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Full Length Research Paper

Investigating pre-service science teachers' critical thinking dispositions and problem solving skills in terms of different variables

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This study was conducted to examine pre-service science teachers' critical thinking dispositions and problem solving skills based on gender, grade level and graduated high school variables. Also relationship between pre-service science teachers' critical thinking dispositions and problem solving skills was examined based on gender, grade level and graduated high school variables in this research. Sample of this study consists of 124 students studying in Science Education Department of Adnan Menderes University Education Faculty in city of Aydin in Turkey. As data collection tools, "California critical thinking disposition inventory and problem solving inventory" were used. T-test, one way variance analysis (ANOVA) and multi regression analysis were used to analyse data. According to the findings of this study, pre-service science teachers' critical thinking disposition levels differ significantly based on gender and graduated high school while no significant difference was found between pre-service teachers' critical thinking disposition levels and grade levels. Another finding indicate no significant difference in pre-service teachers' problem solving skills based on gender and grade level, but a significant difference was found in problem solving skills based on graduated high school type. According to regression analysis results, no significant relationship were found between pre-service science teachers' critical thinking dispositions and problem solving skills based on gender and grade level variables. On the other hand, a significant difference was found in pre-service science teachers' critical thinking dispositions and problem solving skills based on graduated high school type.

Key words: Critical thinking disposition, problem solving skill, pre-service science teacher.

INTRODUCTION

In the current information age, development of science and technology gradually boosts the demand of qualified work force. This situation requires being an individual who has reached maturity, pays attention to individual and social development, thinks, queries, searches, makes rational decisions and thinks critically. One of most the most common ideas are to know 'how' individuals think instead of 'what' they think and teach that to people. As Facione (1990) emphasized, teachers must have critical thinking abilities and be able to apply this to their own study fields in order to create model. Individuals try to produce solutions for issues when they encounter with different situations (Choi and Hannafin, 1995). Tümkaya et al. (2009) define critical thinking as a self controlled and aimed decision which directs individuals to problem solving. Larkin (1980) indicates that students can learn problem solving and suggests problem solving as a part of science curriculum. Although there are lots of researches about critical thinking and problem solving skills until today, these topics arouse most of researchers' interest (Heppner and Petersen, 1982; Facione and Facione, 1996; Barnett, 1997; Halpern, 1998; Mcbride et al., 2002).

As earlier mentioned focus on the importance of critical thinking concept being an important way of thinking and problem solving skills which are crucial for overcoming the problems with which the students are faced.

Therefore, critical thinking and problem solving conceptions will be explained with details in this study.

Critical thinking

Critical thinking conception is one of the most emphasized

conceptions in recent years. Paul (1992) focuses on providing critical thinking abilities as education systems' prior target and defines critical thinking as: 'analysis, synthesis, ability to learn how to ask and answer evaluation questions, make meaningful inferences depending on information and observation'. According to Epstein (1999) critical thinking defined as: 'a defence against world where there are a lot of information and people trying to persuade us. Critical thinking skills save individuals from unverified claims and thoughts. Questioning and criticism to find the truth required for individuals' cognitive developments'. Beyer (1987) indicates critical thinking as using analysis skills to judge correctness, consistency or importance of a claim or belief. As it can be understood from these definitions, propositions and inferences take over in critical thinking abilities. However, thinking process defined as critical thinking shouldn't only exist of propositions and tests, should also includes different abilities (Kökdemir, 2003). Therefore, an individual who can think critical should have abilities as follows (Ennis, 1993):

1) Judge sources' reliability.
2) Determine results, reasons and conjectures.
3) Judge the quality and reasons of a claim including its conjectures and evidences.
4) Develop a stance on result and protect it.
5) Ask appropriate explaining questions.
6) Plan experiments and judge experimental plan.
7) Define terms in a convenient way to general situation.
8) Be open minded.
9) Try to earn high level knowledge.
10) Make careful decisions when authorized.

The biggest task about providing and developing critical thinking abilities is assigned to education institutions and this is especially considered as one of the most important aims of higher education (Browne and Keeley-Vasudeva, 1992). Romiszowski (1996) indicates that it is important for students to have analysis, synthesis, develop critical view point, creative thinking, collaborative study, problem solving and own learning orientation skills, because every individual will need these skills in order to cope with information age's needs which is much more complicated and harder than old centuries. According to Gagne (1980) education's main aim has to teach thinking, using logic and better problem solving to individuals. Özden (2005) indicates that an individual's learning of how to think, and thinking in varied ways are materialized with thinking skills such as 'critical thinking, problem solving, reading comprehension, writing, scientific thinking, creative thinking, creative problem solving' (Braman, 1999).

