Effectiveness of Reigeluth's Educational Model on Attention Degree and Working Memory Capacity of Students with Attention Deficit Disorder

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Abstract

Purpose: The present study aims at determining the effectiveness of the Reigeluth's educational model on the level of attention and working memory capacity of students with attention deficit disorder.

Methodology: This is an applied study in terms of purpose and a quasi-experimental one in terms of data collection, in which, a pre-test-post-test design with a control group was used. The statistical population of the present study includes all fifth grade female students in Tabriz in the academic year 2019-2020. The Conners Parent Questionnaire was used to determine and screen the study sample. Considering the 8% prevalence of attention deficit disorder among students, the Conners Parent Questionnaire was administered to 560 subjects and 30 students with attention problems (scores above 72 in the Conners Parents Questionnaire) were selected as the sample and were randomly assigned to the experimental and control groups. The experimental group was trained in six sessions using the Reigeluth's educational model and the control group did not receive any training. Selective and divided attention test (Sinai Institute, 2014) and working memory test (Kirschner, 1985) were used to collect data. Data analysis was performed using multivariate and univariate factor covariance analysis.

Findings: Findings showed that Reigeluth's educational model improves the performance of selective and divided attention of students with attention deficit disorder and increases their working memory capacity.

Conclusion: An overview of the lesson plan (course perspective) at the beginning of the training creates a clear, stable and organized cognitive structure in the minds of learners. As a result of this structure, students' working memory is activated and meaningful learning occurs. Also, when learning happens among learners in a significant manner, what they have learned remains in their memory for a long time, which will improve their working memory capacity.

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1. Introduction

Attention deficit disorder is one of the most common childhood disorders which are of interest to psychologists and psychiatrists (Biederman, 2005). It begins around the age of 2 to 4 (Conners, 2002) and is one of the most common neurobehavioral disorders in childhood, affecting a large number of the world's children (3 to 7%) (Frawne, et al, 2003). Attention Deficit Disorder is a persistent pattern of inattention or hyperactivity and impulsive behaviors that are more severe and common than those usually seen in children at similar developmental levels (Kaplan and Saduk, 2001). To make this diagnosis, some symptoms should appear before the age of 7. The disorder should be present in at least two areas, and the individual's performance should be impaired in social, educational, or occupational settings, depending on the growth level. Studies show that children with attention deficit disorder experience severe brain dysfunction (Lounsbury, Steel, Loveland, & Gibson, 2014). One of the important areas among these executive functions is working memory. Students with attention deficit disorder have shown evidence of impaired working memory, and the transfer and adaptation of the spatial, visual and working memory. This deficiency occurs in problems, math, time-telling and approximate computations, as well as in reading difficulties, poor verbal short-term memory, and processing speed (Berryhill, 2008). One of the main reasons for this deficiency in memory tasks is that these children, unlike their natural counterparts, do not use effective memory strategies such as mental review (Ghanaii, 2008). Some studies have shown that children with attention deficit disorders perform much worse in terms of working memory than normal children (Enger, 2018).

In addition, insufficient working memory capacity or poor long-term memory organization may cause attention problems. Since the important component of working memory creates many individual differences between people, it should be considered in teaching and learning different subjects. That's because, working memory affects the ability to store information in the brain at a given moment. Loosli, Buschkuehl, Perrig, & Jaeggi (2011) stated that children's ability to store and manipulate information in working memory is closely related to their academic achievement during the school years. In other words, there is a relationship between these working memory abilities and students' attention. Research findings also show that measurements of working memory in school-going volunteers are very strong predictors of children's success in comprehensive assessment of academic achievements over the next three years (Repovs & Baddeley, 2016). Other areas of executive dysfunction in children with attention deficit disorder include defect in attention processes and attention degree, that is, attention is a person's ability to process information, and information processing capacity is limited in these people. In this case, it becomes difficult for the individual to participate in one or more tasks at the same time. The main challenge in adapting to large volumes of information is specifically related to environments that require both high-level skills as well as large amounts of information. In this regard, neuroscientists believe that attention is the result of interaction between different areas of the brain and no specific area in the brain is solely responsible for attention functions (Sterr, 2014). Andersen (1980) considered attention as a limited resource, given that one of the characteristics of attention is its limited capacity, taking into account the fact that a person simultaneously can be focused on only limited numbers of stimuli at a time. If a person tries to pay attention to too many stimuli at a time, interference occurs and at least, interaction with on one of these two tasks decreases (Mortazavi, 2009).

