The Effects of Brain-Based Learning on the Academic Achievement of Students with Different Learning Styles

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Abstract

The purpose of the present study is to investigate the effects of Brain-based learning (BBL) on the academic achievement of students with different learning styles. The study group consists of students from the department of Social Sciences Teacher Education in the Faculty of Education at Mugla University (N=68). In the study, a pre-test-post-test experimental design was used. Data were collected by using academic achievement tests and the Kolb's Experiential Learning Style questionnaire. The findings of the study revealed that the BBL approach used in the experimental group was more effective in increasing student achievement than the traditional approach used in the control group. However, no significant difference was observed among the achievement levels of the experimental group students with different learning styles.

Key Words

Brain–Based Learning, Learning Styles, Social Sciences Students, Measuring and Evaluation Course.

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Kuram ve Uygulamada Eğitim Bilimleri / Educational Sciences: Theory & Practice
10 (4) • Autumn 2010 • 2077-2103

Learning styles are factors directly affecting students' learning processes. Individual differences observed in the acquisition and processing of information during the learning process result in style differences in learning (Felder, 1996). The best way of conceiving individual differences is through understanding learning styles (Hall, 2005). An understanding of learning styles requires some knowledge of how the brain works and learns, and how the brain functions. As the feelings, emotions, attitudes and backgrounds of individuals are different from each other, each person acquires and learns information in different ways. It is claimed that the learning styles of the individuals are determined by the ways the brain functions. Thus, the content, design and presentation of each learning activity should be developed in such a way as to cater to the different thinking and learning styles of students (De Vita, 2001). What matters is how to design and carry out effective learning activities to meet the needs of students with different learning styles. Hence, it seems necessary to teach students how the brain functions and learns while acquiring and processing information.

There are various viewpoints regarding how we perceive and process information (Dunn, 1990; Dunn & Dunn, 1992; Kolb, 1984; McCarthy, 2000). Within the context of the findings suggested by the neurophysiologic theory of Hebb (1949), it is believed that the left and right hemispheres of the brain employ different strategies while receiving different information in different ways (Jensen, 2008; Kolb, 1984; Williams, 1983). Each hemisphere contributes its special functions to cognitive, affective, and physical activities and is neuron or nerve cell rich (Jensen, 2008; Walls, 1999). Neither of these hemispheres is superior to the other; they just have different specialized functions (Gazzaniga, 1998; Organisation for Economic Co-operation and Development (OECD), 2002). The hemispheres spontaneously determine the time spent on thinking about a particular issue (Sprenger, 2002), and the brain serves its function as a whole. At the same time, "every brain is unique" (Caine & Caine, 1994).

Several educators and brain researchers, including Dun and Dunn (1992), Kolb (1984), Hebb (1949), Gregorc (1984), McCarthy (2000), Butler (1987), and Felder (1996) have conducted research and produced materials related to students' learning styles as related to the brain's hemispheres. This research has revealed that individuals learn in different ways; hence, multi-dimensional teaching models should be used. McCarthy (2000), for example, suggested that teachers using her four styles involve both right brain and left-brain processing techniques.

Learning Styles

Learning styles are cognitive, affective, and physiological traits that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment (O'Keefe & Nadel, 1978, p. 32). Previous research (Kolb, Boyatzis, & Mainemelis, 2001) has shown that learning styles are influenced by personality type, educational specialization, career choice, and current job role and tasks. The indicators of "what" and "how" a student processes while learning largely determine his/her learning style. Kolb and Kolb (2005) state that there is no such thing as a fixed learning style; rather, learning occurs on a continuum ranging from concrete to abstract, or from reflective observation to active experimentation.

Kolb's Experiential Learning Theory (ELT) (1984) is based on research conducted on brain hemisphere dominance. Much of the research on ELT has focused on the concept of learning style, using the Learning Style Inventory (LSI) to assess individual learning styles (Kolb et al., 2001; Kolb & Kolb, 2005). The ELT model portrays two dialectically related modes of grasping experience—Concrete Experience (CE) and Abstract Conceptualization (AC)—and two dialectically related modes of transforming experience—Reflective Observation (RO) and Active Experimentation (AE). ELT is a holistic, dynamic, and dialectic theory of learning. Because it is holistic, the four modes that make up the experiential learning cycle (CE, RO, AC, and AE) are conceived of as interdependent (Kolb and Kolb, 2005). Learners can thus be classified into one of four learning styles: converger, diverger, assimilator, and accommodator, mapped in one of the four quadrants (Kolb, 1984).

Accommodators have CE and AE as dominant learning abilities, enjoy new experiences, and act on feelings more than logic. They learn by doing and feeling (Kolb and Kolb, 2005).

