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Original Article

The Effectiveness of Brain-compatible Learning on Academic Self-concept and Academic Self-efficacy

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Abstract

Background and Objective: The human brain has special applications for improving learning, and the use of Brain-compatible Learning enhances students' learning experiences. Therefore, the present study aimed to determine the effectiveness of Brain-compatible Learning on students' academic self-concept and academic self-efficacy.

Materials and Methods: To evaluate the effectiveness of this method, a quasi-experimental design with pre-test-post-test was used, along with a control group. The statistical population of the study consisted of all male high school students (n=1,500) in district one of Maragheh, Iran, in 2022-2023. From the aforementioned population, 30 students were selected as samples using a cluster random sampling method. These individuals were randomly assigned into two experimental and control groups. After the participants were randomly assigned, the academic self-concept and academic self-efficacy questionnaires were administered to members of both groups in the pre-test. Then, the experimental group participated in 18 Brain-compatible Learning training sessions, while the control group received no intervention. After the training sessions, the post-test was administered and a follow-up was conducted after one month. The data were analyzed using the statistical method of analysis of covariance.

Results: The findings showed a significant difference in academic self-concept and academic self-efficacy scores in the two groups (P≤0.01). Therefore, the average scores of academic self-concept and academic self-efficacy of the experimental group in the post-test and follow-up stages were higher than those of the control group.

Conclusion: The results suggest that Brain-compatible Learning mechanisms, such as engaging multiple sensory modalities and creating emotionally supportive environments, foster more positive self-beliefs (self-efficacy) and self-perceptions (self-concept) among students, as supported by statistically significant data obtained in this research.

Keywords: Academic self-concept, Academic self-efficacy, Brain-compatible learning

Background

In recent decades, various approaches to educational processes have emerged in the field of education [1]. Brain-based learning is one of these theories that has attracted the attention of many education experts [2]. This theory introduced new topics into the educational field by emphasizing on the brain and how it functions, and its relation to learning processes. For centuries, scientists have attempted to obtain information from the internal functions of the brain. In 1980, brain-based education was established as a new discipline based on what we have learned about the brain and how it is viewed in education [3]. In recent years, brain-based education has attracted the attention of many researchers and educational agents around the world as an effective model for transforming education. The brain is closely related to everything that educators and students do in the educational environment or school, enabling humans to adapt to the environment and learn [4]. In general, brain-based learning is the application of a set of meaningful principles that help us understand how our brains work during learning [5] and emphasizes how the brain naturally learns. It also seeks to change the framework based on the actual structure and function of the human brain [6]. In this approach, learning is viewed from a brain-based perspective, emphasizing that effective learning practices should be designed in accordance with how the brain naturally processes, stores, and retrieves information [7]. The essential components of brain-centered learning include calm awareness (creating a pleasant emotional environment for learning), coordinated immersion in complex experiences (creating pleasant, optimal, and rich opportunities for learning), and active processing of experiences (creating pleasant ways to consolidate learning) [8]. Brain-centered learning emphasizes meaningful learning rather than rote learning. In other words, the brain does not easily learn things that are not logical or meaningful, and the presence of structure is important for learning [9]. According

to this approach, students will select and implement what they need in school to succeed [10]. Brain-centered learning can significantly improve students' learning motivation, progress, attitude, recall, and learning and cognitive processes [11]. Several studies conducted in the field of Brain-compatible Learning in the classroom indicate the fact that Brain-compatible Learning is effective in improving students' learning [12,13].