Although children with attention deficit have obvious deficiencies in the areas of memory and attention, in recent years, various research and educational efforts have emerged to use special positive strategies to repair deficiencies and improve these functions. One of the methods used to reduce attention deficit disorder is the use of appropriate educational methods (Frey, 2011). One of the educational methods or models that can play a role in improving students' memory capacity and attention deficit is the Reigeluth's model. The Reigeluth's model uses seven educational strategies to describe and expand the content of the training course. For this purpose, the educational designer who uses this model should firstly determine the type of educational contents and components. Accordingly, Reigeluth generally divides

educational subjects into theoretical and practical subjects. Whenever the educational content describes doing something or the production method for a product or the steps required to get the job done, it is known as practical (working method). Here, the components of education are the stages of getting the job done or the stages of producing the product, and theoretical topics refer to all scientific data in all fields (concepts and rules), which, depending on the main axis of the training content, is divided into a conceptual or legal issue. After selecting one of the three types of content, the concept, working method, and rule will be decided upon with the help of an expert on the educational subject. The structure of the subject shows the relationships between the components of the course (such as facts, concepts, rules, working methods). Depending on the subject of the training, it is necessary to identify the conceptual structure or the working or legal method to start the design of the sequences. Depending on the main type of subject structure, the designer can describe the educational subject through a simple to complex sequence (Chiemi, 2014).

Since this educational model addresses students' prerequisites for summarizing, composition, exemplification, and controlling the learner, all of which emphasize student attention, it can also be effective in students with attention deficit disorder. The results of Jordan, Gloating, and Raminy (2016) indicated that increasing processing speed, cognitive flexibility, verbal, declarative and visual memory scores all indicate improved cognitive processes through the Reigeluth's educational method. Kessler, Lakayv, and Joe (2018) showed that Reigeluth's model significantly increased memory scores in terms of processing speed, verbal and declarative flexibility, and visual cognition and also played a significant role in increasing the activity of the forehead cortex. Each educational model has different effects on the level of attention and use of students' working memory according to its emphasized principles. Today, students commonly fail to acquire real-life transferable abilities and skills, have less understanding of course content, and have a low level of attention to the educational course. It should be noted that today, the student is not in a barren plain, seeking knowledge. He is floating in an ocean of information. The teacher is no longer considered a pond in the desert, he is also a passenger in the same boat as students and should help them to rank information and make sense of it (Moradi, 2010).

Considering the importance of educational methods in creating attention and achieving the desired learning outcomes, and taking into account this and other goals could not be achieved without careful educational design, and that in studies on the effectiveness of Reigeluth's educational model, the working memory or attention capacity were not studied and also in Iran, the effectiveness of these models in students with attention deficit has not been determined among students with attention deficit disorder, this study addresses the effectiveness of Reigeluth's educational model on the attention level and working memory capacity of students with attention deficit disorder.

2. Methodology

This is an applied study in terms of purpose and a quasi-experimental one in terms of data collection, which used a pre-test-post-test design with a control group.