Problem solving

Although problem solving had been used as conception for long time, it was systematized firstly by John Dewey, US Educator. Problem solving is generally making plan to answer a question, offer satisfying reply to a hard task, find a solution or declare interest (Mark, 1994). Solving problem is not a result but a process. Problem solving process exists from realizing problem, gathering required information, examining basis of problem, searching and finding solving methods, determining best solution and problem solving steps (Kneeland, 2001). Developing student's problem solving skills is one of the most important aim of education institutions. Individuals should be supplied with problem solving skills for their adaptation to social life and change (Kalayci, 2001). Several authors supported problem solving teaching in order to develop thinking skills for students (Heppner and Peterson, 1982). In 1950 problem solving was only seen as part of teachers' activities in science classroom (Mayer, 1991), but today is used in order to help students to use their solutions to real life. Thus, students will learn how to approach problems, how to express their thoughts, how to participate in discussions, how to solve problems (Yeh, 2002). Bilen (1996) considered problem solving as a technique used when providing high rank mind activities. Problem solving is seen as practice level activity based on information and compherension level, two of cognitive steps. Also indicated that instruction of this technique have to be in front, because training creative, critical and analytic thinkers depend on this technique. On the other hand, Heppner and Peterson (1982) used problem solving as synonym to cope with problem concept. In real life personal problem solving is defined as directing cognitive and affective processes such as internal and external request or behavioral response to targets.

Problem solving is about an individual's aim, need, value, ability, habit and attitude. Problem solving is an overcoming process of difficulties encountered when reaching the main aim. This can be explained as solution process using information and adding originality, creativity or imagination. Individual's disposition of problem solving, courage and self confidence feeling are effective in problem solving. Individual's past experiences, values, perception strength and attitudes can be affected by problem solving skills in varied rates. Individual's sum of past experiences forms her identity. Accordingly effective factors in identity formation such as thoughts, emotions, beliefs, values, knowledge, behaviors', used words and did jobs etc. are result of past experiences and also future experiences by another point of view (Bingham, 1998). Problem solving is an individual's perception about the way between him and the objective while working to reach that objective (Bingham, 1998; Morgan, 2000). According to Dewey who has argued problem solving stages, obstacle, complication and doubt exists in nature of thinking and these factors direct individual to think about. Problem solving stages determined by Bingham (1998) based on Dewey's problem solving approach are listed as follows:

1) Be aware of the problem and will to deal with it.
2) Explain problem, recognize study field related to problem and try to understand problem group related to it.
3) Gather information about problems; find the best suitable solution for the problem.
4) Find possible solutions under enlightenment of gathered information.
5) Evaluate solutions and choose the best one.
6) Apply selected solution.
7) Evaluate used solution.

Problem solving is generally defined as consciously making plan to reach an objective which can not be reached so quickly; a complicated interaction process to adapt into internal or external needs (Heppner and Krauskopf, 1987; Heppner and Baker, 1997). Therefore, in nature of problem solving, reasoning provides thinking and this thinking method is reflected in behaviour.

The aim and significance of the research

The education based on critical thinking skills provide effective learning products and results. One of these learning products is problem solving skills. Training new generation to shape the future that has critical thinking and problem solving skills is a crucial aim in all steps of the education, from primary education to university. Because, one of the most important factors in development is to reach a specific workforce standard quantitatively. The qualities of the modern people are listed in European Union publications by 2000s as knowing basic mathematics, science and technology literacy, learning to learn, comprehending interpersonal and intercultural social sufficiency, entrepreneurship and cultural awareness (Bologna-Berlin, 2007). Science is defined as analysing observed nature and natural events systematically, estimating unobserved events. For that reason, including science lesson in curriculum can be explained with general aims such as: to present general knowledge in science subjects, to provide intelligence and manipulative skills with the help of science lessons, to set ground for vocational education in science or technology domains. In line with these aims, science and technology curriculums which are based on students' learning by experience and incrementally takes place and also cognitive skills such as critical thinking, creative thinking, problem solving and making decision in which are the targeted basic skills involved (Çepni, 2005). For this purpose, some enterprises can be done to get increased quality of science education in the last one hundred years. Most of these enterprises consist of development of new curriculum which is appropriate for change (Ayas, 1995). Moreover, because science and technology change rapidly, science teacher training curriculums should also be an overview and need to get an international standard. That is why developing critical thinking and problem solving skills are involved in 2004 primary school curriculum (MEB, 2007).

