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Brain Based Biology Teaching: Effects on Cognitive and Affective Features and Opinions of Science Teacher Trainees

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ABSTRACT

This study investigates the effectiveness of a brain based teaching approach on biology achievement, attitude, critical thinking disposition and self-efficacy scores of science teacher trainees. Also, science teacher trainees' opinions about brain based teaching were investigated. A mixed method approach was used in the current research and it was composed of two parts: Part A and Part B. Part A was comprised of a sample of 65 science teacher trainees and Part B was composed of nine science teacher trainees. The results of Part A revealed no significant effect of the teaching method on achievement, attitude, critical thinking disposition and self-efficacy scores. On the other hand, the results of Part B showed brain based teaching to some extent affects cognitive, affective and metacognitive features. This is similar to the results of some other studies. This study also indicated that various factors may affect students' cognitive and affective features besides the teaching method.

Keywords: Brain Based Learning; Pre-Service Science Teachers; Achievement; Attitude; Critical Thinking Disposition; Self-Efficacy.

INTRODUCTION

In the last 25 years, with the growth of neuroscientific knowledge, some scientists and educators are becoming increasingly aware of the benefits neuroscience is making in terms of the brain and its function when students learn (Howard-Jones, 2008). However contemporary opinions exist regarding the relationship between neuroscience and education - on the one hand, neuroscience is believed to have potential for solving many important challenges educators face and on the other hand, it is thought that neuroscientific knowledge is irrelevant to educators' understanding of learning. This debate continues to be discussed (Bruer, 1998; Geake & Cooper, 2003; Davis, 2004; Goswami, 2004; Howard-Jones, 2008; Bawaneh et al., 2012; Clement & Lovat, 2012). However it is clear that neuroscience provides additional data related to human learning and learning deficits. Therefore, educators can benefit from those data. However they should avoid direct applications of neuroscience findings to education since learning is related to several factors such as social, cultural and contextual (Mason, 2009).

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Leslie A. Hart synthesized the findings of many disciplines including neuroscience and proposed a theory known as the “Proster Theory” which is a brain based theory of human learning (Hart, 1981). Various researchers have taken her work as well as data of current neuroscience in order to develop methods and strategies that will complement the brain's natural development (Caine & Caine, 1990; Caine & Caine, 1995; Jensen, 2000; Prigge, 2002; Roberts, 2002; Willis, 2007; Nuangchalerm & Charnsirirattana, 2010; Hardiman, 2012). These researchers assisted educators in implementing brain based teaching strategies in the classroom. Caine and Caine (2002) define brain-based learning as “recognition of the brain’s codes for a meaningful learning and adjusting the teaching process in relation to those codes.” Therefore, instruction should be planned and organized so that it is respectful of the brain’s natural learning system and educators should know how the brain receives, processes, interprets, connects, stores and retrieves information (Greenleaf, 2002).

The aim in constructing a brain based classroom is to help students optimize the usage of their brain potential and learning during each lesson. This needs students to feel safe and also to be cognitively, physically and emotionally prepared to learn a given topic in the classroom, since research findings presented that environment, diet, teaching time, chronotype, amount/quality of sleep, music, colour, oxygen, temperature, humidity, movement, exercise, and water intake all affect the way our brain responds and learns (Taylor, 2007; Azevedo et al., 2008; Valdez, Reilly & Waterhouse, 2008; Wilmes et al., 2008; Kotsopoulou & Hallam, 2010). Therefore, teachers’ decisions on what, where and how much should be done in order to improve learning outcomes and achieve meaningful learning are important. The main goal in these decisions should be to create an enriched environment where all students can learn and develop. Therefore, brain based learning is closely related with the constructivist theory of learning which indicates learning is individual and unique (Cercone, 2006). However, teaching in higher institutions is still conducted without considering individual differences (e.g. learning styles and learning approaches) and is generally teacher-centred. This implies that current practices and instruction may in fact diminish or prohibit learning and its quality.

