

# **A review on learning styles and critically thinking disposition of pre-service science teachers in terms of miscellaneous variables**

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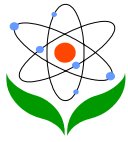
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## **Abstract**

The present study was carried out in order to review learning styles and critical thinking disposition of pre-service science teachers in terms of sex, grade and age,



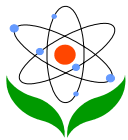
and to address the relationship between their learning styles and critical thinking disposition. It used Kolb's Inventory of Learning Styles and California Scale of Critical Thinking Disposition. The study found that total scores of learning styles and critical thinking disposition of pre-service science teachers were not statistically significantly different in terms of their sex, grade and age groups. It was also found that the pre-service teachers mostly preferred divergent learning style (43.3%) followed by the assimilator learning style (33.0%) and that they least preferred the accommodative (13.0%) and convergent (10.6%) learning styles. Furthermore, it was determined that there was a low level of positive relationship between learning styles and critical thinking disposition for the pre-service science teachers, a low level of negative relationship between learning styles and critical thinking disposition for those with divergent learning style, and a low level of statistically significant relationship between learning styles and critical thinking disposition for those with accommodative learning style.

**Keywords:** Pre-service science teacher, Learning style, Critical thinking disposition.

## Introduction

Recently, how students think and how they learn have been among the discussed topics in the educational system. Especially, in our modern age of "Information Society", the opinion that individuals should be able to know and implement several thinking methods such as ability to conduct research, to solve problem, creative thinking, and critical thinking, and should be active in process of learning has brought the subjects of how thinking and learning would be performed into prominence (Güven and Kürüm, 2006). Renzulli and Dai (2001) determined that the individual's knowing how to learn made the first step to learn better or to be active in the process of learning. In this regard, an individual knowing how to learn might be defined as one who knows his own features, or in other words, his own "learning style". When this is reviewed in terms of thinking, how the individual should think gains importance rather than what he will think and this view reveals the concept of critical thinking.

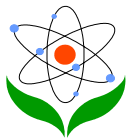
One of the most important concepts expressing individual difference is the concept of learning style. Kolb (1981) defined the learning style as the individually most preferred way in gaining and processing information. Having many studies on



learning style, Dunn and Dunn (1993) viewed the learning style as a way beginning with an individual concentrating on new and challenging information and continuing with the process of gaining the information and allocating it in the memory. Furthermore, each individual has own learning style just like he has a distinct fingerprint. According to Keefe (1979), learning style is defined as a pattern of cognitive, auditory and physiological features indicating how individuals perceive, how they interact with, and how they react to their learning environment.

Considering the above definitions, one can briefly say that learning style is a concept indicating tendencies of the individual to learn or his preferences. Numberless studies have been conducted on the concept of learning style which emerged in 1940s and many models of learning style have been developed. According to Gregorc's model of learning style (1998; in Ekici 2003), individuals' ideas on nature of learning begin with their life philosophy. Fundamental objective of the life is an individual's to perform and understand basic humanity features, spirituality and individuality. Capacities to perceive, arrange, take over and make associations being helpful in an individual's learning are the most skills in his learning. Thus, learning styles are divided into four categories as concrete consecutive, abstract random, concrete random and abstract consecutive. Model of learning styles developed by Dunn and Dunn (1992) was built on the theory that each individual was distinct in his biological and developmental features and emphasized four learning styles. These learning styles may include environmental factors (noise, light, heat and sitting position), emotional factors (motivation, determinateness, responsibility, structure), sociological factors (working alone or with groups of several sizes, working with peers or an authority), and physical factors (auditory, visual, tactile or kinesthetic perceptual preferences, requirements for food and drinks, energy level, requirement for change).

Kolb's learning style, or so-called experiential learning model is based on learning model put forward by Jung 1923. Being inspired by Jung's learning model, Kolb put forward experiential learning model (In Mutlu and Aydogdu, 2003). Developed by Kolb (1984), the "Experiential Learning Model" was built on the view that experiences had a significant role in learning process and the information was formed by form changes in the experiences. Experience has been defined as individual's objective and subjective interaction with his environment. According to this theory, the ideas are not constant and non-changing factors and they may be formed again for several times by experiences. In developing his theory, Kolb was

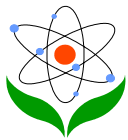


aspired by learning theory of Lewin and Piaget and considered experiences, perception, cognition and behaviors as critical factors in learning process.

According to Kolb, effective learning consists of four stages. These include an individual's encountering concrete experiences (Concrete experience) (CE), making observations about these experiences and process of reflecting them (Reflective observation) (RO), then developing abstract concepts from these reflections (Abstract conceptualization) (AC), and lastly, transferring evaluations and generalizations on these concepts to his active experiences (Active Experimentation) (AE). Askar and Akkoyunlu (1993) noted that learning ways symbolizing each learning style were different from each other, and explained that these were "by feeling" for concrete experience, "by observing" for reflective observation, "by thinking" for abstract conceptualization, and "by doing" for active experience, respectively.

According to the experiential learning theory, learning is a cycle and it is inevitable for an individual to pass through this cycle for many occasions in his learning process. Learning style of each individual is a product of these four learning styles. Coupled points reveals an individual's different preferences ranging from abstract to concrete and from active to reflective. Components of these two groups of different learning styles form basis for Kolb's two-dimensional learning style. Coupled points indicates in which category of learning style an individual is. These learning styles are as follows: Product of learning styles of Concrete Experience and Reflective Observation, **Divergent**; Product of learning styles of Reflective Observation and Abstract Conceptualization, **Assimilator**; Product of learning styles of Abstract Conceptualization and Active Experience, **Convergent**; and Product of learning styles of Concrete Experience and Active Experience, **Accommodating**.

Individuals adopting divergent learning style are very successful in viewing concrete situations from many perspectives, prefer making observations rather than taking action for the events, and enjoy concentrating on situations in which different ideas are generated and communicating people. They are patient, objective and careful in learning process, like group works and taking individual feedbacks but they don't prefer discussing on the topic and activities toward implementation. They are also skillful in focusing on ideas and linking several ideas such as in brain-storm. They consider their own feelings and ideas in forming the ideas. Descriptive question for these individuals preferring individual working in



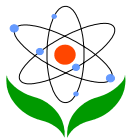
learning activities is “Why”. Such students explain lesson materials and experiences by linking them with their interests and future occupation (Kolb 1984; Jonassen and Grabowski 1993; Felder 1996; Riding and Rayner, 1998).

