

# The Effectiveness of Neurofeedback on Enhancing Cognitive Process Involved in Entrepreneurship Abilities among Primary School Students in District No. 3 Tehran

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## ABSTRACT

**Introduction:** The aim of this study is to investigate the entrepreneurial traits of school children in the city of Tehran.

**Methods:** For this purpose, 48 students were selected with an average IQ between 90 and 119. Ranging from 7th to 12th grades, all the subjects were assessed using Nowicki-Strickland's Locus of Control Scale (N-SLCS), Torrance Tests of Creative Thinking (TTCT), and Hyperkinetic Syndrome Assessment Method (HKSD). The obtained results were then organized and categorized into three groups. One of the groups was randomly chosen as experimental and the other as the control group and the last play group. In this empirical study, the students received Sensory Motor Rhythm (SMR) and Beta neurofeedback for 20 sessions. The play group was assigned to play mind games for 20 sessions. At the same time, the control group received no experiments. After the end of the experiments, all the students in three groups were reassessed by Torrance Tests of Creative Thinking, Hyperkinetic Syndrome Assessment Method, and Nowicki-Strickland's Locus of Control Scale.

**Results:** The results from MANOVA showed that the neurofeedback group had demonstrated a meaningful change in creativity and locus of control while the adaptability of risk-taking was on a meaningful level for the experimental group. The results also indicate an improvement in creativity for the neurofeedback group in comparison with the play group on a 0.02 meaningful level. Similarly, the results suggest an improvement in creativity for the neurofeedback group on a 0.000 meaningful level in comparison with the control group. This is while the play group and the control group do not show any meaningful difference. The results also show an improvement in the internal locus of control for the neurofeedback group in comparison with the play group on a 0.032 meaningful level; while, it is meaningful on a 0.01 level for the neurofeedback group in comparison with the control group.

**Discussion:** The findings for the play group and control group do not show any meaningful difference. The paper concludes that neurofeedback training can be used for increasing the level of entrepreneurial traits in students.

## Key Words:

Neurofeedback,  
Entrepreneurship abilities,  
Locus of control, Creativity,  
Risk-taking

## 1. Introduction

Entrepreneurship is at the center of attention in developed and third world countries. Accord-

ing to the Third Economic, Social and Cultural Development Plan of Iran, while teaching entrepreneurship in the form of entrepreneurship development plan has been the focus of attention, it has not received due attention on the educational

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level. Despite increasing attention to graduate entrepreneurship programs in developed countries, for example, by institutions such as the European Commission and the National Council for Graduate Entrepreneurship, there remains a paucity of research on entrepreneurial intentions and enterprise/entrepreneurship education in developing countries (Dickson, Solomon & Weaver, 2008).

The present paper poses the following question: How it is possible to develop entrepreneurial personality traits (creativity, risk-taking and locus of control) in students? Experts and researchers have used different ways to answer this question. One of the new methods that are used for the development of entrepreneurial personality traits is neurofeedback.

## 1.2. Neurofeedback

Neurofeedback or EEG biofeedback is a form of biofeedback that enables the individual to change his/her psychological condition by regulating his/her brain (Thomas, 2002). NF is beneficial in two important aspects: 1) it moderates the EEG; 2) it fosters self-advancement and flexibility (Demos, 2005).

Neurofeedback is a form of behavioral intervention that aims at improving the skills in the area of intelligence and brain activity (Heinrich, Gevensleben & Strehl, 2007). Neurofeedback training serves as a mechanism for changing the brain activity and affects people's behavior which benefits ill and healthy people equally (Dempster & Vernon, 2009). It is a safe and painless method, during which some sensors (called electrodes), are placed on the head (Kaiser & Othmer, 2000).

Neurofeedback training involves asking children to do a video game (only using his/her mind). It employs the obtained information from registering brain waves which come through the connected electrodes on the head. It is important to note that the instruments used during the process of neurofeedback (electrodes and the brain activity registering machine) are merely used to help register and deliver the information and they have no adverse effects. In this method, there is no use of hands, and there is no control page. During the game, the mind waves are controlled by means of an amplifier and a computer that process the signs and deliver the appropriate feedback. Gradually the mind responds to the signs of the continuous feedback and creates some changes which lead to improved activity, attention and self-regulation (Coben, Linden & Myers, 2010). In other words, neurofeedback is the process of recording and remitting the data toward the applicant. In this way, some sensors are attached to the skin of the head of the applicant. These sensors show the related information about their level of brain activity. The