The quality of learning is closely related to students’ beliefs about their abilities, attitudes towards courses and how they accept the learning content (Enochs et al., 1995; Beşoluk & Önder, 2010; Brígido et al., 2012). In higher education students are expected to be good critical thinkers who can interpret, analyse, evaluate and criticise the content taught. Meanwhile, their judgments regarding their capabilities to execute a given type of performance should be positive since those judgments affect their effort, goals and commitment to learn (Bandura, 2006). In fact, brain based teaching can meet expectations of higher education since, in brain based teaching, students are encouraged not to limit their learning with the content provided, have creative thinking skills, criticise the information obtained, be aware of what they have learned and construct relations between the concepts so as to learn meaningfully (Bulut, 2014).

Several studies investigating the effectiveness of brain based learning indicated that teaching designed on brain based learning affects positively students’ cognitive and affective features, such as; conceptual understanding and learning motivation (Saleh, 2012), knowledge and practice of healthy behaviour (Banchonhattakit et al., 2012), academic achievement (Cengelci, 2007; Özden & Gültekin, 2008; Duman, 2010; Odabaşı & Celkan, 2010; Çelebi & Afyon, 2011; İnci & Erten, 2011; Aziz-Ur-Rehman et al., 2012; Oktay & Çakır, 2013) and attitude (McFadden, 2001; İnci & Erten, 2011; Şeyihoğlu & Yarar Kaptan, 2012; Yavuz & Yağlı, 2013). However, contrary to the aforementioned experimental studies McFadden (2001) and Yavuz and Yağlı (2013) indicated no significant differences in achievement scores when brain based methods were compared to traditional methods. Similarly, no significant reduction in anxiety was obtained when methods were compared in McFadden’s study.

Studies that explore the effectiveness of brain based learning on some cognitive and affective variables are generally conducted on primary and secondary school students. Few of these studies questioned the effect of brain based learning on university students and even less is longitudinal. Therefore the objectives of this long term study were 1) to investigate the effectiveness of brain based teaching on biology achievement, attitude, critical thinking disposition and self-efficacy scores of science teacher trainees, and 2) to find out their opinions about brain based teaching.

METHODOLOGY

A mixed method approach was used in the current research and it was composed of two parts: Part A and Part B. The research design of Part A was quasi-experimental with a non-equivalent control group pre-test-post-test design. The experimental group received instruction based on brain based learning while the control group was taught with conventional teaching. Part A lasted 14 weeks (one semester). Part B was conducted at the end of the Part A. In Part B a phenomenological approach was followed. Nine students from the experimental group of Part A were interviewed in order to capture their thoughts, feelings, and perceptions regarding the application of the experimental treatment and its effects. Semi-structured interviews were conducted and each interview lasted 25 to 30 minutes.

a) Sample

The participants in Part A were 65 sophomore elementary science teacher trainees enrolled in Elementary Science Teacher Education Programme at Sakarya University, Turkey. There were 30 students in the experimental group and 35 in the control group, all of whom were from a General Biology class. In the experimental group, 66.4% of the subjects were female and 33.4% male while in the control group, 71.4% of the subjects were female and 28.6% male. The mean age of the sample was 20.2 years (ranging between 19 and 21). The participants in Part B were nine sophomore elementary science teacher trainees. They were selected randomly from the experimental group of Part A. Five of the participants were female and four were male.

b) Procedure

Procedure of part A: Once the experimental and control group were defined, students in the experimental group received a four hour workshop about how the brain learns, what brain based learning is, what they were going to do in the biology course throughout the semester, their learning styles and learning approaches. Meanwhile, the importance of learning styles and approaches in teaching and learning were discussed. The biology course is a six hour compulsory course. Since the course was given by the same instructor, the course for the control and experimental group started at different times of the day. In the control group the course started at 10:00 a.m. and ended at 11:45 a.m. while in the experimental group the course started at 3 p.m. and ended at 4.45 p.m. in a three day of a week. One of the researchers thought out the course for both the experimental and the control groups. At the beginning of the research, researchers developed the materials, power point presentations, animations, models, laboratory activities and concept maps that were going to be used while teaching the course. Meanwhile photographs and music were chosen. Classical music without lyrics was chosen in order not to disturb the students' attention and to make the process more enjoyable and interesting (Brewer, 1995; Dosseville et al., 2012) since listening to music engages the entire brain (Jensen, 1998). Kolb Learning Style Inventory III and Revised Two Factor Study Process Questionnaire were administered before the study in order to determine students' learning styles and approaches and for arranging instruction and informing students (see Table 1).