Table1. Pre-test and post-test design with control group

Control and experimental groups	Pre-test	Independent variable	Post-test
GE1	T1	X1	T2
GC1	T1	----	T2

The statistical population of the present study includes all fifth grades, female students in Tabriz in the academic year 2019-2020. In this study, the Conners Parental Questionnaire was completed by the parents of elementary school female students (considering the 8% prevalence of attention deficit disorder among students, the Conners Parents Questionnaire was administered to 560 subjects). In this study, the students with scores above 72 in the Conners parental form and had been diagnosed with attention deficit disorder in their academic record were identified as subjects with attention problems. The sample size consisted of 30 students with attention disorders who were purposefully selected and randomly assigned

to the experimental (n=15) and control (n = 15) groups. The experimental group was trained in six sessions using the Reigeluth's educational model and the control group did not receive any training. The inclusion criteria of the study included: 1- Similar cultural and economic characteristics (selection of schools from areas with average cultural and economic status) 2- Obtaining a score higher than the average (72) in Parental Conners questionnaire 3- Being recognized as students with average intelligence level in the Raven IQ test (based on academic record), and 4- Average academic performance (grade point average between 17 to 19 in the fifth grade). Exclusion criteria of the study included: 1- Reluctance to attend educational sessions 2- Absence from more than two educational sessions.

Sinai Institute's selective and divided attention test (2012) was used to assess attention. It measured the selective and divided attention in different age groups. The test was designed by Sina Institute in collaboration with Dr. Monavar Yazdi. This test has two stages: first, the selective attention test is performed, in which, two letters of the alphabet (for example, M and S) are displayed on the screen. Then the experiment begins. If the mentioned letters were displayed, the subject should check; otherwise, he should not check.

The time interval between the display of two stimuli is considered half a second, which of course is variable. The type of letters is also variable. Then the divided attention test is performed. At this step, the above two letters are displayed on both sides of the screen. The subject should respond only to the right-side stimulus with the right hand and to the left-side stimulus with the left hand, and should not respond in case any change occurs. Answering in this case is considered an error. In Zare, Farzad, Alipour and Nazer (2015), to evaluate the reliability, between pre- and post-tests of the control group, which was performed one month apart, the correlation coefficient is in the Stroop correct synchronous response and 0.904 in the Stroop correct asynchronous response. The coefficient was also obtained as 0.862 for the selective attention and 0.933 for the divided attention. Also, in order to evaluate the validity between the inconsistent response in the Stroop test and the selective attention in the selective and divided attention test, a significant correlation coefficient of 0.390 was obtained in 300 subjects of the group with and without trauma. In Nahravanian et al. (2015), the reliability of the test was 0.85 for the selective attention and 0.87 for the divided attention.

Kirschner's (1985) working memory test was used to assess students' working memory. This test is related to the task of measuring cognitive function in relation to executive impulses and was first introduced in 1985 by a researcher named Kirschner. Since the test involves both storing cognitive information and manipulating it, it is very suitable for measuring the performance of working memory. Validity coefficients in the range between 0.54 and 0.84 indicate the high validity of this test. The validity of the test is also very acceptable as an indicator of working memory performance (Kane, quoted by Ghorbani, 2015). The overall score in this task was the sum of correct answers from which incorrect answers and unanswered items were deducted. Overall score, incorrect responses and reaction time for correct answers were recorded in this task. Validity coefficients are in the range between 0.54 to 0.84 and the high validity of this test is an indicator of high working memory performance (Kane, Kenway, Miura and Kelflesh, 2007; Kasaian, Kiamanesh and Bahrami, 2013). Reliability coefficient of the test was obtained 0.78 in Nahravanian et al. (2015). In Iran, this test has been validated by Taghizadeh, Nejati, Mohammadzadeh and Akbarzadeh (2014). The following model was used for education with the Reigeluth's educational model:

Table2. Education using Reigeluth's model (Reigeluth, 2005)

Sessions	Steps	Description
Session 1	Pre-test	Working memory and attention questionnaire was implemented.
Session 2	Sequence of learning prerequisites	Prerequisites were taught before introducing new content.
Session 3	Summary	In educating, the material learned was reviewed regularly to prevent it from being forgotten.

Session 4	Composition	The topics were presented by comparing them with each other and relating these topics to the learner's previous knowledge.
Session 5	Exemplification	New concepts became understandable by relating them to familiar concepts.
Session 6	Cognitive-motivational strategy	Educational course was designed to encourage learners to use cognitive skills and asked learners directly for a specific approach.
Session 7	Learner control	Learner was free in choosing, content sequencing and how to use educational strategies, etc.
Session 8	Pre-test	Working memory and attention questionnaire was implemented.

