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# The Effectiveness of the Training based on Executive Functions on Student's Working Memory

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## Abstract

This study aimed to investigate the effectiveness of the training based on executive function on student's working memory. The study adopted a quasi-experimental design with pretest-posttest and a control group. In this study, the statistical population was all fifth-grade male students of Shahreza (Iran) in the academic year 2021-2022. 40 students from a primary boy school were randomly selected using the available sampling method who were randomly assigned to two experimental and control groups with 20 participants each. The experimental group underwent 10 sessions of training based on executive functions while the control group did not receive any intervention. The Daniman and Carpenter's (1980) working memory scale was used for data collection in the pre-test and post-test stages in the two groups and the collected data were analyzed using the ANCOVA. The findings indicated that the training based on executive function enhanced students' working memory in the experimental group compared to the control group in the post-test ($P<0.05$). Results showed that the training based on executive function can strengthen students' working memory in schools and educational centers.

***Keywords:*** Executive Functions, Training, Working Memory

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## Introduction

Nowadays, education is an important part of student's lives and its quantity and quality play an important role in their future in various dimensions (Shaykhal-Islami & Karmianpour, 2018). Educational success has a close relationship with progression and purposefulness of that society (Sadoughi et al, 2017). It is worth mentioning that the degree of academic achievement and decline is one of the criteria determining the efficiency of the educational system (Salsbili & Ghasemi, 2005). In addition, the discovery and study of variables affecting academic performance can lead to a better understanding and prediction of variables affecting academic achievement in school (Sepahvandi et al, 2016).

One of the variables affecting academic achievement in school is working memory. Working memory is the foundation of learning and is linked to academic achievement as well (Atkinson et al., 2021). Working memory consists of a short-term system with a limited

capacity which is available under all conditions (Debruine, Jolles & van den Broek, 2021). This memory temporarily and simultaneously stores simple and complex information and processes (Alloway, 2006). Working memory is a part of the mind to keep information when doing complex things and is one of the effective factors in learning. This memory is closely related to people's academic achievement in reading, writing, or mathematics (Gathercole, 2008). It can also be used for a variety of abilities, including learning, reasoning, planning, and decision-making (Martin et al., 2021).

Today, working memory as one of the important topics in neuroscience has attracted the attention of many researchers (Dahlin, 2013). Working memory consists of three central components as phonological ring, spatial and visual plane (Badli, 2007). The importance of working memory is because of working memory character to be an active and dynamic system used to store and temporarily manipulate information and to perform complex cognitive tasks such as learning, reasoning, perception, and thinking. Recovery practice is a learning technique that is useful to some students (Bertelson et al., 2021). When you mentally review, retrieve, and recall information, in fact, that information is transferred from long-term memory to working memory. Working memory is also actively associated with information that is being transferred to long-term memory (German et al., 2012).

On the other hand, executive functions mean purposeful and future-based skills (Nozari et al., 2019). Most researchers believe that executive functions are self-regulatory actions, which demonstrate the student's ability to inhibit, self-modify, plan, organize, use working memory, problem-solving, and goal-setting for homework (Grinblat & Rosenblum, 2016). These actions describe behaviors such as self-monitoring, change, self-initiation, planning, response inhibition, sustained attention, and organization, working memory, and regulating behavioral outputs (Smith, 2010). Since working memory capacity is also limited and we are not able to focus simultaneously on a large number of items, we can use the organization, which is the simplest form of this category of information, to reduce memory load and increase focus power (Seif, 2021). Working memory is associated with the ability to use past experiences for current success and to use problem-solving strategies for the future (Dawson & Guare, 2004).

Working memory consists of a central executor and several subsystems. The central executor is the alternative term to refer to attention control system, which is involved in coordinating and organizing the performance of various tasks, selective attention, attention shift, attention reflection, and planning (Baddeley, 2012; Tronsky, 2005). The system of rules is kept in working memory as active content and the situation that generates the excitement is reprocessed. A person may increase or decrease the emotional response by reaching more motivating aspects (Garner, 2009). Working memory holds only the most recently activated part of long-term memory and sends these activated elements in and out of the memory cache (Dosher, 2003). Encryption, storage, and recovery are three stages of memory. Data entry into memory is called encryption. When a physical input (such as sound waves) corresponds to what is to be entered into memory (for example, a person's name), it becomes an accepted code or representation of that memory, and that representation is stored in memory. This password is stored at a time interval called the storage step. When that password is recalled from memory, it is called the recovery phase (Atkinson, 2021). In any process that requires reasoning such as reading, writing, and mental arithmetic, working memory is involved, like repeating a list of numbers that are read to you and you have to retell them in reverse order, or translate simultaneously or drive (German et al, 2012). By repetition and mental review, information is transferred from short-term memory to long-term memory.