Table 1. *Students Learning Styles and Learning Approaches*

Group		N	Learning Styles (f)				Learning Approaches (f)	
			Converger	Diverger	Assimilator	Accommodator	DA	SA
EG		30	4	12	3	11	23	7
	Female	20	3	7	2	8	16	4
	Male	10	1	5	1	3	7	3
CG		35	3	18	8	6	26	9
	Female	25	2	13	6	4	19	6
	Male	10	1	5	2	2	7	3

Note: EG: experimental group, CG: control group, DA: deep learning approach, SA: surface learning approach, N: number, f: frequency

Biology Achievement Test, Attitude Scale towards Biology, California Critical Thinking Disposition Inventory and Biology Self Efficacy Scale were administered as pre and post-tests to both groups before and at the end of the research. Below the teaching processes in both groups were summarised.

The students in the experimental group received instruction based on brain based learning. The instruction was designed mainly considering twelve principles and three elements mentioned by Caine and Caine (1990; 1995) for brain based learning. Meanwhile, instruction was conducted considering individual differences between students such as learning styles and learning approaches. Therefore, several activities, models, visuals and animations were included and students were free to study alone or in a group. In addition, students developed posters and PowerPoint presentations and they worked individually or as a group on a project they had selected. Also they performed open ended laboratory experiments. The lecturer was responsible for helping students concentrate on a subject and to help them when they needed support. Moreover, students were allowed to drink water and eat something while courses were occurring and were reminded of the importance of healthy feeding for learning from time to time.

In one of the lectures, for example, the lecturer started with an event he had experienced about plants and posed a question regarding photosynthesis (How the anatomy of leaves affects the performance of photosynthesis in various environmental conditions?). While students were working as a group the lecturer presented some visuals that would help them realise the problem and find some clues. Students searched on the internet, looked at the PowerPoint presentations prepared, watched videos explaining the photosynthesis and read their books in order to provide an answer to the question. While students were working, a lecturer supported each group and joined groups as one of the group members in order to observe the process and help groups. Then answers from each group were gathered and discussed. After the discussion the lecturer asked them to design and then conduct an experiment that would help students to understand better the answer to the question they had just discussed.

The students in the control group received conventional teaching in which the course was mainly taught by lecturing. Major concepts (photosynthesis, immunity, reproduction, blood circulation, respiration, excretion etc.), equations, and definitions were presented by the lecturer and students were asked to take notes while listening to the lectures. The laboratory activities were designed as closed-end experiments.

Procedure of part B: Each of the nine science teacher trainees (STT) was interviewed separately and all interviews were video-recorded. The duration of the interviews varied from 25 to 30 minutes. Then, the interviews were transcribed and these transcripts were checked by comparison with the video-recordings. The data were analysed by following a qualitative content analysis approach. The researchers individually decided on categories and themes based on careful reading of the nine records. The classification of the data among the researchers was reviewed and the reasons for the classification were discussed during a one hour meeting. In the case of inconsistencies in classification among the researchers, agreements and disagreements were discussed until consensus was achieved.

c) Instruments

Data collecting tools that were used for informing students and arranging instruction before the study are presented below.

Revised two factor study process questionnaire: The Revised Two-Factor Study Process Questionnaire (R-SPQ-2F) which was developed by Biggs, Kember and Leung (2001) and was adapted into Turkish by Önder and Beşoluk (2010) was used to measure the students' approaches to learning. It is a 20-item Likert-type instrument with deep and surface approach scales. The total score in each scale ranges from 10 to 50. The test retest validity was reported as 0.60.

Learning style inventory: Learning style preferences were determined using the Kolb Learning Style Inventory III (KLSI-III) which was developed by Kolb (1999). This scale was adapted into Turkish by Evin Gencel (2006). The scale contains 12 items. The total score in the scale can range between 12 and 48. The internal consistency coefficients reported for the sub-scales in the adapted version were changing between 0.71 to 0.84.