In the present study, the data obtained from the questionnaires in the pre-test-post-test were analyzed using descriptive statistical methods such as mean, standard deviation, frequency distribution and also hypotheses were analyzed using inferential statistical methods, such as multivariate analysis of covariance. Spss22 was used for data analysis.

3. Findings

The following tables provide descriptive information about the research variables in the control and experimental groups and in pre-test and post-test stages:

Table3. Descriptive information about research variables

Variables	Test	Control group		Experimental group	
		Mean	SD	Mean	SD
Total attention score	Pre-test	108/60	8/57	106/46	6/90
	Post-test	112/26	5/28	112/26	8/10
Divided attention	Pre-test	34/46	2/32	20/33	2/67
	Post-test	34/60	3/01	35/66	2/60
Selective attention	Pre-test	51/13	4/51	49/86	3/75
	Post-test	52/60	3/83	53/86	3/50
Reaction time	Pre-test	14/80	1/26	16/26	1/86
	Post-test	14/93	1/43	14/80	1/37
Capacity of working memory	Pre-test	64/33	4/35	63	4/27
	Post-test	65/73	11/65	72/66	10/25

Hypothesis 1: Reigeluth's educational model has an effect on the attention degree of students with attention deficit disorder. In order to investigate the first hypothesis of the study, considering the positive effect of Reigeluth's educational model on the attention of students with attention deficit disorder, multivariate analysis of covariance has been used. Attention has three subscales: divided attention, selective attention, and reaction time. In this section, the pre-assumptions of multivariate analysis of covariance are examined. First, the hypothesis of homogeneity of slopes, which is one of the basic pre-assumptions of analysis of covariance is investigated, the results of which are reported in the table below.

Table4. Investigation of regression slope homogeneity

	Dependent variable	sum squares	df	Mean squares	f	Significance
Pretest group	Divided attention	32/735	2	16/368	3/185	0/60
	Selective attention	57/562	2	28/781	2/413	0/112
	Reaction time	14/040	2	7/020	3/360	0/052

Considering that the significance level of all three variables of divided attention, selective attention and reaction time is higher than 0.05, the homogeneity of regression scales for covariance analysis is a true assumption and here is a linear relationship within the groups between dependent variables and covariate variables. Leven test was used to test the assumption of consistent variances in the study groups, which is another assumption of analysis of covariance. The results of this test are presented in table below.

Table5. Leven test to examine the assumption of consistent variances

Dependent variable	F	Df1	Df2	Significance
Divided attention	0/002	1	28	0/968
Selective attention	3/722	1	28	0/229
Reaction time	1/510	1	28	0/064

The results of this table indicate that the significance levels of all three variables of divided attention, selective attention and reaction time are higher than 0.05 and the assumption of consistent variances is established in the study groups for analysis of covariance. Another pre-assumption of the multivariate covariance test is the test of equality of covariance matrices of the dependent variables between the different groups. This test was performed using Box'M statistics and the results are presented in the table below.

Table6. Box'M test for the equality of observed covariance matrices of dependent variables between groups

Box·M	F	Df1	Df2	Significance
9/924	0/724	6	53/803	0/630

According to the results of the above table, since the value of F (0.724) is not significant at the given error level (0.630), the null hypothesis is not rejected. This means that the observed covariance matrices are equal between different groups. To test the hypothesis, the researcher chose the Wilks's Lambda statistic from among Pillai's Trace, Wilks' Lambda, Hotelling's Tracec and Roy'sLargestRoot for the calculation.

Table7. Multivariate analysis of the effect of Reigeluth's educational model on attention

Multivariate Test	Statistic	F	Df of hypothesis	Df of Error	Significance level
Wilks's Lambda	0/621	4/674	2	23	0/011

According to the above table, Wilkes's Lambda (P.0 0.05, F = 4.67) shows that the hypothesis of similar means of the population can be rejected based on dependent variables for control and experimental groups.