The role of teacher is so important in developing these skills. For that reason, it is thought necessary to conduct researches for developing critical thinking and problem solving skills of pre-service science teachers. From this point of view, the necessity of specifying critical thinking and problem solving skills of pre-service science teachers emerges. Science is crucial for countries' development and economical growth. For that reason, countries give a special importance to science education not to fail scientific and technologic developments and to provide permanence of growth for training students producing knowledge and technology. Morever, science teachers training these students should be the one who teaches thinking, investigating, commenting, creating, solving problem and thinking critically. In Turkish literature, there are lots of researches investigating critical thinking dispositions and problem solving skills according to demographic attributes. The studies investigating critical thinking dispositions and problem solving skills together and comparing them are so limited (Tümkaya et al., 2009). For that reason, this research is crucial because of investigating critical thinking dispositions and problem solving skills together and comparing them according to demographic attributes and was conducted with the thought of making a contribution to the study field. The sub-problems of the research are given as follows:

Research questions

1) How do pre-service science teachers' critical thinking dispositions differ based on gender, grade level and graduated high school variables?
2) How do pre-service science teachers' problem solving skills differ based on gender, grade level and graduated high school variables?
3) What is the relationship between pre-service science teachers' critical thinking dispositions and problem solving skills based on gender, grade level and graduated high school type variables?

METHODS

The model of the research

This study is conducted with relational survey. In survey analysis, main objective is explaining what are events, objects, beings, institutions and various events with descriptive statistics such as frequency, percentage, mean and standard deviance (Karasar, 2007). Within this aim, "California critical thinking disposition inventory" which has 51 items (Facione, 1992) and "problem solving inventory" (Şahin and Şahin, 1993) were applied to sample.

Sample

The sample of this study consists of students attending Adnan Menderes University, Education Faculty, Primary Education Section

Science Education Department in 2008 to 2009 academic year in spring semester. A total of 124 students, in which 73 are female students (58.9%) and 51 are male students (41.1%) form the study's sample. The sample is for the students that participate in practice voluntarily.

Data collecting tools

In this study, data collected with California critical thinking disposition inventory was developed by Facione and Facione (1992) and "problem solving inventory" was developed by Heppner and Peterson (1982). For determining student's socio-demographic characteristics, "personal information form" was developed the by author. First part of data collection tools is California critical thinking disposition inventory (CCTDI). The inventory performed by Facione (1992) compose of 75 items and 7 factors; considering criteria in critical thinking definition indicated at the end of Delphi Project by American Philosophy Organisation (Facione et al., 1995). It has a grading of Likert type (1 to 6). The currency and confidence studies in Turkey had been made by Kökdemir (2003), and it had been decrease to 51 items, and inferred 6-factors. Subscales are analyticity (10 items), open mindedness (12 items), curiosity (9 items), self confidence (7 items), search for truth (7 items) and systematicity (6 items). Answer items in scale are 'totally agree', 'agree', 'partially agree', 'partially disagree', 'disagree' and 'totaly disagree'. In scale, 'totaly agree' is given 6 points while 'agree' is given 5, 'partially agree' is given 4, 'partially disagree' is given 3, 'disagree' is given 2 points and 'totaly disagree' is given 1 point. Reliability coefficient for analyticity subscale is .75, while open mindedness is 0.75, curiosity is 0.78, self confidence is 0.77, searching for truth is 0.61 and systematicity is 0.63. Reliability coefficient for full scale is 0.88. Every subscale in CCTDI gives a determined score. If individual's scores in every subscale are under 40, it indicates low critical thinking disposition. On the other hand, if scores are above 50 it indicates high critical thinking disposition.