Students' self-concept is among the factors involved in academic performance [14]. In the last few decades, the view of psychologists on the nature of self-concept has changed. Early scholars assumed that the nature of self-concept was unidimensional, unitary, and fixed. However, contemporary scholars believe that self-concept is a dynamic and multidimensional construct [15]. Students who value themselves more are more successful in dealing with others and show greater resilience in the face of difficulties [16]. Therefore, one of the goals of education in all societies is to help individuals achieve high self-efficacy and a positive self-concept. Therefore, if we can identify the factors that influence self-efficacy and academic self-concept, we will be better equipped to support education in achieving its goals [17]. Some researchers consider general self-concept to consist of two parts: scientific self-concept and non-scientific self-concept. Each person's general self-concept is composed of several specific concepts, including academic self-concept (e.g., English self-concept and mathematical self-concept). Non-academic self-concept is also composed of separate and more specific self-concepts, such as self-concept of physical ability, physical appearance, and peer relationships. Self-concept is a dynamic system that is related to the beliefs, values, interests, talents, and abilities of the individual [18]. Academic self-concept, which refers to an individual's perception of their abilities and competencies in the academic field, plays a crucial role in academic success. This perception can affect motivation, effort, choice of field, and even how to deal with failure [19]. Students with high academic self-concept are usually more motivated to learn, see challenges as opportunities, and do not lose hope in the event of failure [20]. Brain-compatible Learning can play an important role in strengthening students' academic self-concept by influencing various factors, such as motivation, academic performance, anxiety, sense of control, and negative beliefs [21]. Another factor affecting student success is academic self-efficacy, which is an individual's belief in their abilities to perform academic tasks. Students with high academic self-efficacy are usually more motivated, put in more effort, and show greater resilience in the face of challenges [22]. Studies show that students' self-efficacy is a positive predictor of academic performance in various subjects, including mathematics, science, and reading [23]. Self-efficacy is also strongly associated with a variety of academic outcomes, such as higher levels of effort and persistence in difficult assignments [24], and is correlated with key motivational constructs such as causal attributions, self-concept, optimism, achievement orientation, academic help-seeking, anxiety, and value [25]. In general, self-efficacious students tend to put in more effort to succeed in a task [17]. They are not easily discouraged when faced with difficulties, use meaningful learning strategies, and show intrinsic interest in academic tasks [24]. Brain-compatible Learning directly affects students' academic self-efficacy by providing a learning-centered environment, personalizing instruction, increasing their understanding of the learning process, and reducing anxiety [26]. This method also leads to better academic performance in students with high academic self-efficacy, enabling them to cope better with challenges, and ultimately become more successful individuals [27]. Findings extracted from various studies showed that Brain-compatible Learning has an impact on students' academic self-concept and academic self-efficacy. Among these studie, Amjad, Tabbasam & Abbas (2022) reported that brain-based learning affects students' self-efficacy for learning and performing mathematics [27]. In addition, research by Sahin, Ökmen & Kiliç (2023) showed that brain-based strategies increased students' self-confidence, reduced their negative behaviors, and increased their academic progress [4]. Habibnezhad Allameh et al. (2024) concluded that brain-based learning improves the cognitive and emotional outputs of learners [28]. In this regard, there is little research on the effect of Brain-compatible Learning-based education on students' academic self-concept and academic self-efficacy, and the majority of the research conducted has focused on the effect of this intervention method on motivational attitudes and processes [9], academic achievement [10], and memory and information processing [10]. Given the importance of Brain-compatible Learning in students' academic achievement and the fact that limited research has been conducted on the psychological constructs related to it, this study seeks to examine the effectiveness of Brain-compatible Learning on academic self-concept and academic self-efficacy.

Objectives

The present study aimed to determine the effectiveness of Brain-compatible Learning on

students' academic self-concept and academic self-efficacy.

Materials and Methods

This research was based on a semi-experimental method with a pre-test-post-test type and control group. The statistical population of the present study included all male high school students (n=1,500) in Maragheh, Iran, in the academic year 2022-2023. To determine the sample size for this study, Gall, Borg, and Gall (2012) recommended at least 15 participants per group for experimental and quasi-experimental designs. Accordingly, 30 eligible participants were selected using purposive sampling, based on predefined inclusion and exclusion criteria. The selected individuals were then randomly assigned to either the experimental group, which received the brain-compatible learning intervention, or the control group, which continued with traditional instruction under otherwise similar conditions. For the educational intervention, two questionnaires assessing academic self-concept and academic self-efficacy were administered to all participants in both groups. Then, the Brain-compatible Learning training plan was administered to students in the experimental group over 18 sessions, each lasting 45 minutes. The control group received no intervention during this period. Inclusion criteria for participation in the study included mental health and willingness to participate in the study. Exclusion criteria cmprised non-cooperation during the study, absence from intervention sessions, and participation in concurrent educational interventions. In this study, participants from two groups attended an explanatory session where the objectives of the study were outlined to obtain their consent for participation. During this session, the research cooperation form was completed by the students, and it was emphasized that participants had the right to terminate their cooperation with the researcher at any stage of the study based on their desire and discretion. The researcher assured the participants that all materials presented in the training sessions and the results of the questionnaires would remain confidential, and would not be disclosed to any individual or organization. Moreover, it was clarified that the results would be analyzed as a group without mentioning the participants' names. Following the completion of the intervention, the same questionnaires measuring academic self-concept and academic self-efficacy were re-administered to both the experimental and control groups in order to assess post-intervention outcomes. Subsequently, the research findings were analyzed using SPSS software (version 22). Descriptive statistical methods, including mean, standard deviation, tables, and graphs were used to analyze the collected data. Furthermore, a one-way covariance test was used in the inferential analysis.