Data collecting tools that were used in Part A and B of the study are presented below.

Biology achievement test: The Biology Achievement Test was developed by the researchers of the study. This test was administered to both experimental and control group students as a pre and post-test. The test was composed of 61 multiple choice questions related to the biology concepts they will study throughout the semester. The test contains items related to Embryonic Development, Nervous System, Hormone System, Reproductive System, Circulatory System, Respiratory System, Excretory System, Immune System and Digestive System. In order to establish whether the content universe addressed by the test is appropriate, the test was judged by two experts in biology teaching. They have indicated that the test adequately samples the intended universe which is an evidence of content validity. The internal consistency of the test was 0.73 and a Split-half reliability coefficient was 0.75.

Attitude scale towards biology: This scale was developed by Geban et al. (1994) and was adapted to the Biology course by Özatlı (2006). It was used to measure students' attitudes towards Biology as a school subject. The scale contains 15 items in 5 point Likert-type scale. The internal consistency coefficient of the scale was reported as 0.92. The Cronbach's α for the scale of the current study was 0.89 and .86 in pre and post administrations respectively.

California critical thinking disposition ınventory: Critical thinking dispositions were measured by the California Critical Thinking Disposition Inventory (CCTDI) developed by Facione, Facione and Giancarlo (1998). This scale was adapted into Turkish by Kökdemir (2003). The original scale contains 75 items, however the adapted scale contains 51 Likert-type items. The adapted scale consisted of six sub-scales which are; analyticity, open-mindedness, inquisitiveness, self-confidence, truth-seeking and systematicity. In CCTDI a score with marks above 300 indicates a positive overall disposition towards critical thinking. Kökdemir (2003) found an overall alpha coefficient of 0.88, with 0.61 to 0.78 on the sub-scales. In the present study, the Cronbach's alpha of the CCTDI was 0.83, and for the sub-scales was 0.55 to 0.81.

Biology Self Efficacy Scale: Self-efficacy scores of the students were determined by the "Biology Self Efficacy Scale" which was developed by Woo (1999) and was adapted into Turkish by Ekici (2009). The scale was composed of 40 Likert-type items and three sub-scales. The total score of the scale can range between 40 and 200. The reliability constant reported for the scale was 0.94. In the present study, the Cronbach's alpha of the scale was 0.89.

Semi Structured Interviews: Semi-structured interview questions developed by researchers were used to collect data on elementary science teacher trainees' thoughts, feelings, and perceptions regarding the application of the experimental treatment and its effects. A semi-structured interview method was chosen since it allows for the obtaining of rich and varied data. The following are the main interview questions used:

1. Which factors do you think were remarkable in the teaching and learning process of this course? Please explain.
2. How were you affected by this teaching and learning process? Please explain.

FINDINGS

Part A

One way ANCOVAs were performed on whether differences existed between the two groups on achievement, attitude, critical thinking disposition and self-efficacy scores. Pre-tests were treated as a covariate in order to partial out their effects on each analysis. Adjusted means and standard deviations of post test scores for experimental and control groups are given in Table 2.

Table 2. *Descriptive Statistics of the Achievement, Attitude, Critical Thinking Disposition and Self-Efficacy Scores*

Group	N	Achievement	Attitude	Critical Thinking Disposition	Self-Efficacy
		Adjusted M ± SD	Adjusted M ± SD	Adjusted M± SD	Adjusted M ± SD
EG	30	56.60±11.75	56.37±8.79	194.53±16.54	102.56±13.57
CG	35	58.36±9.44	56.34±8.31	191.00±15.88	102.57±15.40

Note: M: Mean, SD: Standard deviations

The results of ANCOVAs that were utilised to analyse whether there is a significant difference or not are given in Table 3.