received information about the patient's brain activity is displayed on two monitors. Therefore, the brain activity waves (such as Alpha, Beta, Theta and Delta), that are unconscious processes and out of the individual's control, would become completely understandable for the patient and the therapist. By the help of the therapist and receiving audio visual incentives the children will be able to control Alpha, Beta, Theta or Delta that are identified as unusual according to the existing databases (e.g. higher or lower frequencies, or an intensity below or over the normal level). Through training sessions, such irregularities can be controlled and restored to a normal state (Gunkelman & Johnstone, 2005). The previous research shows that neurofeedback can be used as a powerful instrument in researches that require neuronal correspondence with the cognitive process. For example, findings show that advanced GBA<sup>1</sup> is useful for achieving more correspondence in information backup for short term and long term memories (Keizer, Verment & Hommel, 2010).

Most of the studies about the efficiency of neurofeedback treatment has contributed to the improvement of the symptoms of adulthood growth disorders, especially learning deficiencies, attention deficiencies (Kaiser & Othmer, 2000), Attention Deficit Activity Disorder (ADHD), lack of attention (Fuchs, Birbaumer, Lutzenberger, Gruzelier & Kaiser, 2003; Rossiter, 2004). The present study further shows the high efficiency of neurofeedback for treating these disorders.

Neurofeedback has been beneficial to patients with epilepsy (Kotchoubey et al., 2001), autism (Kouijzer, van Schie, de Moor, Gerrits & Buitelaar, 2010), delusion and insomnia (Cortoo, Valck, Arns, Breteler & Cluydts, 2010). As reported by Vernon et al., healthy individuals can change the rhythm of their sensorimotor activities by controlling Theta/Beta waves and then by neurofeedback training where there will be a meaningful change in brain performance (Cortoo et al., 2010; Raymond, Sajid, Parkinson & Gruzelier, 2005). The results from later studies show that NF training is used as a mechanism to change brain activities in ill people and healthy societies. Vernon (2005) and Vernon & Gruzelier (2008) argue that NF training is performed for heightening the level of a vast range of skills such as sport performance, cognitive ability, creativity, artistic skills (Dempster & Vernon, 2009) and dancing skills (Raymond et al., 2005) in healthy individuals and is crucial for increasing the optimal performance of musicians and enhancing mental performance (Egner & Gruzelier, 2003; Vernon et al., 2003).

## 1.3. Play

Sport games: research suggests a direct relationship between sport activities in primary school children and educa-

1. Gamma Band Activity

tional achievements. Children's participation in sport activities conduce to increased self-confidence, teamwork attitude and leadership skills. It has also been shown that most of the women who are successful in their managerial roles have participated in group activities and sport teams during their childhood or adolescence. Therefore, you would better play a ball game with your children or take a walk with them rather than sitting down to watch TV with them after dinner. It is better to encourage the child to take part in the school's sport teams.

Games provide the natural means for children to express themselves. The renowned psychologist Alfred Adler argues that one should never think of games as a waste of time. To further understand children's games one should observe them at play. Through playing games, children express their feelings, failures and anxieties (Riahi, 2002: 5).

A game is any type of physical or mental activity that follows a purpose and is done individually or in the form of a team for pleasure and fulfills the child's needs. By playing games, children reveal their strengths or weaknesses such as the tendency to lead or to follow, aggressiveness or compliance, sociability or aloofness, and also friendly or hostile attitudes, depression or happiness, desires and ambitions, etc. Children play different games with every game representing a particular emotion. In order to display aggressive behavior, some children play games that allow them to express their anger through attacking normal or moral phenomena. Moreover, to express their desires and ambitions, children have a tendency to dream; and to fulfill what they desire they indulge themselves in imaginative games. And ultimately, to create or find a favorable role, they play imitative games.

#### 1.4. Game Types

According to the theory of Piaget, there are three main types of games:

- Games that involve enjoyable exercises and improve physical skills
- Symbolic games that a child invents and plays on his own and usually involve substantial imitations and emulations.
- Social games that have basics and rules enforced by the team. The violation of the rules is not allowed (Riahi, 2001: 9).