Individuals with assimilator learning style are very skillful in understanding wide variety of information and building theoretical models by unifying them. They prefer focusing on abstract ideas and concepts rather than people, and thus they focus on logic validity of such a theory instead of its practical value in learning style. They like lessons in which straight explaining is utilized, prefer that they are given enough time to assimilate the topic and don't like the exams they are not used to. However, among the most important features of the individuals adopting assimilator learning style are ability to think, and awareness on values and meanings. Such individuals focus on abstract concepts and ideas when they learn something. Descriptive question for such individuals is “What”. Information presented to such individuals should be ranked, logical and detailed. They prefer visual and auditory presentations and lesson narrations (Kolb 1984; Jonassen and Grabowski 1993; Felder 1996).

Implementing the ideas and theories is privileged for the individuals adopting convergent learning style. Furthermore, such individuals are very successful in problem solving, decision making, logical analyze of the ideas and systematical planning. Such people are more successful in the situations in which only one correct answer exists or only one way exist for solving a particular problem. The individuals adopting this learning style should focus on understanding emotions, ideas and values of others by playing more role in the activities they participate. They prefer simulation, laboratory experiments and practice in learning process instead of group working and activities of discussing type.

Problem solving, decision making, logical and systematical analysis of the ideas are main features of the individuals with diverging learning style. Diverging people pay importance to the details and try to comprehend the whole from the parts. They follow the steps in the learning activities by order. Descriptive question for such individuals is “How” (Kolb, 1984; Jonassen and Grabowski, 1993; Felder, 1996; Riding and Rayner, 1998).

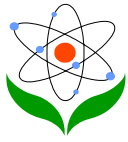
Individuals with accommodative learning style have ability to learn the information by doing and experiencing. They enjoy planning, conducting experiments and participating in new experiences. They are more courageous in taking risk than



individuals adopting other learning styles. In the process of problem solving, they like to produce solution ways by considering others' ideas rather than making some types of technical analyses. In the learning process, they prefer working with others, making field studies and testing different approaches in completing a project and conducting duties and projects in which they can take their own initiative. Additionally planning, implementing the decisions and participating in new experiences are obvious characteristics of the individuals with accommodative learning style. They enjoy learning by searching, exploring something. In other words, they prefer a learning style based on implementation and exploration. Descriptive question for such individuals is "What will be if ...." (Kolb, 1984; Jonassen ve Grabowski, 1993; Felder, 1996).

According to Kolb (1985), preferences of an individual in learning process causes that individual to adopt a particular learning style in long-term. For an individual, having a learning style that he adopted and in which he feels comfortable doesn't mean that he wouldn't be successful in other learning styles. In contrast, a student who is more flexible in passing from a learning style suitable for his own structure and features to another one can more efficiently utilize his learning potential than another student restricted himself with a particular thinking and learning style. Kolb states that the model he proposed could be effectively used in class-room education, group activities, project preparing and planning the exams.

Reviewing the studies using Kolb's Learning Style Inventory, one can see that many experimental and relational studies have been carried out. Experimental studies on this topic rather looked at whether educational situation were arranged based on learning styles and had impact on academic success. The relational studies looked at relationships between learning styles and several variables (Yoon, 2000; Ergür, 2000; Fowler, 2002; Kiliç, 2002; Loo, 2002; Mutlu and Aydogdu, 2003; Kiliç and Karadeniz, 2004; Kaf Hasirci, 2006; Demirbas and Demirkan, 2007; Joy and Kolb, 2009; Ertekin, Dilmaç and Yazici, 2009; Pehlivan, 2010). For example, the study by Bahar and Sülün (2011) examined learning style of the pre-service science teachers based on their sex and academic success. The study found that 39.7% of the students had divergent learning style, 34.2% had assimilator learning style, 15.2% had convergent and 10.9% had accommodative learning style. It was found that there was no relationship between sex and learning style. In their search on students of Education Faculty Bahar, Özen and Gülacti (2009) concluded that learning style of the students didn't vary significantly depending on sex. It was also

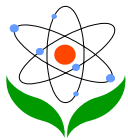


found that most of the pre-service teachers (43.6%) had divergent learning style followed by assimilator learning style.

Another important concept expected from the individuals to gain and being as important as the learning styles is “critical thinking” requiring high level of cognitive skills and defined as complicated and comprehensive process.

Presseisen (1985) considers the thinking skills in four stages as “basic operations, problem solving, decision making, critical thinking and creative thinking”. Skills of critical thinking, which are one of these stages, is briefly summarized as solving the expressions, noticing un-expressed thoughts, noticing the feelings and seeking different ways to express the ideas. According to Facione (1998), critical thinking is a solution and thinking system in which an individual would use in understanding he encounters in his environment, in identifying and trying to solve the problems he experiences, in decision making, and in evaluating the events. Kökdemir (2003) defines critical thinking as an effective, organized and functional cognitive process we perform in order to improve our ability to better understand our own and others’ ideas and to explain them. Ennis (1986) notes that the individuals who are able to think critically should have skills of flexibility, patience, acting by thinking, good intentions, autonomy, and independence. These skills make basis of training of critical thinking as well. Critical thinking and the skills required by it are emphasized in many studies on education and even among the objectives of education (MEB, 2006).

Noting that critical thinking is based on the skills and tendencies of effectively gaining and utilizing the information, Demirel (2002) states that critical thinking has 5 basic domains as “consistency, unifying, feasibility, adequacy and ability to communicate”. Consistency is related to awareness of an individual who can think critically on conflicts in the ideas and his ability to remove them whereas unifying domain is related to ability of an individual to make connections among different dimensions of the idea. Based on feasibility domain, an individual who can think critically must implement his ideas on a model. Adequacy means ability of an individual who can think critically to built his experiences and the outcomes he reached on realistic bases. In the domain of ability to communicate, an individual who can think critically should be able to share his ideas in an understandable way through an efficient communication.

