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The Effectiveness of Cognitive-Metacognitive Strategies Based on Brain-Based Training Approach on the Creativity in Sixth Grade Male Students

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Abstract: The aim of this study was to determine the effect of using metacognitive- cognitive strategies based on the brain-based training approach on the creativity of sixth grade elementary male students. This study was a quasi-experimental method that was performed with a pre-test-post-test design with a control group. The statistical population of this study was all sixth grade male students of Isfahan, in 2021. Sixty students were selected by multi-stage cluster random sampling method and randomly assigned to experimental and control groups. Torrance Creativity Questionnaire (1981) was used to assess creativity. In the experimental group, the package of cognitive-metacognitive strategies based on the brain-centered training approach (Baratali et al., 2013) was performed in 20 sessions of 100 minutes. Results indicated that there is a significant difference between the two groups in terms of mean scores of creativity and each of the components of fluidity, expansion and flexibility. According to the findings, the use of cognitive-metacognitive strategies based on the brain-centered training approach has been able to increase creativity and fluid components, expansion and flexibility, but the intervention could not significantly increase the initiative component in the experimental group. In general, the research supports the application of cognitive-metacognitive strategies based on the brain training approach to improve the creativity of elementary students.

Keywords: Cognitive-metacognitive strategies, brain-based training, creativity, elementary students

Introduction

Undoubtedly, one of the critical periods for learners is the elementary period, in which the basic orientations of one's life are based on the lessons of this period. The sixth grade has been added to the elementary school in Iran in recent years, so it is one of the most controversial and sensitive foundations of this course, because both teachers and students have many issues and concerns in the teaching and learning process of difficult courses in this grade. Also, this grade is the boundary between elementary and the next level (Shamsi Goshki, Mir, Dehvari, & Jahan Tigh, 2022). Understanding the lessons of this grade requires cognitive and motivational abilities. One of these abilities is creativity. Creativity means creating a new and unique something that solves a problem, question, or scientific and social need. The use of mental abilities in combining old elements to create a new, valuable and purposeful thought or solution is called creativity (Suki & Suki, 2017). Creativity has existed as a powerful talent in the human body since childhood. Man is born creative by nature. However, creativity has not evolved in the early stages of life and therefore needs attention, guidance and training (Nilsson, 2010). Today, the focus on creativity, especially in schools, is much higher than

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in the past (Kwiatkowska, Rogoza, & Poole, 2019). In the neurological perspective of creativity, the role of different areas of the brain in creating creativity is considered (Gu, Ritter, Koksma, & Dijksterhuis, 2021). Some studies related to the neurological perspective of creativity have pointed to the role of the right hemisphere of the brain, right and left frontal lip and corpus callosum in creating this ability (Soh, 2017). But in more recent research, creativity is not the result of the activity of a specific area of the brain, but is the product of integrated inter-hemispheric connections of the brain (Rahimi & Shute, 2021). To resolve such a contradiction, it may be possible to consider not one type of creativity but several types of creativity, in some of which a specific part of the brain and in others the connections of different areas of the brain create creativity (Yavand Hassani & Noorabadi, 2022). Creativity has been considered from many perspectives. One of these views is the neurological view. In this view, creativity is the product of specific brain processes and specific areas of the brain(Azmati, Khaleghi, Hassani, & Kayhanfar, 2022). In other words, in this view, it is important to consider which areas of the brain are involved and most active in creating creativity (Lee & Portillo, 2022). Previous studies on creativity have pointed to the role of the right hemisphere in creativity (Arif, Qaisar, & Kanwal, 2022). Some researchers believe that in creative thinking, the right hemisphere plays a key role and the integration of the functions of the two hemispheres is not necessary. Increased right lateral frontal segregation or functional specialization tracked developmental improvements in creative thinking ability. It was indicated that distinct profiles of change in creative thinking ability during middle childhood and identified behavioral and neural mechanisms potentially underlying changes in children's ability to think creatively (Saggar et al., 2019). But other researchers have pointed to the role of interaction between the two hemispheres in creativity and this interaction facilitates the integration of a variety of separate cognitive abilities, fostering creative thinking (Lindell, 2011). Nowadays, experts consider creativity as a fundamental knowledge for any change and innovation and an important factor in accelerating human scientific and technological innovations (Ohler, 2013). Research shows that creativity is not a gift that certain people have because it can be cultivated by using appropriate methods. One of these approaches is brain-centered training approach (Schmoelz, 2018). The effect of using cognitive-metacognitive strategies based on the brain-centered training approach is a new approach that creates connections between brain function and educational activity. Recent neurological research shows that training techniques that are familiar to and compatible with the brain provide a bio stimulus framework for effective training (Bonomo, 2017). Brain training is an instructive program to develop a person's innate inner capacity to achieve health, well-being, optimal development and relaxation through effective management of his brain. Brain training is a new revision of the traditional Eastern mind, and physical training is integrated with the findings of neuroscience. The brain training approach is deeply empirical. People participate in physical, emotional, and cognitive exercises, and posture and breathing techniques, guided imagery, and games designed to improve sensory awareness, movement control, balance, emotion modulation, attention, imagination, and creativity. Brain-based learning is the result of a new discipline that some experts have called "educational neuroscience" and "mind