Full scale score under 240 (40 x 6) indicates low general critical thinking disposition, full scale score between 240 to 300 indicates average critical thinking disposition and full scale score above 300 (50 x 6) indicates high critical thinking disposition. Second data collection tool used in this study is problem solving inventory (PSI). PSI was used to assess the problem-solving ability. Inventory developed by Heppner and Peterson (1982) in USA and adapted to Turkish by Şahin et al. (1993). Cronbach alpha coefficient for scale found as 0.88. The respondents were required to rate each item on a 6-point Likert scale (1 = strongly agree, to 6 = strongly disagree). Some items contain positive expressions and others contain negative expressions. When scoring, items number 9, 22 and 29 are kept out of scoring. 32 items are kept inside of scoring. Items number 1, 2, 3, 4, 11, 13, 14, 15, 17, 21, 25, 26, 30 and 34 are scored reversely. Scores can be obtained from inventory are between 32 to 192. Inventory contains subscale scores and total score. Subscales in inventory are hasty approach (item no: 13, 14, 15, 17, 21, 25, 26, 30 and 32), thinking approach (item no: 18, 20, 31, 33 and 35), avoidant approach (item no: 1, 2, 3 and 4), estimator approach (item no: 6, 7 and 8), self confident approach (item no: 5, 23, 24, 27, 28 and 34) and planned approach (10, 12, 16 and 19). High scores from inventory indicates low problem solving skill perceptions while low scores from inventory indicates high problem solving skill perceptions. In scoring of subscales, in subscales measuring desirable approaches (thinking approach, self confident approach, estimator approach and planned approach) lower scores indicate more frequent uses of these approaches while in subscales measuring ineffective approaches (hasty and avoidant approach) lower scores indicate less frequent uses of these approaches.

Data analysis

T-test, one direction variance analysis (ANOVA) and multi- regression analysis were used in data analysis. Obtained data's were tested on SPSS 14.0 statistic programme; significance level in all analysis determined was 0.05.

FINDINGS

Analysis results obtained from pre-service science teachers' critical thinking dispositions and problem solving skills are shown here.

Research question 1

How do pre-service science teachers' critical thinking dispositions differ based on gender, grade level and graduated high school variables?

Critical thinking disposition-gender

Difference of pre-service science teachers' critical thinking disposition scores based on gender was analysed with t-test and given in Table 1. In Table 1 it can be seen that pre-service science teachers' critical thinking disposition scores differ significantly based on gender in favor of female students in open mindedness subscale. However, it can also be seen that pre-service science teachers' critical thinking disposition scores do not differ significantly based on gender in analyticity, curiosity, self confidence, search for truth and systematicity subscales.

Critical thinking disposition-grade level

Difference of pre-service science teachers' critical thinking disposition scores based on grade level was analysed with one direction variance analysis and given in Table 2. When subscales in Table 2 are examined, no significant relationship between critical thinking disposition and grade level can be found in analyticity, open mindedness, curiosity, self confidence, search for truth and systematicity subscales. What is more, there is no significant relationship between pre-service science teachers' total critical thinking disposition scores and grade level. According to this result, it can be said that there is no significant relationship between pre-service science teachers' critical thinking dispositions and grade level.

Critical thinking disposition-high school type

Difference of pre-service science teachers' critical thinking disposition scores based on graduated high

Table 1. T-test results about pre-service science teachers' critical thinking dispositions based on gender.

Variables		N	$\bar{x}$	Ss	T	fl	P
Analyticity	Female	73	2.232	0.486	0.179	122	0.264
	Male	51	2.215	0.576			
Open mindedness	Female	73	1.315	0.467	1.476		0.002*
	Male	51	1.196	0.400			
Curiosity	Female	73	1.958	0.587	-0.195		0.845
	Male	51	1.980	0.616			
Self confidence	Female	73	1.589	0.597	1.053		0.611
	Male	51	1.470	0.643			
Search for truth	Female	73	1.438	0.577	0.631		0.467
	Male	51	1.372	0.564			
Systematicity	Female	73	1.452	0.528	0.428		0.272
	Male	51	1.411	0.497			
Total score	Female	73	1.054	0.229	-0.095		0.850
	Male	51	1.058	0.237			

school type was analysed with ANOVA and given in Table 3. In Table 3, it was found that there is a significant difference between pre-service science teachers' critical thinking disposition scores and high school type variable in self confidence subscale. The difference is between Anatolian High School grades and Academical High School grades and in favor of Anatolian High School grades. There is also a significant difference between Anatolian High School grades and Super High School grades' critical thinking disposition scores in favor of Anatolian High School grades in self confidence subscale. After analysis, it was found that pre-service science teachers' total critical thinking disposition scores differ significantly based on graduated high school type. The difference is between Anatolian High School grades and Academical High School grades in favor of Anatolian High School grades.