Seif (2019) conducted a study entitled "the effect of executive function training on children's working memory performance in fourth and fifth-grade elementary school students with learning disabilities in Shiraz". The statistical population included 100 male and female fourth and fifth-grade students with learning disabilities in Shiraz.The results of the study showed that enhancing executive functions increased working memory performance in students with learning disabilities. The effect of executive function training on students' working memory performance did not differ significantly with regard to gender. Also, Lan et al. (2011) examined the role of three components of executive functions (inhibition, working memory, and attention) in the academic achievement of reading, simple (counting), and complex (calculating) in American and Chinese students. In this study, working memory had an effective role in computational ability. Performance functions also have a significant impact on students' future for necessary skills, such as memory, creativity, and self-control. Considering the point, there is a real need to develop programs that promote the development of these functions in the early stages of schooling (Romero-Lopez, 2021). According to cognitive perspective, mental processes are enhanced through educational interventions, and thus, it would be possible to improve these processes in students. Furthemore, educational intervention provides opportunities for students that make them aware of their

strengths and weaknesses, and improve their attention, processing speed, and learning. Since the late 18th century, various programs have been implemented to develop cognitive abilities. The most promising of such programs are educational interventions based on executive functions for students and many studies have shown the usefulness of this program (Belenky &Nokes-Malach, 2009; Chen et al, 2020; Gaylo, 2017; Zimmer et al., 2021).

Executive functions are a set of cognitive processes that have been introduced in the form of planning, organizing, working memory, response inhibition, time management, task initiation, and goal-based resistance (Dawson & Guare, 2004). Executive functions depend on factors such as self-efficacy, personal control over success and failure, and the value of students' homework and effort (Linnenbrink & Pintrich, 2003). These functions are essential in attention control, inhibition control, working memory, as well as reasoning, problem-solving, and planning (Diamond, 2013).

Executive dysfunction is associated with impulsivity, emotional dysregulation, uncontrollability, attention deficit, planning, and problem-solving (Chen et al, 2020). Keshavarzian and Zarei Guniani (2016) showed that executive function training has an effect on neuropsychological abilities and attention control in children with learning disabilities. Sadeghi (2018) showed that executive function training is effective in improving the planning and working memory to the students with math disabilities. After designing the educational package of executive functions, Azizian et al. (2017) confirmed its effectiveness on the academic achievement of late learners. Research has shown that training and the development of executive functions have played a key role in the development of social and emotional competencies (Marceau et al., 2018).In previous studies, the lack of research examining these variables is clear, and research on executive functions, especially in Iran, has been more focused on learning disabilities, hyperactivity, and deficiency. Therefore, this research focused on this topic. The result of this research can be considered a fundamental effort to improve the psychological condition of students to enhance students' working memory. Accordingly, the question of the present study is whether the executive function-based educational package affects students' working memory.

## Method

### Design

The present study adopted a quasi-experimental design with pretest-posttest and a control group.

### Participants

The statistical population of the present study included all the fifth-grade male students of in Shahreza province during the academic year 2021-2022. In this study, 40 primary school boys were randomly selected according to the inclusion criteria as the study sample by the available sampling method and then were random assigned to the experimental and control groups with 20 participants in each. The ethical considerations of this research were the confidentiality of the collected information, obtaining the consent of the student's parents to participate in the research, as well as the necessary freedom to participate in the study.