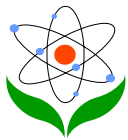


Recently, the concept of critical thinking has taken part in skills in primary school curriculum and become topic of many studies with increasing interest paid to it. By the means of healthy communication in the community, it has become mandatory to put this concept in the educational curriculum because of importance of throw up individuals not accepting the events as they are and querying and searching them. Teaching this skill and throwing up qualified persons for the community is responsibility of the teachers. In order to throw up qualified people to accommodate the changing world, the teachers must be those individuals having such knowledge and skills. During their training period, the teachers are anticipated to have these skills to improve them. Thus, it becomes important to determine what level of skill the pre-service teachers have to provide the students with this skill of critical thinking.

When the studies in the literature is reviewed, it is usually seen that the studies are usually focused on measuring the disposition of the pre-service teachers to think critically and searching this skill in terms of several variables (Facione, Facione and Giancarlo, 2000; Giancarlo and Facione, 2001; Akbıyık, 2002; Rudd and Moore, 2003; Kökdemir, 2003; Phillips, Chesnut and Rospond, 2004; Hamurcu, Günay and Akamca Özyılmaz, 2005; Özdemir, 2005; Semerci, 2006; Kirişçiöğlü, Başdaş and Başöncül, 2007; Tümkaya and Aybek, 2008; Genç, 2008; Saçlı and Demirhan, 2008; Korkmaz, 2009; Ekinci and Aybek, 2010). For example, in the study in which the university students' disposition to think critically was examined, Özdemir (2005) concluded that pre-service teachers were at intermediate level in terms of critical thinking and their disposition to think critically didn't show significant differences by sex. Genç (2008) concluded that disposition of pre-service teachers to think critically exhibited significant differences in domains of open-mindedness and curiousness by their sex. Exploring the differences between sexes in topic of disposition to think critically, Facione, Giancarlo, Facione and Gainen (1995) found that female students were predisposed to be open-minded and to be mature cognitively much more than male students whereas male students were more predisposed to think analytically than female students.

In terms of human qualifications aimed by the information society, it is known that learning and thinking are two concepts supporting and completing each other. In this regard, one could say that concepts of learning style and thinking critically are important in terms of being a student able to query and making causal relationships (Güven and Kürüm 2008). In fact, the studies carried out so far reveals that a relationship exists between learning styles and thinking critically (Campell and



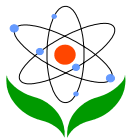


Davis, 1988; Torres and Cano, 1995; Colucciello, 1999; Myers and Dyer, 2006; Suliman, 2006; Güven and Kürüm, 2006; Güven and Kürüm, 2008; Tümkaya, 2011). For example, in a study by Toress and Cano (1995) on last grade university students, the relationship between thinking critically and age, sex, and academic success contributing thinking process apart from learning styles was examined. Based on results of the study, it was noted that there was a positive relationship between critically thinking and learning styles. Again Coluciello (1999), in a study on nursery students, aimed to determine whether a relationship exists between disposition to think critically and learning styles. In that study in which California Scale of Disposition to Critically Thinking and Kolb's Inventory of Learning Styles, it was found that there was a relationship between learning styles and disposition to critically think. In another study carried out by Güven and Kürüm (2008) to determine the relationship between the pre-service teachers' learning styles and disposition to think critically, California Scale of Disposition to Critically Thinking and Kolb's Inventory of Learning Styles were used. Based on results of the study, it was determined that there was a relationship between the pre-service teachers' learning styles and disposition to think critically. In a study to examine the science students' learning styles and disposition to think critically, Tümkaya (2011) used California Scale of Disposition to Critically Thinking and Kolb's Inventory of Learning Styles. The study concluded that total points of skills of critically thinking of the science students didn't show significant differences by sex and grade. Additionally it was found that 52.6% of the students had assimilator learning style and 29.4% had divergent, 10.5% had convergent and 7.5% had accommodative learning style.

## **The importance of the study**

In regard to current objectives of the schools, students are being tried to throw up who not only think but also think differently and not only memorize the knowledge but also look for the most suitable learning style for themselves among wide variety of learning styles. As a consequence of this, search on such topics as especially how the students think and how they learn has gained importance in recent years.

Science education given to the people born into and grown in a continuously developing world and society and whose interest to science lasts for entire lifespan constitutes an important part of science education continuing for life. In this context, science education should continuously be improved in order to prepare the human

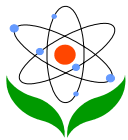


source required by the modern era. This is possible especially by means of improving qualification of the teachers, the most important factor of the educational process (Kaptan 1999).

A qualified teacher is an individual able to improve success of his students and having deep and wide field knowledge, field education, knowledge and skills. Additionally, the teachers are individuals who effectively utilize these skills they have in simplifying, making loveable and directing learning process in order to provide an effective learning environment. In order for the teachers to utilize knowledge, skill and abilities in educational environment, their cognitive features become important. Thus, critically thinking is among the variables that are at top of the list of the important sensorial features affecting occupational success of the teachers. So, increasing awareness of the science teachers' critically thinking disposition and improving this disposition is very important in the institutions giving education to the teachers.

Being suitable of educational activities for the learning style of the student is one of the other factors that may impact academic success. For an individual, knowing the optimum learning style helps improving learning power (Askar and Akkoyunlu, 1993). Considering that the education given will provide success if it can respond to individual requirements, it is thought that considering the learning styles that are among individual difference in the educational process will impact the thinking dispositions. In this context, searching learning styles and disposition to think critically of the pre-service science teachers and the relationship between them seems to be an important factor for studies to improve education of the pre-service teachers and thus to eliminate the inadequacies in the science education and to improve it. Reason for this study was carried out on pre-service science teacher was that success level of the students in Turkey was much lower than those in the developed countries. There were many factors causing these inadequate results. These may include that the science lessons are given in a teacher-centered manner, the teachers spend effort to teach the topic, and the question in the evaluation period are overwhelmingly based on memorizing the topics (Bagci-Kiliç, 2002). The present study is expected to fill the gap in this area and guide other studies that will be performed in the future.

Because the studies performed out of Turkey pay attention to individual differences in educational concept, two important factors, “critically thinking” and “learning styles” have been began to emphasized more frequently in those studies. However,



although many studies exist on especially these two concepts in Turkey, studies are scarce on whether there is a relationship or what type of a relationship exist between them. Hence, the present study seems to be important in terms of contributing to this field of study.