Research question 2

How do pre-service science teachers' problem solving skills differ based on gender, grade level and graduated high school variables?

Problem solving skills-gender

Difference of pre-service science teachers' problem solving skill scores based on gender was analysed with t-test and given in Table 4. Table 4 shows no significant relationship between pre-service science teachers' problem solving skill scores and gender. According to this finding, it can be said that there is no relationship between pre-service science teachers' problem solving skills and their gender.

Problem solving skills-grade level

Difference of pre-service science teachers' problem solving skill scores based on grade level was analysed with one direction variance analysis are given in Table 5. According to Table 5, it was found that there is no significant relationship between pre-service science teachers' problem solving skill scores and grade level variable. Thus, it is possible to say pre-service teachers' problem solving skills do not differ based on their grade level.

Problem solving skills-high school type

Difference of pre-service science teachers' problem solving skill scores based on high school type was analysed with one direction variance analysis and given in Table 6. In Table 6, findings about relationship between pre-service science teachers' problem solving skills and graduated high school type were given. A

Table 2. One direction analysis results about pre-service science teachers' critical thinking dispositions based on grade level.

Variance source		Square sum	FL	Square mean	F	p
Analyticity	Between groups	1.814	3	0.605	2.254	0.086
	Within groups	32.458	121	0.268		
	Total	34.272	124			
Open mindedness	Between groups	0.023	3	0.008	0.038	0.990
	Within groups	24.265	121	0.201		
	Total	24.288	124			
Curiosity	Between groups	0.598	3	0.199	0.557	0.644
	Within groups	43.274	121	0.358		
	Total	43.872	124			
Self confidence	Between groups	2.170	3	0.723	1.948	0.125
	Within groups	44.918	121	0.371		
	Total	47.088	124			
Search for truth	Between groups	1.013	3	0.338	1.038	0.378
	Within groups	39.355	121	0.325		
	Total	40.368	124			
Systematicity	Between groups	0.640	3	0.213	0.803	0.495
	Within groups	32.160	121	0.266		
	Total	32.800	124			
Total score	Between groups	0.162	3	0.054	1.011	0.391
	Within groups	6.446	121	0.053		
	Total	6.608	124			

significant difference was found in problem solving skills based on high school type in avoidant approach subscale. Difference found in avoidant approach was between academical high school graduates and other high school graduates and in favor of other high school graduates. However, no significant relationship was found between pre-service teachers' problem solving skills and high school type in hasty approach, thinking approach, estimator approach, self confident approach and planned approach subscales.

Research question 3

What is the relationship between pre-service science teachers' critical thinking dispositions and problem solving skills based on gender, grade level and graduated high school type variables?

Critical thinking disposition and problem solving skills relationship

Relationship between pre-service science teachers' critical thinking dispositions and problem solving skills based on gender, grade level and graduated high school type variables was analysed with multi-regression analysis given in Table 7. In Table 7, relationship between pre-service science teachers' total problem solving scores and total critical thinking scores based on gender variable was examined and no significant relationship was found ($p>0.05$). According to this result we can say that total scores of gender and problem solving skills don't infer pre-service teachers' critical thinking levels. Relationship between pre-service science teachers' total critical thinking disposition scores and total problem solving skill scores was examined based on grade level variable and no significant relationship between problem solving skills and critical thinking dispositions was found based on grade level in Table 7 ($p>0.05$). According to these results, we can say that pre-service science teachers' total scores of problem solving skills and grade level don't infer critical thinking diposition levels. In Table 7, relationship between pre-service science teachers' critical thinking disposition total scores and problem solving skill total scores was examined based on graduated high school variable and a significant relationship was found between

Table 3. One direction analysis results about pre-service science teachers' critical thinking dispositions based on high school type.