Table8. Results of multivariate analysis of covariance on the effect of Reigeluth's educational model on attention

Model	Dependent variables	Sum of squares	df	Mean squares	F	Significance
Group	Divided attention	22/507	1	22/507	4/286	0/049
	Selective attention	12/092	1	12/092	6/347	0/019
	Reaction time	17/163	1	17/163	8/542	0/007
Error	Divided attention	131/275	25	5/251		
	Selective attention	375/605	25	15/024		
	Reaction time	50/229	25	2/009		
Total	Divided attention	37072	30			
	Selective attention	83201	30			
	Reaction time	7326	30			

The results of the intergroup effects of post-test with decreasing the effects of pre-test in the above table show that there is a significant difference between the means of the experimental and control groups in the subscales of divided attention, selective attention and reaction time. Examination of the mean scores of the experimental and control groups in Table 2 shows that the Reigeluth's educational model has increased divided attention, problem approximation, and decreased reaction time.

Hypothesis 2: Reigeluth's educational model has an effect on the working memory capacity of students with attention deficit disorder. In order to investigate hypothesis 2 of the study, the univariate analysis of covariance has been used based on the positive effect of Reigeluth's educational model on working memory capacity. In this section, the assumptions of univariate analysis of covariance are examined. First,

the hypothesis of homogeneity of slopes is examined, which is one of the basic assumptions of analysis of covariance, the results of which are reported in table below.

Table8. Investigation of homogeneity of regression slope

	Sum squares	df	Mean squares	f	Significance
Group in pre-test	733/691	2	366/845	3/300	0/052

Since the significance level of the group in the pretest is higher than 0.05, it can be assumed that the homogeneity of regression slopes is established for analysis of covariance and there is a linear relationship between dependent variables and covariate variables within the groups. To test the same assumption of consistent variances in the study groups, as another assumption of analysis of covariance, Leven test was used, the results of which are presented in table below.

Table9. Leven test to examine the assumption of consistent variances

F	Df1	Df2	Significance
0/044	1	28	0/835

The results of the above table show that at the significance level higher than 0.05, the assumption of consistent variances is established in the study groups for analysis of covariance. To evaluate the effect of Reigeluth's educational model on working memory capacity, univariate analysis of covariance was used and the results are presented in the table below.

Table10. Results of univariate analysis of covariance of the effect of Reigeluth's educational model on working memory capacity

	Sum squares	df	Mean squares	f	Significance	Eta coefficient
Pretest	394/203	1	394/203	3/572	0/070	0/159
Group	478/946	2	478/946	4/339	0/047	0/152
Error	2980/064	27	110/373			
Total	147394	30				

The results of the post-test intergroup effects with decreasing pre-test effects in the above table show that there is a significant difference between the means of the experimental and control groups in the variable of working memory capacity. Examination of the mean scores of the experimental and control groups in Table 2 shows that the Reigeluth's educational model has increased the working memory capacity of students with attention deficit disorder.

4. Discussion

The first finding of the study showed that the Reigeluth's educational model is effective on the attention of students with attention deficit disorder. This is consistent with the findings of Ponce, Lopez and Mayer (2012), Kast, Baschera, Gross, Jancke and Meyer (2011) and Dahlin (2015). In their study, Ponce, Lopez, and Mayer (2012) aimed at investigating the effectiveness of Reigeluth's educational model on comprehension teaching strategies in the attention process of fourth grade elementary school students in Chile and showed that Reigeluth's educational model has been very effective in this regard. Kast, Baschera, Gross, Jancke and Meyer (2011) examined the effect of the Reigeluth's educational model on dyslexic and normal students and concluded that hyperactive children developed spelling skills as much as normal children. Also, the level of attention of hyperactive children had increased through this educational program. Dahlin (2015) found in his study that computer training based on Reigeluth's educational model can improve reading comprehension skills in children with attention problems.