## **The objectives of the study**

The present study was carried out in order to review learning styles and critical thinking disposition of pre-service science teachers in terms of sex, grade and age, and to address the relationship between their learning styles and critical thinking disposition. In this context, answers were looked for the following questions:

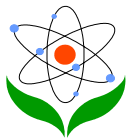
1. Do learning styles of the pre-service science teachers vary by their sex, grade and age groups?
2. Do disposition to think critically of the pre-service science teachers vary by their sex, grade and age groups?
3. Does a relationship exist between learning styles and disposition to think critically of the pre-service science teacher?

## **The method of the research**

The present study, which is a descriptive one, in of relational screening model among the screening models. Single and relational screening models were utilized in it (Karasar, 2007). The single screening model was used to determine the learning styles and disposition to think critically whereas the relational screening model was used to determine the relationship between learning style and disposition to think critically.

### **Universe and sample of the study**

The universe of the study was Primary Education Division of Educational Faculty of Adnan Menderes University in Aydin, a city on western part of Turkey. Sample of the study was chosen from the students attending on the second, third and fourth grades of Department of Science Teaching. The sample of the study included the students who were present in the lesson during the time on which the study was performed and who agreed on participating in the study. A total of 330 participants



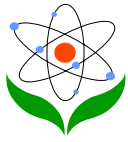
were included in the study whose 63% (n = 207) was female and 37% (n = 123) was male.

### **Data collection tool**

Data required for reaching the determined aims of the present study were obtained from the Individual Information Form consisting of 8 questions along with “Inventory of Learning Styles” and “Scale of Disposition to Think Critically”.

The first part of the data collection tool contains the “Inventory of Learning Styles” developed by Kolb (1985) and then translated into Turkish by Askar and Akkoyunlu (1993). The inventory consists of 12 items with four options requesting the individuals to rank four learning styles best defining their own learning styles. Each of four options in each item in the inventory reflects one learning style. These are, (1) Concrete Experience (CE), (2) Reflective Observation (RO), (3) Abstract conceptualization (AC), and (4) Active Experience (AE). The points from the inventory are grouped according to the experimental learning theory as divergent style based on reflective observation and concrete experiences, assimilator learning style based on reflective observation and abstract conceptualization, convergent learning style based on abstract conceptualization and active experience, and accommodative learning style based on active experience and concrete experience. As a consequence of response to each option by the participants, total point for one option ranges between 12 and 48. Reliability co-efficients of sub-scales of the Inventory of Learning Styles was found by Askar and Akkoyunlu (1993) as 0.58 for active experience, 0.70 for reflective observation, 0.71 for concrete conceptualization, 0.65 for active experience, 0.77 for concrete-abstract experience, and 0.76 for active-reflective. In the present study, reliability of the scale was re-estimated and was found to be 0.63 for concrete experience, 0.69 for reflective observation, 0.72 for abstract conceptualization, 0.65 for active experience, 0.72 for abstract-concrete experience, and 0.71 for active-reflective.

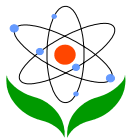
The second part of the data collection tool contains the “California Scale of Disposition to Think Critically”. The original version of the scale developed by Facione and Facione in 1992 consists of 75 items and 7 sub-scales ((Facione, Giancarlo, Facione, Ganien, 1995). The scale originally created in English was translated into Turkish and its validity, reliability studies were carried out by Kökdemir (2003). The new scale obtained at the end of the analyses consists of six sub-scales and a total of 51 items. The sub-scales are as follows: analyticalness



sub-scale of 10 items, sub-scale of open-mindedness of 12 items, sub-scale of curiousness of 9 items, sub-scale of self-confidence of 7 items, sub-scale of seeking the truth of 7 items, and sub-scale of being systematical of 6 items. For each item in the scale, it was opted to give 6 points to the option of “I absolutely agree”, 5 points to the option of “I agree”, 4 points to the option of “I partially agree”, 3 points to the option of “I partially don’t agree”, 2 points to the option of “I don’t agree” and 1 point to the option of “I don’t agree at all”. Reliability co-efficient of the sub-scales was 0.75 for the sub-scale of analyticalness, 0.75 for the sub-scale of open-mindedness, 0.78 for the sub-scale of curiousness, 0.77 for the sub-scale of self-confidence, 0.61 for the sub-scale of seeking for truth and 0.63 for the sub-scale of being systematical. Internal consistency of the scale as a whole was 0,88. Reliability of the scale of disposition to think critically was re-estimated for the present study and it was found to be 0.59 for the sub-scale of analyticalness, 0.61 for the sub-scale of open-mindedness, 0.69 for the sub-scale of curiousness, 0.74 for the sub-scale of self-confidence, 0.58 for the sub-scale of seeking for the truth, and 0.53 for the sub-scale of being systematical. For the present study as a whole, reliability co-efficient of the scale of disposition to think critically was found to be 0,79. For estimating the points of the scale of California Dispositions to Think Critically, certain points were determined for each sub-scale. Accordingly, it was considered that disposition to think critically was low for the participants with 40 points in each scale and that those with 50 points or above for each scale were disposed to think critically. Additionally, for the whole scale of California Disposition to think Critically it was stated that the disposition to think critically was low for the participants with less than 240 points (40 x 6), intermediate for those with 240 to 300 points, and high for those with 300 points or above (50 x 6) (Kökdemir, 2003).

### **The analysis of data**

Data from the present study were analysed by SPSS software, v.19 and percentages and frequencies of the data were documented. Chi-square test, T test, one-way variance analysis were done and Tukey’s test was used to determined among which groups significant differences exist. Furthermore, correlation co-efficients were also calculated. Significance level was set at 0.05 for the analysis of data.



## Findings

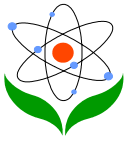
Learning styles of the pre-service science teachers by their sex were analyzed by chi-square test and findings were given in Table 1.

Table 1: Results of Chi-square test on learning styles of pre-service science teachers by their sex.