Divergers combine CE and RO and enjoy brainstorming, being active and gathering information (Kolb and Kolb, 2005). They have cultural interests, they are imaginative and emotional, and they like working in groups.

Convergers combine AC and AE, and they like learning through experimenting and reflective observation. They use hypothetical-deductive reasoning while focusing on a specific problem (Smith & Kolb, 1996). These learners prefer to experiment with new ideas, simulations, and practical applications (Kolb & Kolb, 2005).

Assimilators conceive information through abstract conceptualization (AC), and they process it through reflective observation (RO). They learn by thinking and observing. Assimilators classify information into logical categories, develop theories, and favor abstract concepts. Assimilators prefer readings, lectures, and exploring analytical models (Kolb and Kolb, 2005).

According to this model, individuals conceive information by feeling or thinking and process it by observing or doing. However, the learning style of an individual is not determined by only one skill. It is the common outcome of the combination of four learning skills. Thus, the development of learning activities catering for all the components of an individual's learning style requires the design of teaching-learning models that can stimulate all the senses and the lobes of the brain. In this respect, BBL seems to be the most promising approach for the design of such a model.

Brain Based Learning (BBL)

BBL involves accepting the rules of how the brain processes, and then organizing instruction bearing these rules in mind to achieve meaningful learning (Caine and Caine, 1994). BBL is a way of thinking about the learning process. It is a set of principles and a base of knowledge and skills through which we can make better decisions about the learning process (Jensen, 2008).

The objectives of brain research studies include teaching to individual differences, diversifying teaching strategies, and maximizing the brain's natural learning processes (Gülpınar, 2005; Tileston, 2005; Zadina, 2004). Without knowing the working system of the brain, it is not possible to understand the nature of learning. According to Zull (2002), the art of teaching must be the art of changing the brain. For Kolb and Kolb (2005), meaningful learning does not occur in a single way, but in a unity of circulation because the brain works in a unity while learning. Teaching should start with the exploration of the brain. While challenges may promote learning, threats may hinder it (Caine and Caine, 1994).

Based on the findings of neuroscience, BBL guides according to the principles and workings of the brain to improve the best way of learning, increase academic achievement, and provide equal opportunities for individual differences

The Relationship between BBL and Kolb Experiential Learning

It is suggested that, in BBL approach, discussion should be done by students sharing their experiences and the lessons that they have learned from those experiences with each other in class. The principles of BBL are followed in experimental learning with the application of principles such as patterning, parallel processing, and challenges to enhance learning (Phillips, 2005). This process of experiential learning is related to the process of brain functioning as shown in Figure 1. "Put into words, the figure illustrates that concrete experiences come through the sensory cortex, reflective observation involves the integrative cortex at the back, creating new abstract concepts occurs in the frontal integrative cortex, and active testing involves the motor brain. In other words, the learning cycle arises from the structure of the brain" (Kolb and Kolb, 2005; Zull 2002). Zull (2002) illustrates the parallelism between the brain's natural cycle of le

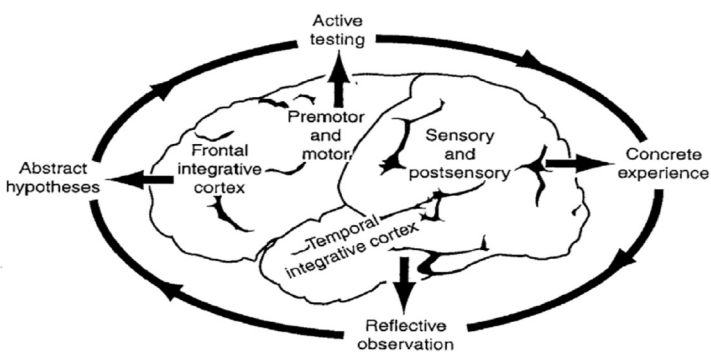

Figure 1. *The Experiential Learning Cycle and Regions of the Cerebral Cortex (Zull, 2002)*

Kolb's learning cycle model accounts for students' gaining internal insights about their own learning preferences. Through experiences and physical activities, students can strengthen the synaptic links between neurons. Experiences physically change the brain through internal and external stimuli (Roberts, 2002). According to Zull (2002), change is learning. Learning is a process, and it occurs through experiences. The most important shared concept of ELT and BBL is experience, and the relationships between BBL and Kolb's experiential learning model can be summarized as follows:

BBL	ELT
1. The brain works in unity 2. Each brain is unique 3. The brain is divided into two hemispheres and they have different functions. 4. The left brain is analytic and abstract; the right brain is holistic and concrete. 5. The brain has four lobes, and each lobe serves different functions and duties.	1. Learning takes place in the form of a circulation. 2. Every learning style equips students with particular perceptions and processing skills. 3. The cycle of learning defines two dimensions of learning. 4. The first is the conception of information and the second is information processing. 5. The cycle of learning has four learning styles. Every individual has his/her own particular learning styles.