Evaluation Tools

1. Academic Self-concept Questionnaire: To measure academic self-concept, Saraswat (1984) self-concept questionnaire was used [29]. This questionnaire consists of 48 items. The items in this questionnaire are based on a 5-point Likert scale, which is scored from 1 to 5. Eight items of this scale measure academic self-concept, and these items were selected for this study. The results of confirmatory factor analysis showed that two items of this subscale had a factor loading lower than 0.3; therefore, they were eliminated from this study. The reliability of this subscale using the test-retest method was reported by Saraswat as 0.88. In a study by Sufi and Ganji, the Cronbach's alpha coefficient was measured at 0.77 [30]. In the present study, a 6-item academic self-concept questionnaire was used, and its reliability using Cronbach's alpha method was obtained as 0.81.

2. Student Academic Self-Efficacy Questionnaire: The Student Academic Self-Efficacy Questionnaire was developed by Jing and Morgan in 1999 [31]. This questionnaire has 30 items and three subscales of aptitude, effort, and context. The questionnaire is scored on a 4-point Likert scale. In a study by Sabzian and Ground [32], Cronbach's alpha coefficient for overall self-efficacy was estimated at 0.74, and the subscales of aptitude, effort, context were measured at 0.71, 0.67, and 0.64, respectively. Furthermore, in the present study, Cronbach's alpha for overall self-efficacy was measured at 0.85.

3. Brain-Based Learning Training Package: The basis of brain-based learning training is the implementation of the 12 principles of brain-based learning by Cain, Cain, McClinton, and Climax (2005) [8]. This training was conducted over a total of eight sessions, each lasting 50 minutes. In these sessions, the basic components of Brain-compatible Learning are taught, including mindfulness combined with relaxation (creating a pleasant emotional environment for the brain and learning), coordinated immersion in complex experiences (creating pleasant, optimal, and rich opportunities for learning), and active processing of information (creating optimal and rich opportunities for learning) [11]. Training sessions are summarized in Table 1.

Table 1. Brain-compatible Training Program

Sessions	Content
1	Establishing connections, the need for Brain-compatible Learning, students' familiarity with the structure of the brain and its evolution, the function of each part of the brain about learning
2	A) mindful relaxation, B) coordinated immersion in complex experiences, C) active processing of experiences
3	Explaining real-life problems in education, the teacher's friendly attitude towards students, explaining ideas, creating a challenging atmosphere through individual assignments, solving puzzles during learning, group and collaborative learning, creating orbital experiences through love, respect for elders to overcome old habits and create new habits.
4	Providing a tangible environment and content, reflecting prior knowledge, creating a context for stimulating curiosity, a desire for exploration and discovery, strengthening the desire to deal with problems, and creating a happy environment through positive activities such as telling jokes, using calming colors (green, blue, and brown), reflecting students' interests in the content, and creating a desired emotional atmosphere in the classroom and school.
5	Using various methods to activate students' brains, moving from part to whole in learning (an example from the tenth lesson of the Experimental Science textbook was presented regarding the position of the Earth in space), emphasizing stress control and its role in learning, physical exercises, and relaxation, maintaining health, using Brain-compatible nutrition during breaks, using water bottles for each student and encouraging their use.
6	Using real-life experiences to emphasize the role of modeling in learning, integrating the curriculum with everyday life topics, encouraging students to extract patterns from the information provided and not imposing patterns, providing learning programs that take into account the developmental and developmental structures of students, paying attention to the level of understanding and comprehension, paying attention to the zone of proximal development and using its principles.
7	Providing learning activities related to current affairs to connect knowledge and skills with natural memory, conducting classroom demonstrations related to topics, field visits, retelling stories, stimulating students' interest and enthusiasm through modeling, and using feedback methods such as timely correction of worksheets.
8	Providing sufficient breaks during teaching to process information, encouraging students to ask questions in class and answer the questions posed, praising innovations and resolving students' ambiguities, and providing varied and multifaceted teaching to stimulate students' visual, tactile, emotional, and auditory interests, taking into account individual differences.