Table 3. *ANCOVA Results of Achievement, Attitude, Critical Thinking Disposition and Self-Efficacy Scores*

Factors	Source	SS	df	MS	F	p
Achievement	Covariate (pretest)	2235.93	1	2235.93	28.90	.00
	Group	45.21	1	45.212	0.58	.45
	Error	4795.82	62	77.35		
	Total	222849.00	65			
Attitude	Covariate (pretest)	1571.43	1	1571.43	32.26	.00
	Group	54.14	1	54.14	1.11	.29
	Error	3019.41	62	48.70		
	Total	211015.00	65			
Critical Thinking Disposition	Covariate (pretest)	2909.77	1	2909.77	13.26	.00
	Group	33.17	1	33.17	0.51	.69
	Error	13601.68	62	219.38		
	Total	2428643.00	65			
Self-Efficacy	Covariate (pretest)	1836.46	1	1836.46	9.83	.00
	Group	52.04	1	52.04	0.27	.59
	Error	11573.46	62	186.66		
	Total	697239.00	65			

Note: SS: Sum of Squares, df: Degrees of freedom, MS: Mean Square

Results of ANCOVAs performed indicated a non-significant group difference in achievement ($F_{1,62}$= 0.585, p > .05) and attitude ($F_{1,62}$ = 1.112, p > .05). Similarly, there were no significant differences between groups on critical thinking disposition ($F_{1,62}$ = 0.151, p > .05) and self-efficacy scores ($F_{1,62}$ = 0.279, p > .05).

PART B

During qualitative data analysis three main themes were developed: "Teaching Materials", "Outstanding Factors", and "Attention to Physiological Needs" regarding the teaching and learning process. Meanwhile four main themes were developed: "Affective Domain", "Metacognitive Awareness", "Cognitive Skills", and "Habits" regarding the effect of the experimental treatment. Tables 2 and 3 show the frequency and percentages of science teacher trainees for each category of beliefs, based on their responses. Below each table narrations and quotations were provided to explain the meaning of each theme in relation to the study aim.

Table 4. *Science Teacher Trainees' Opinions about Remarkable Things in Teaching and Learning Process*

Codes	Themes	f	%
PowerPoint presentations	Teaching Materials	7	33.4
Videos		5	23.8
Posters		4	19.0
Animations		3	14.3
Pictures		2	9.5
Total		*21*	*100*
Music	Outstanding Factors	7	28.0
Enjoyable activities		6	24.0
Open-ended experiments		5	20.0
Friendly atmosphere		2	8.0
Increased workload		2	8.0
Learning by discovery		1	4.0
Mutual interaction		1	4.0
Boring course		1	4.0
Total		*25*	*100*
Water	Attention to Physiological Needs	3	33.4
Feeding		2	22.2
Oxygen		2	22.2
Sleep		1	11.1
Lighting		1	11.1
Total		*9*	*100*

As it can be seen in Table 4, science teacher trainees mostly mentioned some experiences they had in the teaching and learning process (outstanding factors) and teaching materials as remarkable factors of the course. Meanwhile, some of them also stated the importance of paying attention to physiological needs. In considering teaching materials, science teacher trainees generally indicated visual elements such as PowerPoint presentations, videos and posters. For example, two of them gave the following explanations in the interviews:

"STT2: ...especially presentations, I mean PowerPoint presentations were remarkable. We saw how the things were in reality in the presentations and videos"

"STT7: The posters were attractive and fairly interesting for me and the videos were useful in visualisation of things."

Music, enjoyable activities and open-ended experiments emerged as the main outstanding factors from the interviews. Regarding music some of the participants presented positive feelings, however negative and neutral feelings were also stated. Some quotations from interviews were presented below:

"STT5: Music helped me to gather my attention and concentration and motivated me."

"STT4: Music actually everybody says is positive but in fact it was not positive for me, rather I was distracted. I think I cannot do two things at the same time. Frankly, both listening to music and the lesson was not favourable for me."

"STT8: To be honest, music did not affect me either positively or negatively..."