Gender	Learning Styles				
		Divergent	Convergent	Assimilator	Accommodative
Female	N	88	22	72	25
	%	42.5	10.6	34.8	12.1
Male	N	55	13	37	18
	%	44.7	10.6	30.1	14.6
Total	N	143	35	109	43
	%	43.3	10.6	33.0	13.0

$$\chi^2 = .990, sd=3, p=0.804$$

Changes in points of learning styles of the pre-service science teachers by their sex were analyzed by chi-square test and it was found that points of learning style didn't significantly vary by sex ( $\chi^2 = 0.990, p > 0.05$ ). Accordingly, one may consider that no significant relationship exists between points of learning styles and sex of the pre-service science teachers. As a consequence of percentage and frequency analysis on average sub-scale points of learning styles of the pre-service teachers, it was found that 143 (43.3%) pre-service teachers had divergent learning style, 35 (10.6%) pre-service teachers had convergent learning style, 109 pre-service teachers (33.0%) had assimilator learning style, and 43 pre-service teachers (13.0%) had accommodative learning style. It was found that ratio of the pre-service teachers with divergent and assimilator learning style was higher and the ration of those with accommodative and convergent learning style was low. Based on these findings, one may comment that female and male pre-service teachers usually had divergent learning style containing abstract conceptualization and active experience and that they prefer to be successful in problem solving, decision making, logically analyze the ideas and planning systematically and to be interested in technical issues rather than social and inter-individual activities.



Learning styles of the pre-service science teachers were analyzed by their grade using chi-square test and findings were given in Table 2.

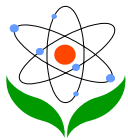
Table 2: Results of chi-square test on relationship between learning styles and grade of the pre-service science teachers.

Grade	Learning Styles				
		Divergent	Convergent	Assimilator	Accommodative
1st grade	N	37	6	29	12
	%	44.0	7.1	34.5	14.3
2nd grade	N	28	10	32	9
	%	35.4	12.7	40.5	11.4
3th grade	N	37	7	25	8
	%	48.1	9.1	32.5	10.4
4th grade	N	41	12	23	14
	%	45.6	13.3	25.6	15.6
Total	N	143	35	109	43
	%	43.3	10.6	33.0	13.0

$$\chi^2 = 7.745 \text{ sd}=9, p=0.560$$

Based on the results in Table 2, it was found that points of learning styles of pre-service science teachers didn't vary significantly by their grade ( $\chi^2 = 7.745$ ;  $p > 0.05$ ). Based on this finding, one may conclude that points of learning style of pre-service science teachers are independent of their grade. Furthermore, as a result of percentage and frequency analysis on average points of learning style sub-scales, first grade students of science teaching had mostly divergent learning style (44.0%), second grade students mostly had assimilator learning style (40.5%), third grade students (48.1%) and fourth grade students (45.6%) had mostly divergent learning style. Overall, it was determined that pre-service science teachers had mostly assimilator learning during their second year of education whereas they had mostly divergent learning style during first, third and fourth years of their education. Convergent learning style was the least during the first, third and fourth grades while accommodative learning style was the least one during the second year.

Learning styles of the pre-service science teachers were analyzed by their age group using chi-square test and findings were given in Table 3.



**Table 3: Results of chi-square test on relationship between learning styles and age groups of the pre-service science teachers.**

Age group		Learning Styles			
		Divergent	Convergent	Assimilator	Accommodative
Between 17 and 20	N	66	18	67	23
	%	37.9	10.3	38.5	13.2
Between 21 and 24	N	76	17	43	20
	%	48.7	10.9	27.6	12.8
Total	N	142	35	110	43
	%	43.0	10.6	33.3	13.0

$$\chi^2 = 5.212, p = 0.157$$

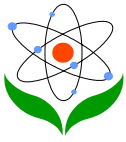
According to the results of chi-square test in the Table 3, it was concluded that points of learning style of the pre-service teachers didn't vary statistically significantly by their age group ( $\chi^2 = 5.212, P > 0.05$ ). Accordingly, it may be said that there is not a significant relationship between learning style and age group of the pre-service teachers. It was found that pre-service teachers at the age of 17 to 20 years had usually assimilator learning style (38.5%) whereas those at the age of 21 to 24 years had usually divergent learning style (48.7%).

Total and sub-scale points of pre-service teachers' disposition to think critically were analyzed by their sex using t-test and findings were given in Table 4.

**Table 4: Results of t-test on relationship between disposition to think critically and sex of the pre-service science teachers.**

	Gender	N	X	Ss	t	sd	p
Being Analytical	Female	207	48,2222	4,74074	1,378	327	0,190
	Male	123	47,4180	5,69303			
Open-mindedness	Female	207	47,5266	8,23254	3,019		0,003*
	Male	123	44,6230	8,53900			
Cruiousness	Female	207	39,4686	5,55447	-1,234		0,223
	Male	123	40,2623	5,77370			
Self-confidence	Female	207	28,5749	4,78397	0,506		0,622
	Male	123	28,2869	5,30317			
Seeking for the	Female	207	24,1691	5,32856	1,477		0,153





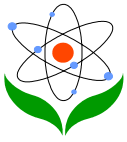
truth	Male	123	23,2295	5,96656		
Being	Female	207	21,5411	3,79409	-1,489	0,149
Systematical	Male	123	22,2131	4,21573		
Total	Female	207	211,5894	21,23631	1,371	0,175
	Male	123	208,2295	21,88467		

In the Table 4, total and sub-scale points of pre-service teachers' disposition to think critically were analyzed by their sex using t-test and it was found that total points of pre-service teachers' disposition to think critically didn't vary statistically significantly by their sex ( $t=1.371$ ,  $p > 0.05$ ). Additionally, points of pre-service teachers' disposition to think critically didn't show statistically significant differences by sex in the sub-scales of Being Analytical, Cruiousness, Self-confidence, Seeking for the truth, and being Systematical whereas they showed statistically significant differences only in the sub-scale of Open-mindedness ( $t=3.019$ ,  $p < 0.05$ ). This difference found in the sub-scale of open-mindedness was found to be in favor of female pre-service teachers.

Total and sub-scale points of pre-service teachers' disposition to think critically were analyzed by their grade using one-way variance analysis and findings were given in Table 5.

Table 5: Results of Variance Analysis on the relationship between disposition to think critically and grade of the pre-service science teachers.