The BBL and ELT models explain learning based on the brain's lobes and the working principles of learning. According to BBL theory, individuals have their own personal circulation and circadian rhythm (Jensen, 2008).

The present study also reviews previous studies about BBL and learning styles. In a meta-analysis study conducted on learning styles, 42 different studies were reviewed, and this review revealed that coherence between learning activities and learning styles enhances academic achievement (Hein & Budny, 2000; Bayraktar, 2000; Sünbül, 2004). Learning-centered teaching that take learning styles into consideration has been found to positively affect creative intelligence, academic achievement and motivation (Bajraktarevic, Hall & Fullick, 2003; Butler,1987; Demirbas & Demirkan, 2007; Felder, 1996; Kolb, 1984; McCarthy, 2000; Scales, 2000).

Different teaching styles are required for different learning objectives (Gagne, Briggs, & Wagner, 1992). Teaching should be performed by considering the style differences of students (Gardner, 1993), and no single learning-teaching theory is adequate on its own. There is, therefore, a need for integration of different models based on brain-compatible learning conditions.

Although the literature reveals many studies about BBL and learning styles, of more importance is the need to synthesize BBL and learning styles together and use this synthesis in experimental classroom environments. This study aims to fill this space in the experimental area. In this respect, a learning and instruction model which is appropriate for the principles and conditions of BBL in the literature is developed and applied.

The Purpose of the Study

The present study deals with the organization of learning according to the characteristics of students with different learning styles and the working principles of the mind so that each individual can equally draw on learning conditions. That is, the study aims to investigate whether BBL makes similar contributions to the academic achievement of students with different learning style. For this purpose, answers are sought for the following questions:

1. How is the learning style distribution of the students in the groups?
2. Are there any significant differences between the effects of the BBL approach on the academic achievement of the experimental group students and the effects of a traditional method on academic achievement of the control group students?
3. Are there any significant differences among the academic achievement levels of the students in the control group depending on their learning styles, and are there any significant differences among the academic achievement levels of the students in the experimental group depending on their learning styles?
4. Are there any significant differences between the academic achievement of the experimental and control groups according to different learning styles?

Method

The design of the study is a pre- and post-test experimental model with a control group. The present study compares the effects of independent variables of the study (BBL approach used in the experimental group, and a traditional approach—lecture, question-answer—used in the control group on the dependent variable (student achievement).

Participants

The study was carried out by the researcher among third-year students of the Education Faculty of Mugla University in the 2006-2007 academic year. While forming the sample, attention was paid to the need for students in the groups to be from the same departments, and with similar university entrance exam

(ÖSS) scores. Through the pre-test, academic achievement scores of the students were equalized. Then, the students were randomly assigned to the control and experimental groups.

Out of the 34 experimental group students, 18 (52.9%) are females and 16 (47.1%) are males, and out of the 34 control group students, 15 (44.1%) are females and 19 (55.9%) are males. The age range is 20-22 years in both groups. The socio-economic and cultural conditions of the participants are similar. Participation was on a voluntary basis, and the research was conducted during a course on the subject of measurement and evaluation. Participants were informed of their learning style preferences at the end of the study.

Instrument

For this study, an academic achievement test and the Kolb's learning styles inventory (LSI) were used. In order to determine experimental and control groups, Kolb's (LSI), "Personal Information Form", developed by the researcher, and an academic achievement level test were administered.

The Academic Achievement Test: In order to develop an academic achievement test, literature about the unit "measurement and evaluation" was reviewed, and the topics to be studied in this unit were determined as follows: 1. Concepts concerning Measurement and Evaluation 2. Structural characteristics of measurement tools 3. Measurement Tools and Methods used in Measurement 4. Reliability and Validity of Measurement Tools. An academic achievement test including 45 questions was designed by the researcher. Expert opinions were sought for the validity of this achievement test, and the test was piloted among 148 fourth-year students from the Faculty of Education. Through item analysis, the difficulty level and discrimination power of the questions were investigated. Kehoe (1995) states that good test questions should be correctly answered by 30-80% of the participants; that is, item difficulty should be between 0.30 and 0.80. According to the level of difficulty, items having a difficulty level below .30 were considered to be too difficult, and items having a difficulty level above .80 were considered to be too easy. For the discrimination value, .40 and above were considered to be acceptable values. As a result, five questions were discarded from

the test, and the remaining 40-item test was used as the achievement test in the present study. The KR-20 reliability coefficient of the test was found to be .86. This multiple-choice achievement test was administered to both the experimental group and the control group to test their pre-knowledge. For every correct answer, 1 point was assigned, and for every false answer, 0 point was assigned. Every question in the test has four options. The possible highest score that can be achieved in the test is 40. Data concerning the students' academic achievements in relation to their learning styles were also collected with the pre- and post-test academic achievement test.