Variance source		Square sum	FL	Square mean	F	p
Analyticity	Between groups	0.241	2	0.121	0.433	0.650
	Within groups	34.031	122	0.279		
	Total	34.272	124			
Open mindedness	Between groups	0.061	2	0.031	0.154	0.858
	Within groups	24.227	122	0.199		
	Total	24.228	124			
Curiosity	Between groups	0.418	2	0.209	0.587	0.558
	Within groups	43.454	122	0.356		
	Total	43.872	124			
Self confidence	Between groups	4.111	2	2.055	5.835	0.004*
	Within groups	42.977	122	0.352		
	Total	47.088	124			
Search for truth	Between groups	0.373	2	0.186	0.568	0.568
	Within groups	39.995	122	0.328		
	Total	40.368	124			
Systematicity	Between groups	1.031	2	0.515	1.979	0.143
	Within groups	31.769	122	0.260		
	Total	32.800	124			
Total score	Between groups	0.381	2	0.191	3.735	0.027*
	Within groups	6.227	122	0.051		
	Total	6.608	124			

critical thinking dispositions and problem solving skills depending on high school type ($p<0.03$). Pre-service science teachers' problem solving skills subscale scores and graduated high school type variable infer critical thinking disposition levels significantly and in a positive way at 5% rate, ($p<0.05$). According to results, a significant relationship found between hasty approach subscale scores and critical thinking disposition levels in a positive way ($p<0.03$). Hasty approach and graduated high school scores infer 6% of critical thinking disposition levels. A significant relationship was found between thinking approach subscale scores and critical thinking disposition levels in a positive way ($p<0.05$). Pre-service science teachers' thinking approach and graduated high school scores infer 5% of critical thinking disposition levels. It was found that there is a significant relationship between avoidant approach subscale scores and critical thinking disposition levels in a positive way ($p<0.05$).

Pre-service science teachers' avoidant approach and graduated high school scores infer 5% of critical thinking disposition levels. A significant relationship was found between estimator approach subscale scores and critical thinking disposition levels in a positive way ($p<0.05$). Pre-service science teachers' estimator approach and graduated high school scores infer 6% of critical thinking disposition levels. According to the results, a significant relationship was found between self confident approach subscale scores and critical thinking disposition levels in a positive way ($p<0.03$). Self confident approach and graduated high school scores infer 6% of critical thinking disposition levels. A significant relationship was found between planned approach subscale scores and critical thinking disposition levels in a positive way ($p<0.03$). Pre-service science teachers' planned approach and graduated high school scores infer 7% of critical thinking disposition levels.

RESULTS AND DISCUSSION

In this study examining pre-service science teachers' critical thinking dispositions and problem solving skills based on

Table 4. T-test results about pre-service science teachers' problem solving skills and gender.

Variables		N	Mean	Square sum	t	p
Hasty approach	Female	73	30.643	4.900	-2.015	0.550
	Male	51	32.392	4.534		
Thinking approach	Female	73	14.068	3.931	0.485	0.128
	Male	51	13.666	4.913		
Avoidant approach	Female	73	10.671	3.651	-0.536	0.097
	Male	51	11.078	4.480		
Estimator approach	Female	73	8.082	2.716	0.779	0.942
	Male	51	7.705	2.594		
Self confident approach	Female	73	16.726	4.385	0.843	0.820
	Male	51	16.039	4.520		
Planned approach	Female	73	10.835	2.943	0.944	0.731
	Male	51	10.333	2.895		
Total score	Female	73	93.904	15.483	-0.064	0.915
	Male	51	94.078	14.233		

Table 5. One direction variance analysis results about pre-service science teachers' problem solving skills and grade level.

Variance source		Square sum	Fl	Square mean	F	p
Hasty approach	Between groups	33.430	3	11.143	0.478	0.698
	Within groups	2822.138	121	23.323		
Thinking approach	Between groups	15.664	3	5.221	0.273	0.844
	Within groups	2310.368	121	19.094		
Avoidant approach	Between groups	35.859	3	11.953	0.743	0.529
	Within groups	1947.533	121	16.095		
Estimator approach	Between groups	14.746	3	4.915	0.693	0.558
	Within groups	858.454	121	7.095		
Self confident approach	Between groups	58.847	3	19.616	1.005	0.393
	Within groups	2361.953	121	19.520		
Planned approach	Between groups	14.703	3	4.901	0.572	0.634
	Within groups	1036.625	121	8.567		
Total score	Between groups	469.638	3	156.546	0.703	0.552
	Within groups	26930.074	121	222.563		

different variables, pre-service science teachers' critical thinking levels show significant difference based on gender variable in open mindedness subscale. This difference was found in favor of female students. Similar to this result, Zayif (2008), Genç (2008), Gülveren (2007), Hamurcu et al. (2005) and Rudd et al. (2000) also found

Table 6. Variance analysis results about pre-service science teachers' problem solving skills and high school type.