### Instrument

In the present study, the Working Memory Test was administered to the students as the pre-, and post-tests. The working memory capacity test was designed by Daniman and Carpenter (1980) to measure working memory capacity. This test has 27 sentences that are divided into six sections, from two-sentence to seven-sentence sections. The main feature of this test is the simultaneous measurement of two parts of working memory (processing and storage) while performing a mental activity. The range of scores in both processing and storage was calculated from a score of 27 and the working memory score of each participant was obtained from the average of the sum of two scores (processing and storage) which is written as a percentage. Mojtaba Zadeh (2006) obtained the reliability of this test in his research on third-year high school students in Zanjan through Koder-Richardson to be .87. Asadzadeh (2004) also obtained the reliability as.85. Also, there was a correlation coefficient of .88 between this test and the information processing index, which is a computer test for measuring working memory capacity (Asadzadeh, 2009).

### Procedure

After selecting the participants, the pre-test was administered to both groups. Then, the experimental group was trained for the 10 session (each for 70 minutes) package for executive functions using the instructional design model (Azizian et al., 2017) while the control group remained on the waiting list. It should be noted that this training package is based on various theories, sources, and research in the field of executive functions. Inclusion criteria included: belonging to the same age group, fifth-grade male students, and parental consent. Exclusion criteria included more than 2 sessions of absence and not submitting more than 2 research-related tasks. In addition to content validity,

this package was reviewed in terms of face validity by the experts, and its reliability coefficient was calculated to be.89. The reason for using this training package in terms of application compared to pre-determined intervention programs was their ability to modify quality, the ability to include a variety of software games and paper pencils, its accompanying guide, attractiveness, objectivity, and reproducibility (Azizian, 2017). In the end, individuals in both groups responded to the post-test. The stages experienced by the experimental group is demonstrated in Table 1.

**Table 1**
*The Stages of the Intervention*

| Sessions | Topic |
|---|---|
| **Sessions 1 and 2** | Introduction, purpose, motivation, and completion of the pre-test. Attention and concentration training |
| **Sessions 3 and 4** | Working memory training |
| **Sessions 5 and 6** | Inhibition training |
| **Sessions 7 and 8** | Organizing training |
| **Sessions 9 and 10** | training in planning, summarizing, and completing the post-test |

In each session, the exercises of the previous session were reviewed for 10 minutes before the training. 30 minutes of the session were dedicated to electronic games and 30 minutes to hand games. Each session was attended by two students, one playing electronic games and the other engaged in paper-pencil training games, and the researcher simultaneously directly and indirectly guided and supervised their activities. Descriptive and inferential statistics were also used to extract and express the results. After gathering the data, data analyses were performed using the descriptive (mean and standard deviation) and inferential statistics **(**analysis covariance were performed via SPSS-22 software.

## Findings

According to Table 2, the mean age of students in the control group was 11.80 with a standard deviation of 0.9 and the mean age of the experimental group was 11.40 with a standard deviation of 0.8.

**Table 2**
*Comparison of Age of Students in the Experimental and Control Groups*

| Group | Mean | SD | N |
|---|---|---|---|
| **Control** | 11.8 | 0.9 | 20 |
| **Experimental** | 11.4 | 0.8 | 20 |

Table 3 shows the mean and standard deviation of the pre-test and post-test scores of working memory in both control and experimental groups. The data show that working memory capacity has increased in the post-test of the experimental group, and the covariance analysis was used to examine its significance.

**Table 3**
*Mean and Standard Deviation of Working Memory in Pre-Test and Post-Test*

| Variable | Group | Pre-test | | post-test | |
|---|---|---|---|---|---|
| | | Mean | S.D | Mean | S.D |
| **Working memory** | **Control** | 50.79 | 19.64 | 50.77 | 19.71 |
| | **Experimental** | 50.82 | 16.72 | 52.57 | 15.92 |

The assumptions of using parametric tests and analysis of covariance (test of normality of variable distribution and test of homogeneity of variance) were performed and then the research hypothesis was examined using the test. To use parametric statistical tests, we must first check whether the variable distribution is normal or not. To this end, the Kolmogorov-Smirnov test was used. According to Table 4, since the significance levels obtained are greater than 0.05, it can be claimed that the distribution of the research variable is normal and the parametric tests are used to test the data.

**Table 4**
*Test of Normality Using Kolmogorov-Smirnov Test*

| Variable | Z | p-value |
|---|---|---|
| **Pre-test** | 0.912 | 0.376 |
| **Post-test** | 0.942 | 0.338 |

According to Table 5, the value of Levene statistics and the level of significance of working memory are 0.778 and 0.383, respectively, and the assumption of homogeneity of variances is confirmed. Therefore, covariance analysis tests can be used.