Creative games: one of the most important types of creative activities for young children includes creative games. A game is considered creative when the child uses made or familiar things in a new or uncommon way or when he/she is engaged in playing imaginative roles or games. Nothing unleashes the creative spirit more than allowing children to engage in play-

ing improvised and spontaneous games. Children take games seriously and it is critically important for their health to give them time to play games freely. Even in the early stages of childhood, games contribute to the child's physical growth through enhancing sensory perception and fostering motor skills. By playing games and repeating fundamental physical skills, children enhance their abilities and become increasingly capable at doing difficult physical tasks. Games nurture mental development and new ways of thinking and problem solving. Through playing team games, children encounter numerous mental challenges that are associated with measurements, equality, balance, shape, spatial relationships and physical characteristics (Mahjour, 2004).

#### 1.5. Entrepreneurial Personality Traits

The literature includes ample research on entrepreneurial personality traits of entrepreneurs. Entrepreneurs identify and exploit opportunities when there are limited resources, make decisions, are proactive employees and have a wide range of skills, knowledge and abilities (Rauch & Frese, 2007). Some entrepreneurial personality traits include internal locus of control, need for achievement, tolerance of ambiguity and risk-taking propensity (Burns, 2001). The entrepreneurial personality traits differ with entrepreneurs and non-entrepreneurs (Zhao, Seibert & Lumpkin, 2010). The psychological traits such as the need for affiliation, creativity, need for achievement, locus of control, risk-taking propensity and tolerance of ambiguity are the traits of entrepreneurs (Gurol & Atsan, 2006).

#### 1.6. Creativity

Creativity is one of the unique traits of entrepreneurs. In recent years, the concept of creativity has been much discussed and studied in many research meetings (Gurol & Atsan, 2006). While, fostering creativity is undoubtedly considered as one of the most important aims of the education system, there is a lack of unanimity about its definition. However, drawing from the basic entrepreneurial personal traits, most experts agree that creativity involves making new products with a new quality, entering new sell positions, creating new sources out of existing resources or creating a new organization or a new structure in an existing business. Creativity is a behavior with entrepreneurship as its orientation. Peter Drucker believes that creativity is the main driver of entrepreneurship (Gurol & Atsan, 2006).

Santroc (2004) defines creativity as considering things in new and innovative ways and finding unique ways to solve problems. Creativity involves the production of a new and innovative product that is satisfactory to the producer or consumer for a period of time. Even if the idea or product has

been previously discovered by others and people do not consider it as new or innovative, still there is creativity (Renzulli, 1986).

Creative thinking is the process of understanding problems, things, the shortage in information and misplaced factors, making guesses or estimates about shortages, assessing and implementing the guesses or estimates, improving and reassessing them and finally producing results (Torrance & Goff, 1986). Runco believes that creativity is not the only solution for problem solving. Creative thinking can be helpful when solving a problem. Problem solving is the more objective form of creativity and has a more outward and distinctive aim, whereas, creative thinking is an innovative and independent process which entails personal aspects and relies on intuition and analysis (Runco, Millar, Acar & Cramond, 2010).

Torrance and Rockstein argue that personal creativity is the process of becoming aware of problems or shortages when there are no tested ways to solve them. Thus, one must obtain information from memory and the environment and clarify the problems and find the missing pieces and finally find a solution to them or make guesses and persistently try the solutions to reach a result (Morrison & Johnston, 2003). The key to entrepreneurial success is finding creative ways that by using new technologies or better and cheaper marketing of new goods will fulfill the human need in the best way. Creativity is the ability to solve problems, develop new ideas and to find new ways of recognizing problems and opportunities that are useful in achieving personal goals and expanding personal skills like self-confidence and communication (Morrison & Johnston, 2003).

Morrison (2003) also believes that creativity has three stages:

1. Proposing new viewpoints or ideas.
2. Solving problems by posing a viewpoint and executing it.
3. Creating an atmosphere that will foster creativity.

He then points out the following traits for a creative individual:

- 1) The power of creativity and innovation.
- 2) The ability to discover problems or difficulties.
- 3) The ability to recognize priorities.
- 4) Fostering creative and productive thinking.
- 5) Having belief in thoughts and an understanding of schemes.
- 6) Fostering the attitude of faithfulness and forgiveness.

- 7) The ability to have different roles in different situations.

Izans poses that creativity depends on three variables and each of them divides into several factors. These factors include cognition, environment and personality. Factors that conduce to recognition include skills and cleverness. Environmental factors include social, cultural, political, religious and educational aspects. Personality traits like self-confidence, innovativeness and motivation which influence creativity (Naude, 2005: 214).