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science, brain and education" (Kinach, 2010) Brain-based learning is a comprehensive approach to education that uses recent neuroscience research. Brain-based or neuroscience training emphasizes how the human brain learns naturally and the structure and function of the human brain as it learns at different stages of development. Recent neuroscience research shows that training techniques that are familiar to and compatible with the brain provide a bio stimulus framework for effective training. It also helps explain repetitive learning behaviors and is a concept that incorporates a selective combination of techniques. More recently, techniques related to this theory have strongly recommended that teachers be allowed to make connections between learning and real life and learners' emotional experiences, as well as between learners' experiences and learners' personal backgrounds (Butterworth & Laurillard, 2010).

Recently, learning strategies including cognitive-metacognitive strategies of brain-based training have been used as a natural tool to bring about desirable changes in learning. Applying these strategies can pave the way for academic engagement, creativity, and social responsibility in students (Wang, Zhao, Yang, Cheng, & Lau, 2021). These strategies, which are based on the interdisciplinary relationship between neuroscientists and education professionals to review educational programs in educational systems, are the latest findings on changes in human life to solve complex environmental problems and creative learning (Baratali, 2013). On the other hand, brain-based training metacognitive-cognitive strategies is one of the newest topics in the field of cognition in the world. This approach uses neuroscience findings in relation to classroom teaching-learning systems. In other words, cognitive-metacognitive strategies of brain training are a set of strategies based on the findings of neuroscience and brain that teachers and students can use to optimize their meaningful and effective learning (Baratali, Yousefi, Keshtiaray, & Sabouri, 2016). By reviewing the studies were done in Iran, it was found that no related research has been done on the effect of using cognitive-metacognitive strategies based on the brain-centered training approach on students' creativity. In some studies it has been implicitly mentioned and in others inconsistent results have been obtained. For example, Karami, Allah Karami, and Hashemi (2013) in a research entitled the effectiveness of teaching cognitive and metacognitive strategies on creativity, achievement motivation and academic self-concept showed that teaching cognitive and metacognitive skills has a positive effect on students' creativity. Sadeghi, Behrangi, Abdollahi, and Zeinabadi (2016) investigated the effect of education management based on educational neuroscience strategies in improving students 'learning and indicated that education management based on educational neuroscience strategies improved students' learning. According to results of previous studies, the purpose of this study is to investigate the effectiveness of cognitive-metacognitive strategies based on the brain training approach on the creativity of sixth grade male students in Isfahan.