Reigeluth's major educational strategy is simple to complex sequence that improves the ability of learners by creating and strengthening a stable and complete cognitive structure in the realization of meaningful learning. In addition, learners understand the relationships between ideas through a strategy of composition. The summarizing strategy helps learners pay long-term attention by regularly reviewing the material. Motivational and cognitive strategies help learners motivate in higher efforts and better and more

attention to the curriculum. Finally the learner control strategy gives learners the freedom to choose the type and amount of content based on their needs and interests, the sequences, educational strategies, etc. Each of these strategies, with its special features and capabilities, are highly effective in increasing the attention level, and using them in the form of Reigeluth's educational model, will certainly increase attention degree (Kessler and Lakayv and Joe, 2018). The use of motivational strategies (creating interest and motivation) is one of the most important features of the Reigeluth's model. Interest is the most important condition in creating attention. The more interest there is in a subject, the more attention is paid to it. Of course, the more information a person has about a topic, the more interested he or she will be in that topic (Jordan, Glutting and Raminney, 2016).

The second finding of the study showed that the Reigeluth's model is effective in increasing the working memory capacity of students with attention deficit disorder. This finding is consistent with the findings of Loosli, Buschkuehl, Perrig, Jaeggi (2012) and Bakker (2016). Loosli, Buschkuehl, Perrig, Jaeggi (2012) concluded in their study that with just two weeks of dedicated training focused on working memory, which included images of animals and was designed in two parts of processing/encoding and reminder, there was a significant difference between children with developmental problems and those in the control group in terms of working memory and reading performance. Bakker (2016) also confirmed the effect of using the Reigeluth's model on improving memory performance. Explaining the reason for this hypothesis, it can be said that providing an overview of the content of the course (course perspective) at the beginning of the training creates a clear, stable and organized cognitive structure in the minds of learners. As a result of the formation of this structure, students' working memory is activated and meaningful learning occurs. Also, when learning takes place in a meaningful manner, what they have learned stays in their memory for a long time, and this will lead to an improvement in working memory capacity, which is consistent with the results of Gray (1993) and Wei-Fan (2002). In addition to the simple to complex sequence, the effectiveness of other Reigeluth's model strategies in increasing students' working memory capacity should not be overlooked.

In fact, one of the effective methods to increase the direction of working memory as a result of understanding the structure and relationships between the components of learning content is the Reigeluth's educational model. In addition to including the components of increasing working memory capacity, the model has a strong theoretical support in this field, which, if properly used, can achieve the intended goals to increase working memory (Jordan, Glutting and Raminney, 2016). According to this model, education starts with providing an overview or perspective of the educational content and the content of the course is gradually expanded. Reigeluth uses the camera's zooming lens allegory to facilitate understanding of this type of education. Just as the camera zoom lens can provide a comprehensive overview of the subject without reflecting details, the perspective course provides the same overview of the entire education without going into detail. After providing the view, the camera can focus on any part of the scene, which illuminates the details of a part of the image for the viewer. Reigeluth calls this "elaboration". Then, the camera turns back to the overall view. Thus, the learner finds the connection of the learned subject with the whole subject of education. The focus of the camera and the return to the big picture continue until all the problems are dissolved. Since visualizing information alongside words and creating a landscape or perspective helps reinforce working memory and makes better processing and storing of the information, Reigeluth's model enhances students' working memory capacity.

This study had some limitations, including the fact that all samples were of Turkish ethnicity, so generalizations should be made with caution. The reason why some researchers believe that there is a difference in working memory between monolinguals and bilinguals, and others have not observed a significant difference, is different tests and assignments used to measure this performance. In fact, when simpler tests and tasks are performed that do not require information manipulation in working memory, both groups operate at the same level, but when more difficult tests are performed that require more cognitive control and inhibition, bilinguals perform better. According to the research findings, it is

suggested that in future studies, the Reigeluth's educational model is used for other neurodevelopmental disorders such as learning and hyperactivity disorders, and in addition to using the results of the model; the actual and daily performance of these people in school and homework is carefully checked.

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