the cognitive rehabilitation program was effective in self-regulation, as well as its cognitive, emotional, and behavioral components. This finding is in agreement with those reported by Hoffman, Schmeichel, and Badley (2012) (12); (33), Sewer and Pas (2017) (34) and Malhotra, Rajendra, Sharma, and Singh (2009) (26). Cognitive rehabilitation is an expanding field that aims to improve body structure and function, improve activity and participation in areas expressed by the International Classification of Functioning, Disability, and Health(ICF). In this regard, activity and participation focus on one's functional status and include communication,

mobility and dynamism, interpersonal interactions, as well as self-care and learning.

Life and social domains affect a person's ability to perform tasks and participate in roles. Therefore, the goal of cognitive rehabilitation is not to improve neuroscience test scores but to achieve better autonomy in daily life (14). Accordingly, cognitive rehabilitation is another aspect of self-regulation which refers to a process in which learners systematically and independently maintain and guide their cognitions, motivations, behaviors, and emotions in order to achieve their goals (9). Therefore, the ultimate goal of both cognitive rehabilitation and self-regulation is the same.

Some processes, such as cognitive rehabilitation, that enhance one's cognitive abilities to achieve independence, serve self-regulatory goals. Nonetheless, behavioral and cognitive studies also confirmed the relationship between self-regulation and cognitive functions (2). Moreover, in the present study, regarding the application of the principles of optimal cognitive load enhancement in the rehabilitation program and its relationship with self-regulation, the researcher has made this choice based on the theoretical logic of cognitive load concepts and self-regulation. Consequently, based on Deeburn and Vanmerinboer's opinion (2017) (23), self-regulation and cognitive load theory are both rooted in the psychology of learning and memory, and the logic lies in both approaches, providing solutions and guidance.

It is necessary that teachers, designers, and learners regulate the learning process while considering the abilities and limitations of the cognitive system. Sewer and Pas (2017) (34) believe that these two approaches are not fundamentally very different, and both seek to answer the question of how to improve the processes that regulate learning and the impact of this setting on the learning process and promote learning levels. On the other hand, cognitive load theory, by expressing the desired cognitive load, is closer to the concept of self-regulation and suggests techniques that aim to enable the learner during learning and promote the desired cognitive load (32). Consequently, both the concepts of self-regulation and optimal cognitive load focus on learning activities (e.g., individual's mental effort, assessment of self-learning), and both emphasize self-centered learning situations (23).

The self-regulated learners plan for their learning activities and complete their efforts to perform them, which will be a desirable one-time effort for planning. In addition, when students spend their resources on metacognitive processes, the desired burden will be created in the learning process. The burden of learners' metacognitive processes during learning will be a desirable cognitive load that is spent on their deeper involvement with the content, facilitating learning (35).

The principles of strengthening the desired cognitive load by focusing on engaging the learner in the learning process serve self-regulatory goals. For instance, the principles of guided learning and feedback are a fruitful guiding and adjustment framework for self-regulation improvement, signifying that gradual guidance should be provided to the learner while learning to recognize his/her current situation and consider its relationship with the goal. If there is such a constant awareness of the situation, one can react favorably and organize his/her learning process with self-regulation (23). According to the above explanations, it can be argued that the common components among self-regulation, cognitive rehabilitation, and optimal cognitive load lead to the improvement of self-regulatory processes in learners.

Another finding of this study demonstrated that cognitive rehabilitation program was effective in the academic performance of students with special learning disorders. The aforementioned findings are in accordance with those reported by Froelich et al. (2010) (36), Diamond (2012) (37), and Zelazzo et al. (2017) (13). It can be stated that the predictive capability of executive function skills in the prediction of academic performance is better and higher than IQ scores (38-39). Therefore, systematic efforts to improve and strengthen executive function skills improve academic performance.

In the same context, Meltzer (2018) (2) believes that academic success in the digital age is increasingly correlated not only with students' technical expertise (content-driven domain) but more importantly, their mastery of such processes as the maintenance and manipulation of information in working memory, cognitive flexibility, inhibition of information unrelated to the subject, targeting, planning, prioritizing, organizing that are classified as executive functions (memory-based domains). Nonetheless, people with special learning disabilities are impaired in these abilities. As a result, it has become increasingly important for teachers to teach strategies that systematically address executive functioning processes to help students understand how they think and learn and compensate for their shortcomings (13). Accordingly, one of the key areas affecting learning and academic achievement is strengthening executive functions.

Several studies (Swanson et al., 2020; Kwon, 2015) (7, 15) have also supported the role of executive functions in people with special learning disabilities. For example, Kwon (2015) believes that defects in executive functions are among the factors that can be effective in the occurrence of learning disorders. In their research examining executive functions in children with a reading disorder, Fisher et al. (2016) (22) pointed out that these people achieved lower scores than their peers without learning disorders. Based on interventions targeting

executive functions, they lead to strengthening academic achievement in people with special learning disabilities.

In general, it can be stated that students with learning disabilities often exhibit cognitive processing and unique working memory characteristics that may not be in line with the principles of educational design developed with ordinary learners (2). The distinction of students with specific learning disorders, academic deficiencies, etc., becomes more visible when the educational location is changed. When they enter high school, this gap widens, putting them at a greater risk for behavioral outbursts, severe academic failure, and dropouts (7).

Therefore, strengthening the executive functions included in the cognitive rehabilitation program leads to the improvement of learners' academic achievement (40). According to the aforementioned explanations, it can be argued that one of the ways to make education efficient in students with specific learning disorders is through interventions that are targeted at self-regulation and academic achievement. Cognitive empowerment based on the desired burden that was used for the first time in this study plays a prominent role in solving these students' psychological problems.

Furthermore, the efficiency of these cognitive rehabilitation programs in Persian speakers is seriously challenged due to their compilation in other languages and high cost. In addition, students drive great pleasure out of computer programs which motivate them to get involved in education more enthusiastically since they consider learning an interesting game (41). In this study, the rehabilitation program based on computer-based education was considered to increase students' motivation and willingness to education. In addition, in designing this program, the principles of improving the desired cognitive load which leads to schema design and automating were considered to help to eliminate the deficiencies of people with learning disabilities.

Moreover, the advantage of this educational rehabilitation package over previous intervention programs was the application of principles related to optimal cognitive load to improve transfer and schema making in students, thereby increasing the efficiency of the program. Among the notable limitations of the present study, we can refer to the restriction of sample to students with second and third-grade learning disorders. Moreover, the participants were at critical ages of promotion of these domains from the perspective of rehabilitation regarding self-regulation in cognitive and emotional domains, thereby limiting the possibility of generalizing the findings to children who are not in this age period. In addition, a questionnaire was used to collect data and evaluate the level of self-regulation.

It is suggested that future studies be conducted on larger samples in other educational levels to increase the validity and generalization capability of the results. Furthermore, it is recommended that different methods of evaluation (interviewing parents and observing the child) be used in the future. In addition, based on the findings of this study regarding the effectiveness of cognitive load-based cognitive rehabilitation program in the self-regulation and academic performance of children with special learning disabilities, it is suggested that cognitive rehabilitation therapy be used as a complementary intervention to improve academic performance as one of the main problems of children with learning disabilities in psychological clinics and schools. It is believed that such support will be of great help to teachers and students, maintaining their academic motivation to continue their education and attain career success in the future.

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