"STT6: It was more effective to do open ended laboratory experiments since we were discovering. Seeing things was more impressive…"

Also, water, feeding and oxygen were generally mentioned as physiological needs that are considered in the teaching and learning process. They gave the following explanations in the interviews:

"STT7: ...the instructor reminded us every time and said that if you're hungry, eat something because when you feel fear or you are hungry or you are nervous you and your learning will be affected. For example, low oxygen also affects you therefore these all helped me to pay attention to them…"

"STT2: In addition, the relaxation of the brain requires a certain level of oxygen to be in the environment. Therefore, during our courses we opened the windows in the classroom and paid attention to our environment so as to have enough oxygen…"

Table 5. *Science Teacher Trainees' Opinions about How They were affected by the Teaching and Learning Process*

Codes	Themes	f	%
Increase in motivation	Affective Domain	5	35.7
Increase in interest		5	35.7
Increase in attention		2	14.4
Increase in attitude		1	7.1
Distracted attention		1	7.1
Total		*14*	*100*
Recognising how the brain works	Metacognitive Awareness	5	55.5
Recognising his/her own learning style		3	33.4
Recognising his/her own deficiencies		1	11.1
Total		*9*	*100*
Ability to relate their knowledge to daily life	Cognitive Skills	6	66.7
Increasing problem solving skills		1	11.1
Increasing critical thinking skills		1	11.1
Increasing research skills		1	11.1
Total		*9*	*100*
Difficulty in note taking	Habits	2	33.3
Sustain his/her own study habits		2	33.3
Sustain his/her own learning habits		1	16.7
Not preparing for the course		1	16.7
Total		*6*	*100*

According to Table 5, science teacher trainees' opinions mainly focused on Affective Domain, Metacognitive Awareness and Cognitive Skills. Meanwhile, in some views, effects on habits were indicated. In affective domain, science teacher trainees generally mentioned an increase in motivation, interest and attention. For example, some of them said that:

"STT7: So, what we did in the course helped me to give my attention to the lessons, and so I was more interested in the course."

"STT8: I always loved biology and loved it even more this semester…"

"STT6: ...different activities in the course helped me to be more motivated."

With respect to Metacognitive Awareness, interview results indicated that some trainees recognised and presented their positive feelings on understanding how the brain works. Two of them said that:

"STT2: ...in some activities I have realised that the things that we were doing were in parallel with how the brain works and I also understand better how the brain works..."

"STT3: For example, I have realised that I am learning better with visual representations and therefore, I started to give more weight to visuals. For example, I started watching videos about biology; in order to understand the subject better. Also, I bought magazines related to living things."

For Cognitive Skills, science teacher trainees' opinions were mainly concentrated on the ability to relate their knowledge to daily life; on the other hand, few opinions were centred on an increase in problem solving skills, critical thinking skills and research skills. Some quotations were presented below:

> *"STT5: For example, I can now relate biology to problems I have faced, so I can say that this is the case or as follows now."*
>
> *"STT4: ...for example when someone has a headache or an event occurs, I can provide some suggestions and relate it to daily life.*

Finally it is interesting that science teacher trainees resist changing their habits. They still indicated that they have difficulty in note taking, sustaining their study and learning habits and preparing for the course. For example one of them gave the following explanations in the interview:

> *"STT4: I sometimes felt as if I had lost the connection with the lesson while trying to take notes…"*
>
> *"STT5: It was nice to know how the brain works, but I did not change my way of working"*
>
> *"STT3: … learning how one learns was good, but I continued in the same way, so I did not change my learning style."*

DISCUSSION and CONCLUSION

In the current study the effectiveness of brain based teaching on achievement, attitude, self-efficacy and critical thinking dispositions was investigated and no significant effect of the teaching method on achievement, attitude, critical thinking disposition and self-efficacy scores was found. It is an unexpected result to obtain no difference between groups with respect to self-efficacy and attitude scores since brain based education was more student centred. In fact, some studies presented positive effects of brain based education to attitude scores (McFadden, 2001; Yavuz & Yağlı, 2013). On the other hand obtaining no difference in critical thinking disposition scores can be explained to some extent. Although one of the goals of university education is to improve students' critical thinking dispositions, recent studies indicated that university students' critical thinking scores are generally low (Guest, 2000; Van Gelder, 2005; Beşoluk & Önder, 2010) and resistance to using critical thinking is prevalent among higher education faculties (Paul 1990). In the faculty where the research was conducted, courses are generally taught by the lecturing method and the content presents little chance for students to discuss topics so as to enhance their critical thinking dispositions. On the other hand, qualitative results showed that brain based teaching has an effect on affective, cognitive and metacognitive variables of some science teacher trainees. Changes indicated in the affective domain were high compared to other themes. This is contrary to the quantitative results of this study. However, in quantitative analysis group means are used which may in turn hinder to observe the variation in scores individually. Therefore, if we consider both quantitative and qualitative results, we can say that brain based teaching may have an effect on the affective, cognitive and metacognitive domain, and this effect may be different with each individual.