Creative thinking is the ability to consider new aspects of things and insisting on finding ways of solving problems (Amabile, 1996). According to Ruche and Frase (2000), creative thinking is a predictive factor of success in entrepreneurs (Onstenk, 2003) and there is a positive relationship between creative thinking and entrepreneurial behavior (Dama, Schipper & Runhaar, 2010).

### 1.7. Locus of Control

The early studies about internal locus of control began by Ankinson & Rotter (1964-1975). Locus of control is a characteristic variable that is related to generalized expectations of a person and the individual with internal locus of control is able to control his/her life events (Leone & Burns, 2000).

A special predictor that has been studied widely is the locus of control. For an individual that believes achieving a goal is decided by his/her actions and abilities, the factors of chance, etc. are of no account. In his studies, Brockhaus (1980) shows a positive relationship between the locus of control tendency and entrepreneurial success. Robinson (1991) argues that internal locus of control leads to a positive entrepreneurial attitude and most of the university students who receive entrepreneurial information are more likely to achieve a higher level of self-efficacy (Raposo, Paço & Ferreira, 2008). Individuals with internal locus of control believe that their behavior has a significant role in determining the outcome (good or bad) of their actions, while those with external locus of control believe that their decisions and lives are controlled by environmental factors which they cannot influence (Kaufmann, Welsh & Bushmarin, 1995). Individuals with external locus of control believe that their actions are determined by destiny, chance and their fortune, etc. (Chelariu, Brashear, Osmonbekov & Zait, 2008).

Locus of control comprises a set of expectations that suggest outcomes are produced as a result of personal efforts (internal) or by uncontrollable surrounding factors (external). Locus of control has been employed for a set of plans such as learning traditional teachings, industry security, medicine, and recently aviation. Empirical studies on locus of control in



the ambit of aviation are limited, hence we know less about the differences of locus of control with students, passengers or senior pilots (Hunter, 2005).

### 1.8. Risk-Taking

Entrepreneurs are seen as risk-taking individuals. As a result, the term “risk-taking” is frequently used in definitions about entrepreneurs. The tendency toward calculated risk-taking is considered as one of the special characteristics associated with successful entrepreneurs or venturers (Ibrahim & Soufani, 2002). One of the early research efforts in the field of risk-taking has been conducted by Lelz- Brockhaus (1974-1980). He defined risk-taking as the tendency toward getting the rewards associated with the success of a risky undertaking. In other words, risk-taking is the likelihood of getting the rewards as a result of succeeding in a given undertaking that the individual determines before exposing himself to the possible consequences of failure (Brockhaus, 1980).

Timmons et al., also believe that entrepreneurs measure potential risks and then convince other to take part in ventures with them. Gibb (1988) and Rauch and Frese (2000) regard calculated risk-taking as part of entrepreneurship (Dama, Schipper & Runhaar, 2010).

Risk-taking tendency involves taking calculated risks that could be offset by the individual's efforts. Brockhaus argues that there are two major elements at play when taking risks: 1) the entrepreneur's perception of risks involved in a venture; 2) possibility of failure in the event of unsuccessful activity. Be that as it may, by making measured and calculated predictions entrepreneurs could often avert unnecessary risks. After careful analysis of the current situation, entrepreneurs would be likely to take on risks. In a study about risk-taking in businessmen, Moore and Gergen (1985) suggested that risk-taking in an individual is the natural tendency/aversion to risk, decision-making skill and prior experience in risk-taking behavior in the organization; and defined the risk-taking process as the decision to take risks by developing an appropriate strategy in order to minimize risks and conclude

that timely risk-taking is a requirement of careful decision-making (Brockhaus, 1980).

### 1.9. Research Objective

The main objective of the present paper is to examine the effect of neurofeedback on the development of entrepreneurial personality traits in primary school students in Tehran. Therefore, the research seeks to answer how it is possible to develop entrepreneurial personality traits (creativity, risk-taking and locus of control) in students?

## 2. Methods

The research includes 48 students ranging in age from 7 to 12 years of old (mean=9.44 and standard deviation=1.49) with an average intelligent quota (IQ) of 106.08 (standard deviation=9.90) and normal quantitative electroencephalographic. All the students were considered as normal groups.