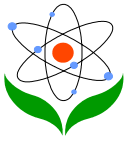
Variance		Sum of Squares	df	Mean Square	F	p
Being Analytical	Between	53,070	3	17,690	0,675	0,568
	Groups	8548,881	326	26,224		
	Within	8601,952	329			
	Groups					
Total						
Open-mindedness	Between	560,461	3	186,820	2,661	0,048
	Groups	22883,527	326	70,195		
	Within	23443,988	329			
	Groups					
Total						
Cruiousness	Between	5,288	3	1,763	0,055	0,983
	Groups	10477,818	326	32,141		



	Within Groups Total	10483,106	329			
Self-confidence	Between Groups	120,893	3	40,298	1,637	0,181
	Within Groups	8022,926	326	24,610		
	Total	8143,818	329			
Seeking for the truth	Between Groups	230,859	3	76,953	2,510	0,059
	Within Groups	9994,232	326	30,657		
	Total	10225,091	329			
Being Systematical	Between Groups	158,288	3	52,763	3,445	0,017
	Within Groups	4992,864	326	15,316		
	Total	5151,152	329			
Total	Between Groups	1053,593	3	351,198	0,760	0,517
	Within Groups	150735,998	326	462,380		
	Total	151789,591	329			

Based on the findings in Table 5, it was found that total and sub-scale points of pre-service teachers' disposition to think critically didn't show statistically significant differences by grade ( $F = 0.760$ ,  $P > 0.05$ ). Additionally, pre-service teachers' disposition to think critically didn't show statistically significant differences by grade in sub-scales of being Analytical, Open-Mindedness, Curiousness, Self-confidence and seeking for the truth while it was observed that their points in sub-scale of being Systematical showed statistically significant differences by their grade ( $F = 3.445$ ,  $P < 0.05$ ). This difference found in sub-scale of being Systematical was between the first and second grade students and was in favor of pre-service science teachers at the first grade.

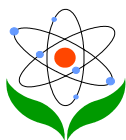
Total and sub-scale points of pre-service teachers' disposition to think critically were analyzed by their age groups using t-test and findings were given in Table 6.



**Table 6: Results of t-tests on the relationship between disposition to think critically and age group of the pre-service science teachers.**

	Age groups	N	X	Ss	t	sd	p
Being Analytical	Between 17 and 20	174	47,9713	5,17601	0,188	328	0,851
	Between 21 and 24	156	47,8654	5,05848			
Open-mindedness	Between 17 and 20	174	45,3563	8,12401	-2,522		0,012*
	Between 21 and 24	156	47,6923	8,64244			
Cruiousness	Between 17 and 20	174	39,5862	5,52985	-0,530		0,596
	Between 21 and 24	156	39,9167	5,78313			
Self-confidence	Between 17 and 20	174	28,6552	4,87729	0,773		0,440
	Between 21 and 24	156	28,2308	5,08869			
Seeking for the truth	Between 17 and 20	174	24,0862	5,76300	0,922		0,357
	Between 21 and 24	156	23,5192	5,35991			
Being Systematical	Between 17 and 20	174	21,7931	4,34798	0,025		0,980
	Between 21 and 24	156	21,7821	3,48322			
Total	Between 17 and 20	174	209,1954	21,91594	-1,003		0,317
	Between 21 and 24	156	211,5705	20,98113			

In the Table 6, Total and sub-scale points of pre-service teachers' disposition to think critically were analyzed by their age groups using t-test for unrelated samples and it was found that total points of the participants for disposition to think critically and their sub-scale points in the sub-scales of Analyticalness, Curiousness,



Self-confidence, Seeking for the truth and Being Systematical didn't vary significantly by their age group ( $P > 0.05$ ). Reason for this may be that the pre-service teachers were at close ages to each others. Additionally, pre-service teachers' disposition to think critically was found to show significant difference in terms of sub-scale points in the sub-scale of Open-mindedness ( $t=2.522$ ,  $p < 0.05$ ). This difference was between the pre-service teachers in the age group of 21-24 and 17-20 years and was in favor of those in the age group of 17-20 years.

Relationship between learning style and disposition to think critically of the pre-service science teachers participated in the present study was examined and results were given in Table 7.

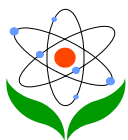
Table 7: Relationship between learning style and disposition to think critically of the pre-service science teachers.

		Divergent	Convergent	Assimilator	Accommodative	Learning styles total score
Pre-Service Science Teachers' Critical Thinking Dispositions	r	-0,079	-0,126	-0,026	0,174	0,129
	p	0,153	0,022*	0,639	0,001*	0,019*
	N	330	330	330	330	330

Based on the results in Table 7, there was a low level of positive and significant relationship between learning style and total points for disposition to think critically of the pre-service science teachers ( $r = 0.129$ ); a low level of negative and significant relationship ( $r = -0.126$ ) between learning style and disposition to think critically for those with convergent learning style; and a low level of positive and significant relationship ( $r = 0.174$ ) between learning style and disposition to think critically for those with accommodative learning style.

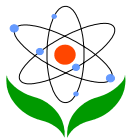
## Discussion

In the view of findings obtained in the present study, it was found that there was no statistically significant difference between learning style and sex of the pre-service teachers. Distribution ratios of female and male pre-service science teachers by



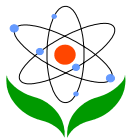
their learning style are similar. In other words, it is concluded that sex isn't an important variable in determining the learning style. The fact that there was no difference between the pre-service teacher in sex indicates that preferences and privileges in learning don't vary by sex. There are studies in the literature supporting this study finding (Gusentine and Keim, 1996; Truluck & Courtenay, 1999; Rudd, Baker and Hoover, 2000; Lukow, 2002; Jones, Reichard and Mokhtari, 2003; Kiliç and Karadeniz, 2004; Uzuntiryaki, Bilgin and Geban, 2004; Demirbas and Demirkan, 2007; Gürsoy, 2008; Denizoglu, 2008; Bahar and Sülün, 2011). It was found, however, as a result of the present study that female and male pre-service teachers usually preferred the divergent (43.3%) and assimilator (33.0%) learning style. It was also found that ratio of pre-service teachers with accommodative (13.0%) and convergent (10.6%) learning style was lower. Parallel to findings of the study, it was found in a study by Bahar and Sülün (2011) on pre-service science teachers that the pre-service teachers usually had divergent (39.7%) and assimilator (34.2%) learning style while ratio of those with convergent (15.2) and accommodative (10.2%) learning style was lower. Similarly, it was determined in a study by Bahar, Özen and Gülaçti (2009) that learning style of the students didn't vary by their sex while the pre-service teacher most frequently preferred the divergent learning style (43.6%) followed by assimilator (29.3%) learning style and that rate of preferring accommodative (16.3%) and convergent (10.8%) learning styles was lower. In another study by Denizoglu (2008), it was found that the pre-service science teacher most frequently preferred the divergent learning style. In this context, it may be suggested that the findings of the studies support each other. On the other hand, studies on pre-service teachers by Wynd and Bozman (1996), Matthewes (1996), Ergür (2000), Heffler (2001), and Güven and Kürüm (2007) indicate that there is a significant difference between learning style and sex of the students. Reason for the fact that findings of the present study are conflicted with those studies mentioned above might be that sampling groups were different.