The Learning Style Scale: The learning style scale developed by Kolb (1984) was adapted into Turkish by Aşkar and Akkoyunlu (1993), and its reliability was found to be .72. There are 12 items in the scale. Each item has four options, each of which represents a learning style. Every item is scored between 1 and 4, so the minimum score to be obtained from the scale is 12, and the overall maximum score is 48. For the data from the learning style scale to be interpreted, combined scores are needed. These are calculated by taking the Abstract Conceptualization-Abstract Experience (AC-AE) and the Active Experience-Experiential Observation (AE-EO) difference. The results of these calculations range from -36 to +36. Positive scores obtained for AC-AE indicate that the student is abstract, and negative scores indicate that the student is concrete. Positive scores obtained for AE-EO indicate that the learner has an active learning style, and negative scores indicate that the learner has a reflective learning style. By placing the values obtained from the calculation on a diagram designed according to Kolb's (1984) Experiential Learning Theory, the learning styles of the students were determined.

Data analysis methods: Test results of Levene statistics were used for the homogeneity of the group variances. The Kruskal-Wallis H-Test and the Mann Whitney U-test were used for the pre-test. Post-test scores were compared to find the difference between the means. In addition, for unrelated measure which doesn't require assumption of normality, the Mann Whitney U-test was used for inter-group academic achievement scores, the Kruskal Wallis H-Test was used for intra-group academic achievement scores, and a t-test was used for binary combinations of different learning styles. The data obtained were analyzed using the SSPS program package. The level of significance is accepted to be .05.

Procedure

Pre-experiment procedure:

1. This study was carried out during a course on measurement and evaluation. For both groups, the study was carried out during a five class-hour week over a six week period. Teaching of the topics in the experimental groups is performed in the following sequence:

1st week: Theoretical and applied studies related to BBL.

2nd week: Measurement and evaluation-related concepts.

3rd week: Structural characteristics of measurement tools.

4th week: Measurement tools and devices used in measurement.

5th week: Reliability and validity of measurement tools.

6th week: General evaluation

2. A pre-test was administered to the groups to equalize their pre-knowledge about the topics to be taught in the measurement and evaluation course.

3. While BBL-based activities were used in the experimental group, traditional teaching approach-based activities were employed in the control group.

4. By using the Kolb learning style inventory, the learning styles of the participants were determined. Students were given detailed instructions on how to complete the questionnaire and how to record their answers.

5. After the study was completed, the test used as pre-test was again administered to both groups as a post-test.

Procedure followed in the experimental stage;

In the experimental group, films and slide shows about how the brain functions were shown. A content-methodology connection was designed by the researcher himself and developed according to the BBL model. This model represents a learning-teaching design based on conditions, processes, and gains that are connected to each other in a complementary manner. This design stemmed from the BBL principles and conditions outlined by many researchers (Caine, Caine, McClintic & Klimek, 2005; Jensen, 2008; Jensen and Dabney, 2000). This "BBL

integrated learning-teaching" model was developed by the researcher and used in the present study for teaching all the topics of the unit. This model is shown in Figure 2.