In the pre-treatment phase, all 48 students were initially evaluated for locus of control, risk-taking and creativity. Then following the standard controlled research design, they were separated into experimental (N=16), play (N=16) and control (N=16) groups. The three groups were organized in terms of age (between 7-12 years) and IQ (between 90 and 110). One of the groups was chosen as the experimental group. The experimental group received 20 sessions of neurofeedback training with the SMR <sup>2</sup>/Beta protocol directed toward regulation of the brain activity. The play group was assigned to play mind games for 20 sessions. The research model has a pre-test/post-test design with a control and a play and an experimental group (Table 1).

### 2.1. Data Collection Instruments

Torrance Tests of Creative Thinking<sup>3</sup> (Runco et al., 2010), Nowicki-Strickland locus of control scale for children<sup>4</sup> (Li & Lopez, 2004), Hyperkinetic Syndrome Assessment Method<sup>5</sup>

2. Sensory Motor Rhythm

3. TTCT

4. N-SLCS

5. HKSD

**Table 1.** Demographic data associated with experimental, play and control groups.

Groups	Age				IQ		
	N	Mean	SD	Range	Mean	SD	Range
Experimental	16	9.88	1.71	7-12	107.25	9.62	90-119
Play	16	9	0.83	7-12	104.56	10.56	90-119
Control	16	9.44	1.71	7-12	106.44	9.96	90-119
Total	48	9.44	1.49	7-12	106.08	9.90	90-119

(Proyer & Häusler, 2007) were used to perform the pre-test/post-test steps.

The TTCT is a widely used instrument. Torrance tests are conducted in two forms: vocabulary and pictures. The instrument is composed of four scores from the initial administration of the TTCT: fluency, flexibility, originality, and elaboration (Runco et al., 2010). Studies also have shown significant convergent validity and correlation.

The N-SLCS is a 40-item form of the Nowicki-Strickland Locus of Control Scale for 7th to 12th grades (Nowicki & Strickland, 1973).

The Hyperkinetic Syndrome Assessment Method has five subtests: Determining inspection time/confident, adaptation to difficulty, reflectivity/impulsivity, motivatability and adaptation to feedback (Proyer & Häusler, 2007).

## 2.2. Experimental Procedure

The NF training of the experimental group lasted 1.5 months (20 one-hour sessions) with each student receiving three training sessions per week. The play program for the play group lasted 1.5 months (20 one-hour sessions). Control group was held on the waiting list. Thought Technology software and Procomp2 amplifier were used for the NF training. The NF training used SMR (12-15Hz) and Beta (18-22Hz) protocols. The SMR protocol was trained to enhance SMR activity and inhibit beta and theta activity. Feedback in SMR protocol at Cz or C3-C4 was audio-visual online in the form

of a video game (Kaiser & Othmer, 2000). The Beta protocol was trained to enhance beta and simultaneously inhibit theta activity. In the Fz or F3-F4 area the Beta training feedback was visual (Vernon et al., 2003). Incidentally, the neurofeedback method is agent conditioning (Egner & Gruzelier, 2003). During neurofeedback training participants learn to perform better i.e. when their brain wave frequencies decrease, they could increase them (Gunkelman & Johnstone, 2005). In the meantime, the data on brain waves would be interpreted by a computer. And the power of each of the waves would be delivered to the subject to enable him/her to increase or decrease the level of waves. Necessary training would be given to the child by showing him/her a cartoon yacht or puzzle on a PC monitor.

## 2.3. Statistical Analyses

The result, of pre-test/post-test phases in the experimental and play and control groups were analyzed using the SPSS.19 software. The two-tailed statistical significance level was set at  $P < 0.05$ . Given the nature of the research variables and their measurement levels, the Multivariate Analysis of the Variance (MANOVA) was employed to allow a comparison between the average score of the three groups in terms of locus of control, creativity and risk-taking.