Variance source		Square sum	Fl	Square mean	F	p
Hasty approach	Between groups	168.103	3	56.034	2.523	0.061
	Within groups	2687.465	121	22.210		
Thinking approach	Between groups	24.613	3	8.204	0.431	0.731
	Within groups	2301.419	121	19.020		
Avoidant approach	Between groups	171.686	3	57.229	3.822	0.012*
	Within groups	1811.706	121	14.973		
Estimator approach	Between groups	4.313	3	1.438	0.200	0.896
	Within groups	868.887	121	7.181		
Self confident approach	Between groups	87.969	3	29.323	1.521	0.213
	Within groups	2332.831	121	19.280		
Planned approach	Between groups	30.233	3	10.078	1.194	0.315
	Within groups	1021.095	121	8.439		
Total score	Between groups	1122.040	3	374.013	1.722	0.166
	Within groups	26277.672	121	217.171		

a significant difference on university students' critical thinking dispositions based on gender variable in favor of female students. Thus, we can say these results support each other. In similar way, Facione et al. (1995) found that female university students are more appropiate to be open minded and cognitively developed than male students. In this quadrennial study, it is indicated that female students' difference is going on (Giancarlo and Facione, 2001). However, studies conducted by Ekinci and Aybek (2010), Tümkaya et al. (2009), Korkmaz (2009), Kawashima and Shiomi (2007), Gülveren (2007), Çekiç (2007), Aybek (2006), Loken (2005), Özdemir (2005), Kökdemir (2003), Dayioğlu (2003), Kürüm (2002), Leaver-Dunn et al. (2002), Thompson (2001), Rodriquez (2000), Jenkins (1998), Scott et al. (1998), Claytor (1997), McDonough (1997) and Yeh (1997) found that university students' critical thinking dispositions do not differ based on gender. Contradiction between these studies and current study may have occured because of different sample. In this study, no significant difference was found in pre-service science teachers' critical thinking dispositions based on grade level. Similar to this result, Kirişçioğlu et al. (2007) found no significant relationship between pre-service science teachers' critical thinking dipositions and their grade level. What is more, Ekinci and Aybek (2010) found no significant difference in pre-service teachers' critical thinking dispositions based on grade level. Therefore, it can be said that these results support each other. However, results of studies conducted in different fields (Gülveren, 2007; Özden, 2005; Scott et al., 1998; McBride and Reed, 1998; Pascarella and Terenzini, 1991) indicate a significant difference on university students' critical thinking dispositions based on grade level variable.

Results indicate that critical thinking is acquired during 1st grade, reach higher point in 2nd grade, rise up with grade level but can become lower in 4th grade. In other studies (Tümkaya et al., 2009; Genç, 2008; Kawashima and Shiomi, 2007; Shin et al., 2006; Hamurcu et al., 2005; Profetto-McGrath, 2003) university students' critical thinking dispositions was getting more as grade level increased, but no significant relationship was found between critical thinking dispositions and grade level. This situation may have occured because pre-service teachers studying in Science Education Department of Adnan Menderes University Education Faculty in city of Aydin does not have a lesson focused on critical thinking. In comparison between pre-service science teachers' critical thinking dispositions and graduated high school type, a significant difference was found in critical thinking disposition total scores and self confidence subscale. Difference in self confidence subscale was in favor of Anatolian High School grades. Also significant difference was found in critical thinking disposition total scores based on high school type. Similar to these results, Kürüm (2002) also found that critical thinking dispositions of pre-service teachers graduated from Anatolian high school is higher than other high school grades. Therefore,

Table 7. Multi regression analysis results about inference of pre-service science teachers' critical thinking disposition levels.