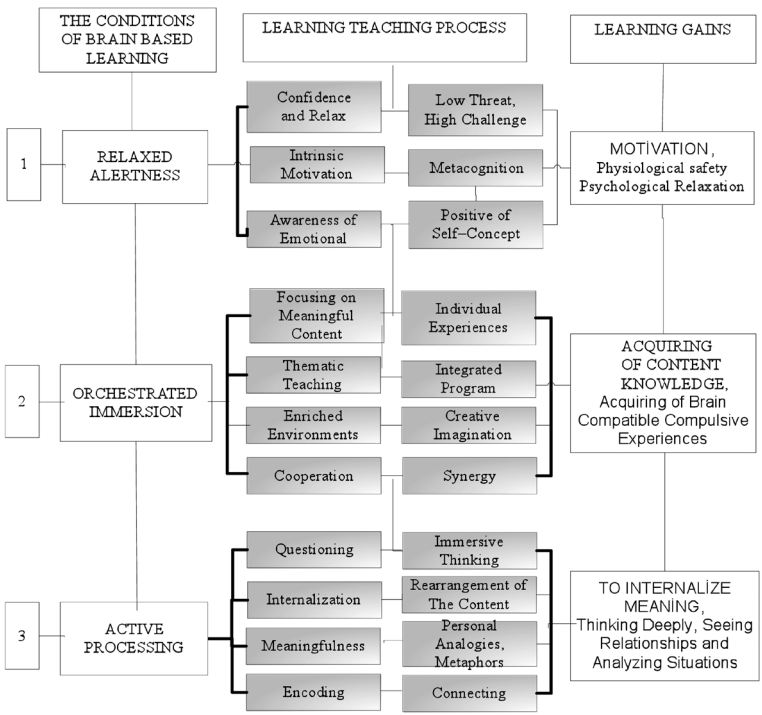

Figure 2. *BBL Integrated Learning-Teaching Model*

This model consists of three vertical and horizontal frameworks. The vertical axes represent "the conditions of BBL", the "learning-teaching process" based on these conditions, and the "learning gains" at the end of this process. The horizontal axes represent elements concerning how the three conditions of BBL are fulfilled in the learning-teaching process. With the use of these elements, gains related to each condition of BBL are obtained. Now, this process can be explored as follows:

> I. For "Relaxed Alertness"; 1. The lesson started with music. 2. The required setting for a positive academic perception of self–concept based on principles such as "every brain is unique and it has unique learning and interpretation capacity" and

the "brain is a parallel processor" was provided. 3. During breaks, students were advised to drink water. 4. Cooperation and group-work opportunities were provided to enhance emotional awareness and relaxation. Students were also allowed to walk around the classroom to discuss freely and brainstorm. 5. The students were told that each individual is responsible for himself/herself to both remove stress and to challenge themselves, and they prepared their own portfolios and evaluated them. Throughout the learning-teaching process, a classroom setting with "physiological safety" and "psychological relaxation" was created.

The basic concepts and topics in the unit "assessment and evaluation" (direct, indirect, absolute, and relative assessments etc.) were associated with factors such as students' exam scores, heights, weights, and the temperature of the classroom. Based on these scores, activities were carried out with many different assessment tools according to the principles of "relaxed alertness."

II. For "Orchestrated Immersion"; 1. For "focusing on meaningful content" and individual experiences, unit topics were projected. 2. For "integrated program and thematic teaching", the main and sub-themes of the unit topics were determined together with the students. Through an analytic approach, themes were separated into either verbal or numerical. Numerical operations in measurement and evaluation such as arithmetic means, standard deviations, percentages and frequencies, Mod, Median T and Z score calculations were associated with daily problems. Verbal operations were patterned around the lives of the students. Then, In-class presentations were performed. 3. For "enriched environments", posters, pictures, graphics and multimedia related to the topic were displayed and caricaturized pictures were hung up. Slide shows parallel to the content were displayed in each lesson. Students were encouraged to participate in whole class discussions about the basic principle of "you cannot evaluate the thing you have not measured and you cannot reach a conclusion about the thing you have not evaluated". These activities were associated with the life experiences of the students. 4. For "synergy based on

cooperation", the topics of assessment and evaluation course were grouped. Every main topic of the unit was assigned to a cooperation-based group, and each group prepared a project about its own topic. Projects were displayed in the classroom and presented through dramatization. "Measurement and evaluation" concepts were dramatized using both natural and produced objects. For example, measurement tools used to measure were classified and their features were explained. Students were allowed to discuss the methods and tools used to evaluate their exam results.

III. For Active processing: 1. For "questioning and deep thinking", "Asking question is the basic condition required to think", "If there is a question, then there is a meaning" principles were exploited throughout the whole experimental process while the activities were being done. 2. For "internalization and rearrangement of the content", students with different learning styles were brought together. Activities were performed according to the learning styles of each group. 3. For "assigning meaning and personal analogies";,topic-related stories were told, educational games were played, crossword puzzles were solved, and drama activities were performed. 4. For "encoding and connecting", It was coded by matching the measurement tools' features (like reliability, validity, usefulness and objectivity) with characteristics that students need to have.

The validity and reliability features that should be possessed by measurement tools were discussed. Sources of error in measurement tools were classified. Interesting examples showing the serious effects of the measurement errors on human life were presented. The students were encouraged to associate the content with their life experiences in order to relate methodology to content.