## 3. Results

Table 2 shows the descriptive index of TTCT/HKSD/N-SLCS for the experimental, play and control groups both in pre- and post-test stages. The results of MANOVA are illus-

**Table 2.** Descriptive index of TTCT/HKSD/N-SLCS in experimental, play and control groups.

	Experimental				Play				Control			
	Mean		Standard Deviation		Mean		Standard Deviation		Mean		Standard Deviation	
Variables	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Creativity	189.29	259.31	67.58	56.45	189.13	216.3	54.24	33.47	183.25	181.06	41.02	36.04
Risk-taking	50.8	58.38	32.6	17.05	63.4	67.5	22.9	14.7	57.2	57.3	25	22.8
Locus of Control	16.3	11.5	6.3	4.5	16	15.9	7.9	5.4	16.2	16.8	5.5	4.5

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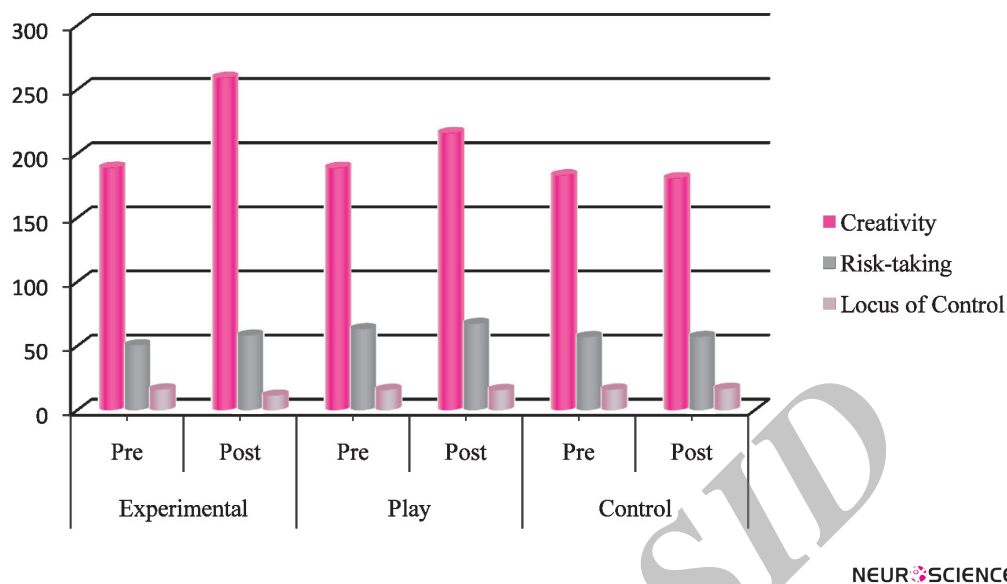
**Table 3.** Result of MANOVA.

Variable	F	Sig	Eta Squared
Creativity	13.11	0.000*	0.368
Locus of control	5.52	0.007**	0.197
Risk taking	1.27	0.291	0.053

Note: DF=2 (DF: Degrees of Freedom)

\* $P < 0.005$ ; \*\* $P < 0.05$

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**Figure 1.** Pre- and post-test results of TTCT/HKSD/N-SLCS in the experimental, play and control groups.

trated in Table 3. It shows that the effect of the intervention factor is statistically significant in the error level of 0.005 regarding two indicators: Creativity ( $F(2)=13.11$ ;  $P=0.000$ ), locus of control ( $F(2)=5.52$ ;  $P=0.007$ ). Risk-taking did not reach the significant level. Figure 1 shows the pre- and post-test results of TTCT/HKSD/N-SLCS in the experimental, play and control groups.

#### 4. Discussion

Neurofeedback affects the development of entrepreneurial personality traits. As different studies have shown, neurofeedback could improve self-confidence and the psychological state of healthy people (Dupee & Werthner, 2010). Other than boosting self-confidence, neurofeedback training with the SMR protocol could also improve perceived motivation (Vernon, 2005) and increase energy, composure and higher tolerance (Hammond, 2007). Based on the present study and supporting the findings from the previous literature, neurofeedback could increase focus, reduce stress, improve emotional control, increase workload tolerance level in the long term, increase failure tolerance level and finally increase self-respect and self-efficacy in individuals, communities and work environments. The results also indicate an improvement in creativity for the neurofeedback group in comparison with the play group on a 0.02 meaningful level. Similarly, the results suggest an improvement in creativity for the neurofeedback group on a 0.000 meaningful level in comparison with the control group. This is while the play group and the control group do not show any meaningful difference, thus supporting the results of other studies on the effect of neurofeedback in improving creativity in students. The results also

show an improvement in the internal locus of control for the neurofeedback group in comparison with the play group on a 0.032 meaningful level; while, it is meaningful on a 0.01 level for the neurofeedback group in comparison with the control group. The findings for the play group and control group do not show any meaningful difference, thus supporting the results of other studies on the effect of neurofeedback in improving internal locus of control in students.

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