**Table 5**
*Levene F Test for Homogeneity of Variable Variance*

| Variable | Levene's statistics | $Df_1$ | $Df_2$ | p-value |
|---|---|---|---|---|
| **Working memory** | 0.778 | 1 | 38 | 0.383 |

To examine the main hypothesis of the research: the effect of educational package based on executive functions on the working memory of fifth-grade male students in Shahreza, a one-way (one-factor) univariate analysis of covariance was used. According to Table 6, since the sig. is less than 0.05, it can be stated that the educational package based on executive functions has an impact on students' working memory. Considering the averages, we find that working memory has improved after the training package based on executive functions. Eta squared values indicate that 17.3% of the working memory variance is explained by a training package based on executive functions.

**Table 6**
*Analysis of Covariance of Work Memory with Training Package Based on Executive Functions*

| Dependent variable | SS | Df | MS | F | p-value | Eta squared |
|---|---|---|---|---|---|---|
| **Pre-test** | 12051.319 | 1 | 12051.319 | 2945.34 | 0.000 | 0.988 |
| **Group** | 31.585 | 1 | 31.585 | 7.719 | 0.009 | 0.173 |
| **Error** | 151.391 | 37 | 4.092 | - | - | - |

## Discussion

This study aimed to evaluate the effectiveness of the training based on executive function on student's working memory. The findings of the study showed significant effects of the training based on executive function on students' working memory. The results are consistent with the results of previous studies such as Seif (2021), Azizian et al. (2017), Keshavarzian and ZareiGuniani (2020), Sadeghi (2018), Bertelson et al. (2021), DeBrigen et al (2018), Greenball and Rosenball (2016), Badley (2012), German et al. (2012), Lan et al. (2011); Smith (2010) and Gathercole (2008).To explain the effectiveness of training based on executive function on the working memory, we can point to the effective role of working memory and especially metacognition in preventing monotony and the desire for useful contributions in the field of sustainable attention. While using executive functions, students avoid impulsive and aimless behavior and focus on the task more intelligently and practically by reflecting on their behavior and that of others.

The results of Blanqui and Knox's (2009) study, which examined the type of manipulation and problem-solving speed (metacognition and problem-centered) as part of the executive processes on learning, showed that students with better executive functions have higher performance in these variables and have higher academic achievement. As a result of teaching the executive function program, students learn skills such as: calming down, thinking before answering, taking turns, waiting, paying attention to various situations, lack of response in certain situations, increasing self-confidence, paying attention to verbal and visual cues and increase attention to detail and reduce inattention, maintain attention in play-related activities, listen to others, follow instructions, organize tasks and activities of continuous mental effort. The higher the use of metacognitive and cognitive strategies as part of executive processes and their combined use, the greater their working memory. Students with higher capacity for executive functions also had higher working memory capacity. Students who have a higher capacity for executive functions in using cognitive strategies and when doing homework, always review their performance and after completing homework, evaluate their performance based on the set goals and always strive to achieve the set goals they do.

## Conclusion

The results of this study revealed that teaching executive functions with a focus on the performance process can lead to a personality review and, as a result, lead to a healthy mindset and performance, which primarily helps the students themselves. It should be noted that in this study, participating in meetings irregularly and attracting the cooperation of families in line with coordinating with them to allocate enough time caused the research process to be longer. Due to the limited research community, the generalization of the results of the current research to all students should be done with caution. In this study, considering that the participants were familiar with the questionnaires in the pre-test, this familiarity as an intervening variable can affect the research results in the post-test. Research and practical suggestions for this research are also recommended, which are briefly mentioned below: Conducting research on female students and comparing it with the present results, examining other variables such as self-esteem, resilience, and psychological state after training based on executive functions. Moreover, due to the time constraints in this study, it is suggested that in future studies, the sustainability of treatment and follow-up period be examined. Also, doing similar research in other cities with more samples can help get better results by further comparing the effectiveness of this training package with other programs in this field on working memory.

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## Conflicts of Interest

No conflicts of interest declared.

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