Material and Methods

The aim of this study was to examine the effect of metacognitive-cognitive strategies based on the brain training approach on the creativity of sixth grade elementary students. The research method was

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a quasi-experimental with a pre-test-post-test with a control group. The statistical population of this study included 57,000 male students in the sixth grade in Isfahan, of which 60 students were selected by multi-stage cluster sampling and randomly assigned to experimental and control groups. Criteria for entering the research include: 1- Sixth grade male students in Isfahan. Exclusion criteria include: 1- Absence of more than three sessions in the classroom during this course 2- Absence in one of the tests (pre-test or post-test) and 3- Mental disorder or a specific problem that undergoes the intervention process affect. Participants were reassured that the questionnaire questions were purely research-based and did not require a first or last name. Students also participated in the study voluntarily and were informed that they could leave the training sessions whenever they wished. The research hypotheses were analyzed using multivariate analysis of covariance. To collect data, Torrance Creativity Questionnaire was used, which is introduced as follow.

Torrance Creativity Questionnaire: This scale was developed by Torrance (1981). This test measures the four components of creativity, namely fluidity, initiative, flexibility and expansion, which include 16, 22, 11 and 11 items, respectively. That is, questions 1 to 22 measure the fluidity factor, 23 to 33 measure expansion factor, 34 to 49 measure innovation factor, and 50 to 60 measure flexibility factors. Each question has three diverse answers A, B, and C (qualitative) with a value converted to a numerical quantity, they have 0, 1 and 2. In each question, the choice of A indicates the least amount of creativity and the choice of C has the highest amount of creativity. The sum of the scores obtained in each subscale indicates the score in that section and the sum of the respondent scores in the four subscales shows the total score of the individual's creativity. Torrance (1981) reported the reliability of the questionnaire in his research using Cronbach's alpha coefficient of .83 and the acceptable validity of the questionnaire in his research using factor analysis. The reliability of this questionnaire in the present study was obtained using Cronbach's alpha coefficient of .70.

Protocol of cognitive-metacognitive strategies based on brain training approach: In this study, the effect of using cognitive-metacognitive strategies based on brain training approach was presented in 20 sessions of 100 minutes based on the protocol of Baratali (2013). The following is a summary of the sessions of this protocol and the specific strategies implemented with the focus on training the brain to increase creativity:

1- Inviting parents and holding the “miracle workshop” to encourage the formation of children's personality 2- Holding two sessions of communication with nature during art lessons and using different senses to observe the components of nature and its surroundings. In this method, students tried to attribute trees, rocks, pieces of wood, animals, objects, etc., to clouds in different forms. The students likened each cloud to a phenomenon or animal by lying on the ground and observing a sky full of white clouds. 3- Weekly puzzle plan in the classroom with multi-dimensional themes of creativity and mindful work 4- Execution of electric car project in the framework of work and technology class: This process was implemented in 8 class sessions and 7 out-of-class sessions and allowed students to use their experiences directly. They experience failure and how to deal with it. 5- Performing three meditation sessions with calm nature music in order to increase concentration,

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mental order, achieving deeper parts of the brain and psychological peace. 6- Having breakfast or snacks before teaching math, in the classroom. 7- In one course, for four weeks, all students were required to give a five-minute lecture on a pre-arranged day and to talk about any concepts they wished to strengthen their expressive power. 8- Teaching five sessions of "*Hedyehaye Aseman*" with brainstorming method 9- Holding three sessions of problem solving and creativity class by teaching problem solving strategies in line with the sixth math concepts 10- Using free and reciprocal discussion method in class of "*Thinking and Research*" 11- Performing essay hours with the subject of creating new and strange questions that no one has ever heard and may not have an answer 12- Showing a clip with the theme of creator power (risk wheel) and exchanging dialogue after that 13- Showing animation with the theme of greed 14- Performing the art activity of collage (sticking piece) in the week of jobs in such a way that students bring their photo along with artistic tools and accessories and stick their picture on the painting by drawing their favorite job. 15- Inviting the grandfather of one of students in the classroom and explain about their profession (for example, carpentry) and students' questions and answers. 16- Performing listening training activities for students by performing music or vocals with glasses, pencils and blows on them, and they were free to perform their favorite song during this period. 17- Making handicrafts with armature with creative ideas such as vacuum cleaner, elevator, etc. 18- Doing stretching exercises between teaching maths, science, etc. 19- Sharing the book of "*Hedyehaye Aseman*" among students to teach by themselves 20- Students were explained about Gardner's theory of multiple intelligences to know that there are individual differences between all. Everyone should know their talents and develop them. 21- Planting a tree on the day of tree planting and sticking paper leaves with different sentences by students to the tree. 22- Forming a virtual group in the social network with the title of school friend and exchange of science lesson points in it by all members of the group. 23- Creating a class blog called school friend and managing it by three students 24- Teaching "Neighboring Countries" in social studies lesson by students by creating exhibitions and booths from each country with the clothes of that country 25- having the "Pasta bell" once a month 26- Performing reminiscence activities, completing unfinished stories, improvised dialogue in art class.