Similar to the results of this study, McFadden (2001) found no significant difference in achievement and reduction in maths anxiety when traditional and brain based teaching methods were compared. Yavuz and Yağlı (2013) also found no significant difference in achievement scores of students who received brain based teaching and conventional teaching. However, qualitative results of the current study and several other studies have found brain based teaching to affect cognitive and affective features (Özden & Gültekin, 2008; Duman, 2010; İnci & Erten, 2011; Aziz-Ur-Rehman et al., 2012; Banchonhattakit et al., 2012; Saleh, 2012). Those studies indicating the effectiveness of brain based teaching on students' achievements are generally conducted in primary or secondary schools. As the age of students increases, it becomes harder to change students' learning and studying habits. Qualitative results of the study support this argument. Therefore, adaptation of university students to new teaching methods becomes difficult. Moreover, Ioakimidis and Myloni (2010) indicated that culture plays an important role and unintended results can occur if instructors employ teaching methods which violate the cultural expectations of students. In countries like Turkey where generally the masculine culture is dominant, students feel most comfortable in structured learning situations where clear objectives, detailed assignments, and strict timetables exist and they expect expert teachers who can answer all the questions. Therefore, it is difficult to develop learner autonomy and the students' ability to learn on their own since it requires them to change their ideas about the teachers' and students' roles in the education process and examine their learning and study habits. One of the reasons for obtaining no effect from the teaching method may result from this fact.

The students in the experimental group took five courses as well as Biology while the study was conducted. They received brain based teaching just in the Biology course, however, in other courses mainly conventional teaching was used by instructors. This could make it difficult for students to change their learning and studying habits and therefore, they probably have had difficulty in adapting to this new environment and teaching. Therefore, the effect of brain based education might be masked by the teaching methods used in other courses. To get more reliable results, brain based education should be conducted in most of the courses. Moreover, in order for students to achieve the maximum benefit from brain based education, they should arrange their life styles, feeding habits, water intake, sleep schedule, study habits etc. Therefore, to help students in arranging these habits, the structure and policy of educational institutions should be designed or arranged in a way that supports brain based education.

The students in both the experimental and the control group received instruction from the same academician and the course schedule was different. In the control group the biology course started at 10:00 a.m. and ended at 11:45 a.m., while, in the experimental group, the course started at 3 p.m. and ended at 4.45 p.m. on three days of the week. Therefore, the results may also have been affected from teaching time because the classes met at different times of the day. The experimental group started the course at a time considered to be a "low" time of the day for the brain to be working (Jensen, 1996). Moreover, students learning and achievement depends on many factors (Fraser et al., 1987; Beşoluk, 2011; Teodorović, 2012) including; methods of instruction, teaching materials, motivation, learning approach, learning styles (Beşoluk & Önder, 2010), anxiety, sleep (Drake et al., 2003), the quality of teaching/teachers, teaching time (Beşoluk & Önder, 2011), achievement goals (Gherasim et al., 2013), chronotype (Beşoluk, Önder & Deveci, 2011), feeding habits (Rampersaud et al., 2005), self-discipline (Duckworth & Seligman, 2005), intelligence, thinking styles (Fabbri et al., 2007), lifestyle regularity (Randler & Frech, 2006), physical condition of learning environments, cultural and social factors (Teodorović, 2012).

As a conclusion, we did not find any statistically significant difference in dependent variables of the study although qualitative results presented some positive aspects. However, knowing that many factors such as culture, school structure, course schedules, age and gender may affect research variables and these effects change individually which may mask the effect of the teaching method, considering both quantitative and qualitative results, we can conclude that brain based teaching may affect some of the teacher trainees' cognitive and affective features.

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