It was found that pre-service science teachers' points of learning style didn't show statistically significant difference by their grade. Additionally, as a result of percentage and frequency analysis on point averages for sub-scale of learning styles of pre-service science teachers, it was found that the pre-service science teachers preferred divergent learning style in grade 1, assimilator learning style in grade 2, and convergent learning style in the third and fourth grades. Based on the findings obtained it may be suggested that pre-service science teachers of grade 1, 3 and 4



preferring the divergent learning style are those with skills of mental analysis, planning systematically and deductive reasoning, who pay attention to the details while trying to comprehend the whole from the parts and with tendency to miss the focus and a confused mental structure, being successful in new ideas, simulations, laboratory duties and practical application and that the pre-service science teachers of grade 2 preferring the assimilator learning style are those having ability to understand comprehensive information and to create theoretical models, being successful in focusing on abstract concepts, preferring systematic, ordered, logical and detailed information and preferring visual presentations and lesson explanations. No study was found in the literature in which learning style of the pre-service science teachers was examined by their grade. However, studies exist in the literature examining the learning style of the pre-service class teachers by their grade (Durdukoca Firat and Aribas, 2010; Karademir and Tezel, 2010; Can, 2011). It was found in a study by Durdukoca Firat and Aribas (2010) that first grade students had assimilator learning style (50%) and third grade students had divergent learning style (45.3%). Can (2011) in his study on pre-service class teachers, concluded that first and second grade pre-service teachers had assimilator learning style whereas third and fourth grade pre-service class teachers had convergent learning style. Additionally, Kolb's Inventory of Learning Styles was applied by Güven and Kürüm (2007) to 215 students in Educational Faculty and it was concluded that learning style of the pre-service teachers differentiated as their grade increased. This finding which contrast to that of the present study may have resulted from the fact that different sampling groups were studied in both studies.

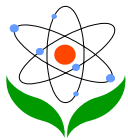
When the points of learning style of the pre-service science teachers were examined by their age group, it was concluded that there was no statistically significant differences. However, it was found that pre-service science teachers aged 17-20 years usually distributed on assimilator learning style (38.5%) and those ages 21-24 years usually distributed on convergent (48.7%) learning style. Based on these results, it may be suggested that the pre-service teachers gain qualifications of thinking ability, being aware of values and meanings, focusing on abstract concepts and ideas as well as features of decision making, logical and systematical planning of the ideas as their age increase. No study was found in the literature examining learning style of pre-service science teachers by their age groups. On the other hand, Can (2011) found in his study on pre-service class teachers that there was no statistically significant relationship between their learning style and age group and that age groups of 17-19 and 20-22 usually had



assimilator learning style whereas pre-service class teachers aged 23 or above usually had assimilator and divergent learning styles. This result is also supported by study findings of Ergür (2000) and Taylor (2000). Furthermore, Ergür (2010) in his study on effects of age group on learning style of students in Faculty of Foreign Languages found that the students aged 17-23 years preferred the assimilator learning style whereas those aged 23 or above preferred divergent learning style. Considering these results and findings of the present study together, it may be suggested that pre-service teachers have divergent learning style as their age increase.

Based on the results of the present study, it was determined that total points for disposition to think critically of pre-service science teachers didn't show statistically significant differences by sex variable. Additionally, points for pre-service science teachers' disposition to think critically didn't show significant differences by sex variable in the sub-scales of being analytical, curiousness, self-confidence, seeking for the truth, and being systematical whereas they showed significant differences by sex in sub-scale of open-mindedness and this difference was in favor of female pre-service science teachers. In the literature, there are studies finding that pre-service science teachers' total points for disposition to think critically didn't show significant differences by sex (Kürüm, 2002; Lea-ver-Dunn et al., 2002; Loken, 2005; Myers and Dyer, 2006; Ekinci and Aybek, 2010; Tümkaya, 2011). In this context, it may be suggested that findings of those studies support those of the current study. On the other hand, studies on university students by Facione, Giancarlo, Facione, Ganién (1995); Rudd, Baker and Hoover (2000); Hamurcu, Günay and Akamca Özyılmaz (2005); Gülveren (2007), Besoluk and Önder (2010) indicate that there were significant differences between total points for disposition to think critically and sex of the students in favor of female students.

Examining the pre-service teachers's sub-scale points for disposition to think critically in terms of their sex, Genç (2008) concluded that pre-service teachers's sub-scale points for disposition to think critically showed significant differences by their sex in sub-scales of open-mindedness and curiousness. Furthermore, examining the differences in disposition to think critically between sexes, Facione, Giancarlo, Facione and Ganién (1995) found that female students were much more tended than males for cognitive maturity and being open-mindedness whereas males were much more tended to think analytically. In this context, it may be suggested that the findings from sub-scale of open-mindedness support the findings of the current study. Tümkaya (2011), however, found a significant difference

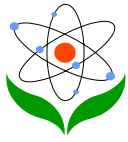


between disposition to think critically between sexes of the students of science teaching which was in favor of female students in the sub-scale of being analytical and being in favor of male students in sub-scale of curiousness.