General strategies implemented with the focus on training the brain to increase creativity: 1- Shortening the teaching time in class hours in all courses. In this approach, an attempt was made to reduce the teaching presentation time to less than 25 minutes, and the remaining time was devoted to consolidating learning. 2- At the beginning of each teaching, 3 to 4 minutes of time were allocated to creating motivation appropriate to the subject of teaching in groups and individually, non-verbally and verbally. 3- A portfolio was provided for all students to collect pencil tests, activity reports, behavior lists and pictures of their artistic activities and drawings, and all of them were required to prepare a portfolio. 4- Most of the topics and content of the book were tried to be taught through active, team and participatory methods. 5- Avoiding the principle of certainty in the process of evaluating courses and providing opportunities for divergent thinking by students, especially in the courses "*Hedyehaye Aseman*", "Thinking and Research" and "Social Studies". 6- Paying more attention to individual

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differences in teaching and evaluation, using different teaching methods and different strategies, changing the evaluation and assessment tools 7- Eating breakfast before entering the class 8- Instilling positive traits in students, such as: You are a hard-working student and ... 9- Teacher uses non-textbooks in leisure hours to invite and motivate students and interest in the culture of reading 10- Performing morning exercise in the school yard continuously 11- Performing post-test.

Results

Table 1 presents the results of one-way analysis of covariance on comparing the mean of the creativity scores of the experimental and control groups. According to Table 1, there is a significant difference between the groups in the creativity at the level of.01. Accordingly, the use of cognitive-metacognitive strategies based on the brain training approach has been able to increase creativity.

Table 1. Results of one-way analysis of covariance on the score of creativity in experimental and control groups

Source	SS	DF	MS	F	p	Eta	Power
Pretest	4829.03	1	4829.03	39.17	.001	.40	1
Group	1604.14	1	1604.14	13.01	.001	.18	.94

Multivariate analysis of covariance (MANCOVA) was performed to compare the means of creativity dimensions in the two groups. According to the value of F, there is a difference between the two groups in at least one dimension of creativity (Table 2). The value of Eta (.268) shows that 26.8% of the difference between the two groups in the dimensions of creativity is explained by the intervention. In order to test the observed differences more precisely, one-way analysis of covariance embedded in MANCOVA was performed. The results are presented in Table 3.

Table 2. Results of multivariate analysis of covariance (MANCOVA) on creativity dimensions scores

Source	Value	F	p	Eta	Power
Group	.26	4.66	.003	.26	.92

Table 3. One-way analysis of covariance embedded in MANCOVA on creativity dimensions scores

Source	SS	DF	MS	F	p	Eta	Power
Fluidity	118.81	1	118.81	10.03	.003	.16	.87
Innovation	32.64	1	32.64	2.93	.09	.05	.39
Expansion	78.52	1	78.52	6.95	.01	.11	.73
Flexibility	171.14	1	171.14	13.10	.001	.19	.94