In addition, while teaching the topics to the experimental group, a content-time matrix was considered. Activities and content presentations in the learning-teaching environment were constructed by considering "Primacy-later, Prime Time-1, Prime Time-2 and Downshift Time (Dwyer, 2002; Sousa, 2006). For example, in Prime-time 1 (the first 15-20 minutes of the lesson) the main and sub-topics of the subject were explained through various materials, power point shows and drama activities. In Downshift-Down-time (when the students lose

their concentration) the topics were taught with an inter-disciplinary approach by using music, drawings, cartoons, and group work. In Prime-time 2 (last 10-15 minutes of the lesson) the content of the lesson was encouraged to be personally constructed and internalized with the help of questioning-based coding. In this stage, the principle of "if there is question and questioning, understanding has occurred" was employed. The lesson ended with a few questions aiming to remind the students of the topic of the following lesson and to arouse interest and curiosity.

In the control group, traditional teaching methods were employed, and approaches used in the experimental group were not capitalized upon. The content is the same as the content dealt with in the experimental group, and lecturing and question-answer methods were used to do the activities.

Results

This section includes distribution of the learning styles of the participants, and findings complying with the purposes of the study are presented.

Learning Styles of Students

Table 1.
The Distribution of Participants by Learning Styles

Learning styles	Experimental group		Control group	
	Frequency	Percentage	Frequency	Percentage
Accommodating	5	14.7	3	8.8
Diverging	7	20.6	8	23.5
Assimilating	12	35.3	16	47.1
Converging	10	29.4	7	20.6
Total	34	100.0	34	100.0

X^2: 1,668 df: 3 p: .64

When Table 1 is examined, it is seen that the most common learning style among the experimental group students is the assimilating learn-

ing style at 35.3% (12), and the least common one is the accommodating learning style at 14.7% (5). In the same way, the most common style among the control group of students is the assimilating style at 47.1% (16), and the least common one is the accommodating learning style at 8.8% (3). Chi square analysis indicates that there is no significant difference between the two groups in terms of learning styles distribution.

Academic achievement pre-test results for students with different learning style within the same group

Levene statistics were used to test the homogeneity of the variance in relation to the pre-test, and the groups were found to be homogenous. Therefore, Kruskal-Wallis Test statistics were administered to pre-test scores to control the difference between the means of different learning styles as presented in Table 2.

Table 2.
Pre-test (Kruskal-Wallis Test) Results for within-Group Different Learning Styles

	Learning Styles	N	Mean Rank	Chi-Square	Df	Asymp. Sig
Experimental group	Accommodating	5	23.10	3.204	3	.361
	Diverging	7	13.79			
	Converging	10	19.20			
	Assimilating	12	15.92			
	Total	34				
Control group	Accommodating	3	7.50	4.395	3	.222
	Diverging	8	19.13			
	Converging	7	15.21			
	Assimilating	16	19.56			
	Total	34				

When Table 2 is examined, it is seen that there is no significant difference among the achievement scores of the experimental group students in terms of their learning styles ($p=0.361>0.05$). The same is true for the control group ($p= 0.222>0.05$).

Pre-Test Results for Different Learning Styles in the Groups

Table 3.
Academic Achievement Pre-Test (Mann Whitney U- Test) Results for Different Learning Styles in the Groups

	Comparison	N	Mean Rank	Sum of Rank	U	P
Within Learning Styles	Experimental group-Accommodating	5	5,70	28,50	1,500	,070
	Control group-Accommodating	3	2,50	7,50		
	Experimental group-Divergent	7	6,64	46,50	18,500	,266
	Control group-Divergent	8	9,19	73,50		
	Experimental group -Assimilating	10	9,30	93,00	32,000	,766
	Control group Assimilating	7	8,57	60,00		
	Experimental group - Converging	12	11,17	134,00	56,000	,059
	Control group - Converging	16	17,00	272,00		

As can be seen in Table 3, the Mann Whitney U-Test was used to analyze whether there are differences between students with the same learning styles from the different groups. This analysis revealed that there are no significant differences among the pre-test scores for learning styles (Accommodating, p=0.070> 0.050, Diverging p=0.266> 0.050, Converging p=0.059> 0.050, Assimilating p=0.766> 0.050). In short, the control group and experimental group students with different learning styles are equal in terms of pre-test academic achievement scores.

Findings concerning academic achievements of the students in the classrooms where BBL and a traditional teaching method were used are presented below.

Findings Concerning Inter-Group Post-Test Scores

In relation to the post-test, Levene statistics were used to test the homogeneity of the variances. The experimental group was found to be heterogenic, and the control group was found to be homogenous. The number of the students with different learning styles (for example, accommodators N=5, assimilators N= 12 etc.) prevents normal distribu-

tion from occurring. Hence, to control the difference among the means of different learning styles, the Mann Whitney U-test, which does not require the normality assumption, was used. The results of the analysis are presented in Table 4.