It was found that total points of pre-service science teachers' disposition to think critically didn't show statistically significant difference by their grade. Additionally, points of pre-service science teachers' disposition to think critically didn't show significant differences in the sub-scales of being analytical, open-mindedness, curiousness, self-confidence and seeking for the truth whereas showed significant difference in sub-scale of being systematical. It was concluded that the difference found was between first and second grade students of science teaching and in favor of pre-service science teachers during their first year of education. When the literature was reviewed, it was seen that total points of pre-service science teachers' disposition to think critically didn't vary significantly by their grade in a study by Kirişcioglu, Basdas and Basöncül (2007). In another study by Ekinçi and Aybek (2010), it was found that total points of pre-service science teachers' disposition to think critically didn't vary by their grade. In this context, it may be suggested findings from several studies support each other. However, in a study by Genç (2008) found that there was a statistically significant difference in pre-service science teachers' disposition to think critically between sub-scale points of the sub-scale of being analytical by their grade. Tümkaya (2011) found a significant difference in pre-service science teachers' disposition to think critically by their grade in sub-scale of self-confidence which was in favor of students at fourth grade. Reason for the fact that findings from that study was different from those in the current one may have been due to that different sampling groups were studied in both studies.

It was found that total points for pre-service science teachers' disposition to think critically didn't show statistically significant difference by age groups. Reason for this may be that the pre-service teachers were in different age groups. Moreover, it was concluded that sub-scale point for pre-service science teachers' disposition to think critically in the sub-scale of open-mindedness showed statistically significant difference by age groups. When the literature was reviewed, limited number of studies were found examining the pre-service science teachers' disposition to think critically by their age groups. It was found in the study by Kürüm (2002) that pre-service science teachers' disposition to think critically showed difference as their age increased and that the younger students' disposition to think critically was higher. Thus, findings of that study might be suggested to be conflicted to those of

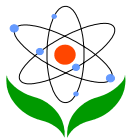




the current study. It may be considered that the conflict mentioned may have originated from the fact that different sampling groups were studied in both studies.

As a result of the current study, a low level of positive significant relationship was found between pre-service science teachers' learning style and their disposition to think critically. A low level of negative relationship was found between learning style and disposition to think critically for the pre-service teachers with divergent learning style. A low level of positive relationship was found between learning style and disposition to think critically for the pre-service teachers with accommodative learning style. When the findings concerning the third sub-problem were evaluated together, it may be suggested that there was a significant relationship between learning style and disposition to think critically of the pre-service teachers. In the literature, limited numbers of studies were found examining the relationship between pre-service science teachers' disposition to think critically and their learning style. (Güven and Kürüm, 2008; Tümkaya, 2011). In a study by Güven and Kürüm (2008) conducted to determine the relationship between pre-service science teachers' disposition to think critically and their learning style, California Scale of Dispositions to Think Critically and Kolb's Inventory of Learning Styles were used. As a result of the study, it was found that there was a relationship between learning style and disposition to think critically of the pre-service science teachers. In this context, the findings from the studies may be suggested to support each other. Additionally, there are studies in the literature conducted on different sampling groups. It was found in a study by Torres and Cano (1995) on students of agriculture faculty that there was a positive relationship ( $r = 0.36$ ) between learning style and disposition to think critically of the students. Similarly, the findings of a study by Suliman (2006) on nursery students also shows that there is relationship to some degree between learning style and disposition to think critically of the students. However, in another study by Rudd, Baker and Hoover (2000) on students of agriculture faculty, it was concluded that there wasn't a significant relationship between the students' total points of thinking critically and points of the students with field-dependent and field-independent learning style. It may be suggested that findings from that study are conflicted to those from the present one. It may be considered that this conflict may have resulted from the fact that different sampling groups were studied in both studies. A larger sampling should be done in order to make sound comments about the topic.

## Conclusions and suggestions

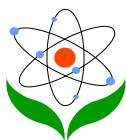


As a result of the current study, it was shown that learning style of the pre-service science teachers didn't vary by their sex, grade and age group. When the percentage and frequency analysis of the data were done, it was found that predominate learning style of the pre-service teachers by their sex was divergent and assimilator learning style. According to grade of the pre-service science teachers, the predominate learning style was divergent learning style at the first grade, assimilator learning style at the second grade, and divergent learning style at the third and fourth grades. Predominate learning style of the pre-service science teachers by their age group was assimilator learning style for the age group of 17-20 years and divergent learning style for the age group of 21-24 years.

It was found that total points for the pre-service teachers' disposition to think critically didn't show statistically significant difference by age group, sex and grade. It was also found that the pre-service teachers showed difference by sex only in the sub-scale of open-mindedness and that was this difference was in favor of female students. Based on grade, it was found that the pre-service science teachers showed significant difference only in the sub-scale of being systematical. It was concluded that this difference was between the pre-service science teachers at the first and second grade and in favor of those at grade 1. It was found that the pre-service science teacher showed significant difference by age group only in the sub-scale of open-mindedness.

Another finding from the present study was that there was a low level of positive significant relationship between pre-service science teachers' learning style and their total points for disposition to think critically. Accordingly, it was found that there was low level of negative significant relationship between learning style and disposition to think critically for the pre-service science teachers' with divergent learning style and a low level of positive relationship between learning style and disposition to think critically for those with accommodative learning style.

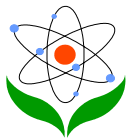
From the findings of the current study, it may be suggested that both learning styles and disposition to think critically are important skills to be acquired by the students in the context of Science and Technology lesson which changed in 2005-2006 educational year in Turkey, and that these skills should be given to the pre-service science teachers being educated in Educational Faculties in the Turkish universities in order to give these skills to the students in primary schools in Turkey. In order for the pre-service teachers to give the students information concerning learning styles and to educate these students as individuals with disposition to think



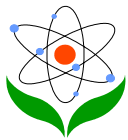
critically, the educational content may be arranged by determining the appropriate topics or lessons. For example, it may be proposed to open lessons titled learning styles and critical thinking and to determine its content. The present study was limited to a certain number of students attending on an educational faculty on western part of Turkey. In order to reveal the current situation in Turkey in general, it may be proposed to conduct similar studies with a wider sampling group and to carry out experimental studies in which learning environments would be created based on learning style and disposition to think critically.

## Reference

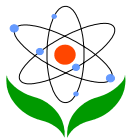
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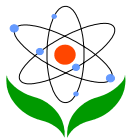
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