According to Table 3, there is a significant difference between the groups in the fluidity dimension scores ($p < .01$). Accordingly, the use of cognitive-metacognitive strategies based on the brain training approach has been able to increase students' fluidity scores. There was also a significant difference between the groups in the expansion scores ($p < .01$). The results showed that there was a significant difference between the groups in the scores of the flexibility dimension as well ($p < .01$). That is, the

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use of cognitive-metacognitive strategies based on the brain training approach has been able to increase students' expansion and flexibility scores. According to Table 3, there is no significant difference between the groups in the scores of innovation. Accordingly, the use of cognitive-metacognitive strategies based on the brain training approach has not been able to increase the scores of students' initiative dimension.

Discussion

The aim of the current study was to investigate the effectiveness of using metacognitive cognitive strategies based on the brain training approach on the creativity of sixth grade elementary male students. The results showed that the implemented intervention was able to increase students' creativity and fluidity, expansion and flexibility. According to the findings, the intervention was not effective on the initiative dimension. Our findings are consistent with the findings of Karami et al. (2013), Sadeghi et al. (2016), Hargrove (2013) and May et al. (2020).

Creativity is one of the cognitive dimensions of the individual that plays an effective role in the growth and development of the individual and human civilization and is the basis of invention and scientific and artistic achievements. Research shows that creativity is not a gift that certain people have because it can be cultivated by using appropriate methods. Torrance (1981) believes that creativity is a individual ability; that is, it depends on factors such as motivation, excitement, emotions, feelings, experiences and personal learning. People who are more effective, confident and capable in doing things have a higher level of creativity and academic self-concept. Cognitive and metacognitive strategies are procedures that aid in learning and recall. Though these strategies can be learned, but some learners cannot learn it and need to be trained in this area (Saif, 2015). Learners who are aware of their own study and learning methods and consciously choose activities to improve them learn higher than learners who are less aware of these issues. From their metacognitive knowledge, they coordinate specific strategies with specific learning objectives, so it is necessary for curriculum and educational planners to consider the necessary arrangements and measures in this field and provide the necessary facilities for familiarization and preparation of school teachers.

Teaching cognitive and metacognitive strategies of brain training increases students' intellectual and mental processes, and since aspects of academic performance and creativity are directly affected by intellectual processes, confirmation of the effect of these trainings on creativity is not unexpected. In fact, teaching these strategies allows the individual to monitor all the actions involved in a cognitive practice from beginning to end and to direct his learning process in such a way that it increases productivity of his mental processes in relation to the available time and resources.

Fluidity is the ability to establish a meaningful relationship between thought and expression and enables people to offer multiple solutions to problems. In other words, fluidity is related to the quantity of individual responses to a problem. If divergent thinking is activated in students, they can achieve multiple answers and new ways. On the other hand, the initiative is the ability to think in an unconventional way. It means giving unusual, strange and clever answers to a problem. Because there

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are pre-determined rules for doing homework in schools, students do not have the freedom to do so. This could be a possible explanation for the ineffectiveness of the intervention on students' initiative scores.

Expansion ability is pay attention to detail while performing an activity. Expanded thought pays attention to all the necessary details for a plan and does not miss anything. Avoiding individual competition and encouraging the group competition is a step in strengthening creativity. Students in a safe and stress-free environment can deal with all dimensions and details of issues as a group. Flexibility is the ability to think in different ways to solve new problems. Flexible thinking designs new patterns for thinking. Flexibility is a key principle in brain-based training. Music has an extraordinary effect on the production of new ideas. Visualization activates the mind and makes the mind better able to search and organize information within itself. These activities increase creativity and its dimensions as well.

The present study has some limitations along with the findings. Conducting research on male sixth grade elementary school students in Bushehr restricts the generalizing the findings to female students in other cities. Based on this, it is recommended to repeat the study on other samples. Also, based on the findings, it is suggested that teachers and parents be taught cognitive-metacognitive strategies based on brain training in educational workshops.

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