Results

Table 2 shows the descriptive statistics of the participants based on the variables of academic self-concept and academic self-efficacy in the pre-test and post-test of the two experimental and control groups.

The mean scores for the experimental group in the pre-test and post-test for the variable of academic self-concept were 57.43 and 69.66, respectively. The mean scores for the control group in the pre-test and post-test were 55.20 and 55.40, respectively. Additionally, descriptive statistics regarding academic self-efficacy indicated that the mean score of the experimental group increased from 55.63 in the pre-test to 69.46 in the post-test. In comparison, the control group's mean scores were 56.10 in the pre-test and 57.05 in the post-test, showing no substantial change during the same period. Moreover, the mean scores for the control group in the pre-test and post-test were 55.29 and 60.26, respectively.

Table 2. Descriptive statistics of the participants in the pre-test and post-test

	Variables	Stage	Mean	SD	Min	Max	Domain
Academic Self-concept	Experimental group	Pretest	57/43	12/97	38	83	45
		Posttest	69/66	13/05	44	98	54
	Control group	Pretest	55/20	11/92	34	87	53
		Posttest	55/40	11/67	32	81	49
	Total	Pretest	56/31	12/40	34	87	53
		Posttest	62/53	14/23	32	98	66
Academic Self-efficacy	Experimental group	Pretest	55/63	12/26	33	91	58
		Posttest	69/46	11/57	54	101	47
	Control group	Pretest	55/29	10/30	37	81	44
		Posttest	60/26	10/07	42	85	43
	Total	Pretest	55/41	11/22	33	91	58
		Posttest	66/86	11/71	42	101	59

Table 3 shows the results of a one-way analysis of covariance between participants in the experimental and control groups. The difference was statistically significant, $F(1, 28)=422.23$, $P<0.001$, mean square=456.22. In addition, it can be concluded that the independent variable in the experimental group was effective and caused the difference between the mean of the experimental group and the control group.

Table 4 indicates the results of a one-way analysis of covariance between participants in the experimental and control groups, which with a mean square of 1162.349, the value of $F = 103.627$ is significant at the 0.001 level. Therefore, it can be concluded that the independent variable was effective in the experimental group and caused the difference between the mean of the experimental group and the control group.

Table 3. ANCOVA results of the academic self-concept in the experimental and control groups

Source of Changes	Sum of Squares	df	Mean of Squares	F	Sig
Academic self-concept	8355/741	1	8355/741	881/790	0/001
Group	2183/456	1	2183/456	230/422	0/001
Error	540/126	57	9/476		
Total	246574	60			

Table 4. ANCOVA results of the academic self-concept in the experimental and control groups

Source of Changes	Sum of Squares	df	Mean of Squares	F	Sig
Academic self-efficacy	6193/986	1	6193/986	552/215	0/001
Group	1162/349	1	1162/349	103/627	0/001
Error	639/347	57	11/217		
Total	8102/933	59			

Discussion

In this study, the effectiveness of Brain-compatible Learning on the academic self-concept and academic self-efficacy of male students in Maragheh was investigated. According to the results obtained, it can be concluded that Brain-compatible Learning education has an effect on students' academic self-concept. This finding is consistent with the results of some studies [11, 16, 19, 23]. In explaining this finding, it can be stated that Brain-compatible Learning, using attractive and diverse methods, can increase students' motivation and interest in learning. This leads to greater student participation in the learning process and improvement of their academic performance. Moreover, Brain-compatible Learning, by emphasizing on practical activities, discussion, and problem solving, helps students develop their critical thinking and problem-solving skills. This method helps students improve their academic self-concept and self-efficacy by creating successful learning experiences. Self-concept is manifested through psychological well-being, self-confidence, positive feelings about oneself, having a positive mood, self-acceptance, and engagement in activities that foster a sense of importance and generate positive feeling within the individual. Self-concept is associated with many educational benefits, such as increased academic achievement, choosing difficult assignments, and improving learning. It may also mediate a wide range of educational and psychological outcomes, including the growth and development of psychological health, academic skills, coping skills, social interaction, happiness, emotional and social adjustment, and parent-child relationships.