Table 4.
Mann Whitney U-test Results Concerning between-groups Academic Achievement post-test Scores

Groups	N	Mean Rank	Sum of Ranks	U	p
Experimental group	34	47.25	1606.50	144.500	.000
Control group	34	21.75	739.50		
Total	68				

The results of the Mann Whitney U-test presented in Table 4 show that post-test scores of the experimental group, where BBL was used, exhibited significant differences when compared to those of the control group taught with a traditional method (U= 144.500, p<.001). This finding indicates that the BBL approach is more effective in increasing students' academic achievement.

Findings concerning the post-test Scores for within-group Different Learning Styles

Table 5.
Post-test Kruskal-Wallis H-test Concerning the within-group Different Learning Styles

	Learning Styles	N	Mean Rank	Chi-Square	df	Asymp. Sig
Experimental group	Accommodating	5	16.10	1.565	3	.667
	Diverging	7	15.57			
	Converging	10	20.75			
	Assimilating	12	16.50			
	Total	34				
Control group	Accommodating	3	16.83	2.887	3	.409
	Diverging	8	12.56			
	Converging	7	20.36			
	Assimilating	16	18.84			
	Total	34				

The Kruksal-Wallis H-test was used to determine whether there are significant differences among the post-test scores for within-group different learning styles. When Table 5 is examined, it is seen that, in this respect, there is no significant difference in the experimental group [x (3) = 1.565, p=.667>0. 05]. The same is also true for the control group [x (3) = 2.887, p=.409>0.050]. Within-group different learning styles do not affect the academic achievement of the students in the group.

Findings Concerning the post-test Scores of the Students from Different Groups and with Different Learning Styles

Table 6.
Findings Concerning the Mann Whitney U-Test Results of Post-Test Scores of the Students from Different Groups and with Different Learning Styles

	Comparison	N	Mean Rank	Sum of Rank	U	P
Within Learning Styles	Experimental group-Accommodating	5	5.40	27.00	3.000	.174
	Control group-Accommodating	3	3.00	9.00		
	Experimental group Divergent	7	11.50	80.50	3.500	.004
	Control group Divergent	8	4.94	39.50		
	Experimental group -Assimilating	10	12.50	125.00	.000	.001
	Control group Assimilating	7	4.00	28.00		
	Experimental group - Converging	12	19.17	230.00	40.000	.009
	Control group - Converging	16	11.00	176.00		

The Mann Whitney U-test was used to determine whether there are significant differences between the post-test scores of the students from different groups but with the same learning styles. Apart from the accommodating learning style (U=3.000, p=.174>0.05), significant differences favoring the experimental group were observed for the post-test scores of Diverging (U=3.500, p=0.004<0.05), Assimilating (U=.000, p=0.001< 0.05), and Converging (U=40.000, p=0.009<0.05) learning styles.

Discussion and Conclusion

When the findings of the distribution learning styles sample groups of the present study are examined, it is seen that the most common learning style possessed by both the control and experimental group students is the assimilating learning style, and the least common one is the accommodating learning style. This finding concurs with the other studies based on Kolb learning styles (Aşkar & Akkoyunlu, 1993; Duman, 2006; Güven, 2004; Hasırcı, 2006; Kılıç, 2002; Stice, 1991)

According to the findings of studies conducted using the Kolb Learning Style Inventory, learning styles vary depending on individuals' majors (social sciences, natural sciences etc.) and occupations (Aşkar & Akkoyunlu, 1993; Kolb, Boyatzis & Mainemelis, 2001). Kolb, Wolfe, Fry, Bushe and Gish, (1981) suggest that there are disciplinary differences in learning styles. Moreover, Kolb suggests that learning styles are shaped gradually by individual experience. In addition, it is emphasized that people who are in the teaching profession mostly have an assimilating learning style (Aşkar and Akkoyunlu, 1993; Ergür, 1998; Hasırcı, 2006). The present study also reveals that the student teachers mainly have an assimilating learning style.

In order to assess academic achievement, the procedure below was followed. The experimental group students' academic achievement posttest scores were compared with those of the control group. BBL more significantly increased the students' academic achievement when compared to traditional teaching method. This finding concurs with the literature (Bowman, 2003; Brodnax, 2004; Caine and Caine, 1994; Caine, 2000; Caulfield, Kidd & Kocher 2000; Cengelci, 2005; Erlauer, 2003; Getz, 2003; Jeffrey, 2004; Jensen and Dabney, 2000; Özden and Gültekin, 2008; Wagmeister and Shifrin, 2000; Wortock, 2002).