Variable		Problem solving inventory						
		Hasty approach	Thinking approach	Avoidant approach	Estimator approach	Self confident approach	Planned approach	PSI total
Gender	R	0.069	0.051	0.054	0.072	0.151	0.173	0.080
	F	0.290	0.160	0.177	0.319	1.414	1.866	0.390
	p	0.749	0.852	0.838	0.727	0.274	0.159	0.678
Grade level	R	0.095	0.089	0.090	0.102	0.173	0.191	0.111
	F	0.556	0.484	0.500	0.643	1.885	2.316	0.759
	p	0.575	0.617	0.608	0.528	0.156	0.103	0.470
High school type	R	0.238	0.228	0.228	0.236	0.251	0.270	0.233
	F	3.658	3.336	3.345	3.591	4.109	4.778	3.511
	p	0.029	0.039	0.039	0.031	0.019	0.010	0.033

we can say that these results support each other. On the other hand, Zayif (2008), Gülveren (2007) and Akar (2007) found there is no significant difference between pre-service teachers' critical thinking dispositions and graduated high school type variable. This contradiction might have occured because of different ages and sample groups. In this study, no significant difference was found in pre-service science teachers' problem solving skills based on gender. This result is similar to results found by Tümkaya et al. (2009), Saracaloğlu et al. (2009); Genç and Kalafat (2007), Alver (2005), Gürçay (2003), Tümkaya and İflazoğlu (2000), Bilge and Arslan (2000). Thus, it can be said that pre-service teachers' problem solving skills are independent from their gender. Similarly, Çam (1997) examined pre-service teachers' formation lessons' effect on problem solving skills and found that variables such as age and gender have no effect.

Taylan (1990) conducted a study on 226 university students and found no significant difference in problem solving skills based on gender. Dikici et al. (2001) who examined university students' harmony and problem solving skills indicated that gender is not an important variable. However, studies conducted by Buluç et al. (2010) and Baker (2003) indicate that female students perceive themselves more capable than male students about solving social and personal problems. On the other hand, Brems and Johnson (1998), D'Zurilla et al. (1998), Heppner et al. (1983) found that male students' problem solving skills are more improved than female students. This differentation between male and female students might be about motivation, confidence and anxiety levels or gender roles. Another result of this study indicates that pre-service science teachers' problem solving skills do not differ based on grade level. Similarly, Buluç et al. (2010), Ceylan et al. (2008), Saracaloğlu et al. (2009), Çalişkan et al. (2006) and Taylan (1990) found that there is no significant relationship between problem solving skills and grade level. These results support current study's finding. In contrast, Tümkaya et al. (2009) conducted a study with university students and found that senior students' problem solving skills are higher. Similar results were also found by Alver (2005), Dikici et al. (2001) and Tümkaya and İflazoğlu (2000). Genç and Kalafat (2007) found that 3rd grade students' problem solving skills are higher than other grades. This contradiction might have occured because of senior students' high future anxieties and lack of solution for his situation. We found that pre-service science teachers' problem solving skills' avoidant approach subscale scores differ based on graduated high school type. This difference on avoidant approach subscale was between academical high school and other high school types and in favor of other high school types.

Another result indicates that pre-service science teachers' problem solving skills do not differ significantly based on hasty approach, thinking approach, estimator approach, self confident approach and planned approach. Some studies indicate no significant relationship between pre-service teachers' problem solving skills and graduated high school type (Buluç et al., 2010; Saracaloğlu et al., 2007). In conclusion, no significant relationship was found between pre-service science teachers' problem solving skills and critical thinking dispositions based on gender variable in this study. In addition, no significant relationship was found between pre-service science teachers' critical thinking dispositions and problem solving skills based on grade level variable. However, it was found that there is a significant relationship between hasty approach, thinking approach, avoidant approach, estimator approach, self confident approach, planned approach subscales of problem solving skills and critical thinking dispositions based on graduated high school variable in a positive way. Results of this study indicate that critical thinking and problem solving skills are still important abilities needed

to teach students after 2005 to 2006 primary curriculum change and it is a must to provide these abilities for pre-service teachers studying in education faculties firstly in order to provide required skills to students. Within this aim, lessons to provide problem solving skills for pre-service science teachers are required in education faculties. What is more, seminars about how to provide critical thinking and problem solving abilities may be needed for students' parents. This study is limited with pre-service science teachers studying in Adnan Menderes University, Education Faculty in city of Aydin, Turkey. To capture the bigger picture, similar studies with larger sample can be advised.

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