In addition, self-concept is known as an individual's attitude, feelings, and knowledge about their abilities, skills, competence, and social acceptance. A strong self-concept is associated with positive affective states as well as high levels of motivation, and a weak self-concept will lead to negative affective states and low motivation. Research results have shown a relationship between learning styles, especially Brain-compatible Learning, and academic self-concept, and teaching Brain-compatible Learning using methods such as starting each topic with an exciting task, providing a suitable environment and space in education, using teamwork methods, and strengthening metacognitive skills increases students' academic self-concept. In general, Brain-compatible Learning helps students feel better about themselves and their learning abilities by creating positive and supportive learning environments. This approach contributes to the development of a positive academic self-concept among students.

The findings of this study also showed that Brain-compatible Learning education has an effect on students' academic self-efficacy. This finding is consistent with the results of some studies [30,29,23]. In explaining this finding, it can be stated that self-efficacy beliefs are directly related to students' behavioral, cognitive, and motivational involvement in academic tasks. In general, self-effective students usually put in more effort to succeed in a task, do not get discouraged easily when faced with problems, use meaningful learning strategies, and show intrinsic interest in academic tasks. The brain-compatible education method, by emphasizing skills such as metacognitive skills and strengthening self-monitoring in students, can play an important role in increasing students' self-efficacy. By creating an appropriate learning environment and self-monitoring skills for students, this method can improve students' judgments about their abilities. Students with high academic self-efficacy have greater confidence in completing academic assignments than students with lower academic self-efficacy, and high levels of academic self-efficacy lead to higher grade point averages and persistence in completing assignments. Students with higher academic self-efficacy have fewer adjustment and anxiety problems and are able to deal more effectively with academic stressors. Therefore, increasing self-efficacy increases individuals' ability to learn better and, as a result, perform better. Brain-compatible Learning enhances students' sense of self-efficacy in learning by providing challenging yet achievable

learning opportunities. This approach is expected to foster increased effort and persistence in learning, which can ultimately lead to improved academic performance.

Conclusions

In recent years, research has shown that traditional teaching methods are not always the most effective ways to learn. For this reason, new approaches such as Brain-compatible Learning have emerged as an attractive alternative. This approach, which is designed based on a deep understanding of brain function and attempts to optimize the learning environment, making the learning process more effective and enjoyable. Given its importance and necessity, Brain-compatible Learning can play a crucial role in improving academic performance and developing various personality dimensions among students. By implementing the principles of this approach in education, we can create more effective learning environments that support students in realizing their full potential. One of the most important effects of Brain-compatible Learning pertains to two important factors in academic success: academic self-concept and academic self-efficacy. Both concepts affect motivation, effort, and the way to deal with failure. Students with high self-concept and academic self-efficacy are usually more motivated to learn, see challenges as opportunities, and maintain hope in the event of failure. This approach can be used as a powerful tool to improve the quality of education and increase students' academic success. However, this study had some limitations, including a limited follow-up on the effects of the educational intervention, a small sample size, a restricted age group, and data collection using questionnaires. The suggestion for future research with larger samples and comparative studies stems from both the current findings and the recognized limitations, such as sample size and generalizability.

Ethical Considerations

This study was approved under the ethical approval code of IR.UM.1403.011.

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Authors' Contributions

The study was conceptualized and designed by F.J. and M.M.A. Data analysis and interpretation were done by F.J. and M.M.A. The manuscript was drafted by M.A. and critically revised for important intellectual content by F.J., M.A., and M.M.A. All authors provided comments and approved the final version of the manuscript.

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Conflicts of Interest

The author declare that he has no conflicts of interest.

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