When the planning, presentation and gains of the lesson are in compliance with the working principles of the brain, positive contributions can be made to students' motivation, attitudes, and academic achievement (Godwin, 2000; Jensen, 2008; Kotulak, 1997; Sousa, 2006; Wolfe, 2002; Zadina, 2004; Zull, 2002).

Within-group comparison of the academic achievements of the students with different learning styles found no significant differences among the academic achievements of the students in the same group but with different learning styles. This may mean that learning style differences do not lead to significant differences in academic achievement.

According to findings of other studies, learning styles-based teaching increases students' achievement but this increases does not vary depending on learning styles (Bielaczyc and Collins, 1999; Whicker, 2001; Williams, 1990, Gencel, 2008). There are some studies showing that there is no significant relationship between learning styles and academic achievement. Williams (1999) compared the effectiveness of not taking with mind maps with that of traditional not taking and found that there is no significant relationship between the dominance of hemispheres and the performance of the participants and learning styles and dominance of hemispheres. Somyürek and Yalın (2007) reported that there is no significant difference among the academic achievements as a result of a study investigating the performance of the field-dependent and field-independent learners in computer-assisted learning environment.

Between-groups comparison of the academic achievements of the students with different learning styles showed that, apart from the accommodating learning style, significant differences favoring the experimental group in the academic achievement levels of the students with diverging, converging, assimilating learning styles. This finding supports the idea that, where it is applied, BBL increases academic achievement in the classroom.

We can argue that the BBL model used in the present study provided an environment and process based on "the natural learning conditions of brain" for students with different learning styles. Carbo, Dunn and Dunn (1986), emphasize that BBL is a new approach to teaching applications related to learning styles. There are many studies demonstrating that matching teaching styles with learning styles has positive impacts on student achievement (Scales, 2000). Several studies have shown that the academic performance of university students is related to their learning styles. Arıpın et al., (2008), in their study investigating students' learning styles and academic performance, found that learning style is a significant factor in determining academic performance. It has been found that the learning styles of high school students have effects on the students' academic achievements by Matthews (1996). Pyryt, Sandals and Begoray (1995) have found that there has been a significant difference between learning styles of the students who have special needs and the ones who are gifted. The findings of McCarthy (1987) revealed that the students with accommodating and diverging learning styles are not successful enough. Studies by McCarthy (1987),

Currie (1995), Bilgin and Durmus (2003), Uzuntiryaki, Bilgin and Geban (2003), Kvan and Yunyan (2005), Demirbas and Demirkan (2007), revealed that academic achievement varies depending on learning styles. According to Kolb (1984), it is of great importance to provide students with activities complying with their learning styles. In this way, students can physically and intellectually participate in teaching process. Students' performances can be improved by organizing appropriate instruction to support more effective learning (Sims & Sims, 1995).

In the present study, the researcher observed that the students were in "psychological relaxation" and "physiologic security" during the activities carried out in line with the BBL approach. Indeed, the BBL model can be claimed to lead to "relaxed alertness" (Caine & Caine, 1994) and metacognition as it is built upon "multiple model and preferences" (Jensen, 2008). Recent BBL research states that diverse learners need differentiated strategies to accommodate a variety of learning styles for learning and reading (Green, 1999; Goswami, 2004; Pool, 1997; Slavkin, 2002; Sousa, 2006). BBL allowed the students to recognize what the features of their brain and learning styles were. Students who can recognize how they learn can immerse themselves into the content deeply. They can process the learning according to their understanding and construct meaning. Students who gain awareness of their learning styles feel both cognitively and affectively relaxed. This relaxation and awareness improves students' self-concept (Bandura, 1997) and increases their motivation. In line with this, Goleman (1995) emphasizes that a positive psychological mood serves the function of a successful catalyst in learning.

When the findings of the present study are examined, it is possible to argue that the BBL method and learning styles-based teaching increased students' academic achievement, but academic achievement does not vary much depending on different learning styles within the same group. The issue of whether there is significant correlation between academic achievement and learning styles is a controversial one; however, if we want our students to be successful, it is surely a good idea to use brain-compatible and integrated learning-teaching designs that can convert learning into a basic need.

Consequently, the most important implications of this study are that BBL made similar positive contributions to the academic achievement of the students with different learning styles. BBL used in the present

study made positive contributions to the achievement both in the integrated whole-class activities and teaching activities individualized according to different learning styles.

To increase the academic achievement levels of students with different learning styles at the same level, the design of the learning-teaching processes and environments should be modeled based on BBL. In the development of in-class activities and daily lesson plans, the findings of the present study investigating the effects of the BBL model can be capitalized upon.

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