A Comparison of Thinking Styles of Social Sciences and Mathematics Students throughout the Process of Problem Solving[1]

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Abstract

This research aims to study the differences, if any, in the ways of thinking of the students studying social and mathematical sciences while solving the problems that require social or analytical thinking and to analyze the relationship between problem solving approaches and creative thinking skills. The research data were obtained from 243 undergraduates; 138 in social sciences and 105 in mathematical sciences. As data collection tools, social and analytical-theme problem scale, Torrance Creative Thinking Tests and demographical information form were used. It was observed that there are some differences between students' ways of thinking in problem solving and there is a relation between score types of creative thinking skills and the approaches for problem solving. Some differences were found in favor of mathematical sciences students in both problems that require social analytical thinking skills.

Keywords: Problem Solving approach, creative thinking, problem solving in social sciences, problem solving in mathematical sciences.

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A problem can be defined as an obstacle which obstructs and hinders an individual in achieving his/her goals. While this definition has a negative perspective regarding problems, there are other definitions indicating a problem as an opportunity (Lumsdaine & Lumsdaine, 1995). To turn disadvantage into an opportunity, individuals need to activate certain cognitive capabilities and psychological supports such as determination, courage and analytical thinking. A problem is composed of three components, "*data, objectives and processess"*. Data corresponds to information provided as a part of the problem. Objectives define the finalization required for solving the problem. Finally, processes are potential activities regarding accomplished objectives of the solution (Polya, 1954). In the course of problem solving, it is inevitable that such components form a roadmap.

Problem solving is defined as one of the brain's inborn functions (Polya, 1954; Wallas, 1926, cited. Aslan, 2001; Wang, Wang, Patel, & Patel, 2006; Wilson & Clark, 1988, cited in Zhong, Wang, Chiew, 2010). While mathematical thinking is related to resolving the relationship between digits, social thinking skills mostly require understanding and disclosing relationships between individual or social events and figures.

Analytic thinking means inductive thinking and assessment by means of dividing a subject, problem or an issue into sub-topics and then examining each of them one by one and evidencing connections between them (Ozden, 2005). Analytic thinking is a way of thinking mostly considered in connection with mathematical problem solving. Educational specialists claim that mathematical thinking skills improve innovative thinking and productive problem solving skills and help individuals gain self confidence. Analytic thinking mainly developed in connection with analytic philosophy. It represents a reaction against synthesis of absolute reality and idealism. Idealist philosophy assumes that the reality is totally independent on images and philosophy concerns such an independent field. On the other hand, in analytic philosophy, the function of philosophy is independent on our senses, and it is necessary not to speculate on the area of assumption or belief, but instead to analyze through linguistics what the true meaning of information is, that we call information.

As for social problem solving, it is the cognitive-behavioural process in which an individual manages himself/herself, and discovers ways to identify and cope with problem situations faced in daily life (D'Zurilla & Goldfried, 1971). The identifier '*social'* is not limited to problem solving for a special problem case, rather used for drawing attention onto problem solving activity in natural social environment. Two types of measurements are used to assess the ability of problem solving: (a) Process measurement and (b) Outcome measurement. The former is directly concerned with special cognitive and behavioural variables, whereas the latter is devised to assess the outcome of the process where a special problem was solved (D'Zurilla & Maydeu-Olivares, 1995). The aim of studying problem solving concepts is to increase an individuals' success in life, maintain their psychological health and increase their productivity. Therefore, the ability to solve mathematical problems is not the only purpose of this study. It is expected that finding common aspects of social and mathematical problems, and finding out process steps used by successful individuals will make important contributions to literature. In the context of problem solving, Turkish researchers have been interested in problem solving in mathematics and social sciences for the last 10 years (Sani, 1997; Balcıoglu, 1998; Budak, 1999; Saygılı, 2000; Yurttas, 2001; Ciftci. 2001; Eroglu, 2001; Sonmaz, 2002; Cetinkale, 2006; Kayan, 2007).

Analytic thinking style is not only for mathematical, but also social and psychological problems. In the case of social problem solving, an individual's knowledge of communication and personality psychology, thinking styles, and analytical thinking ability will bring her/him success and superiority. As problem solving is cognitive, it necessitates realizing the connection between the brain and thinking styles as the same time. Hermann (1996; cited Otrar, 2006), departing from studies on parts and functions of the brain, indicates differences between thinking styles and learning depending on zones dominantly used. It is listed as follows:

1. Left Cerebral Zone Dominant: (logical, conceptual, critical, technical, analytic, quantitative).
2. Left Limbic Zone Dominant: (conservative, structural, sequential, planned, organized, elaborative).
3. Right Cerebral Zone Dominant: (visual, holy, intuitional, innovative, conceptual, fictitious).
4. Right Limbic Zone Dominant: (relational, kinaesthetic, emotional, sensorial, spiritual, sensitive).

Wallas and Polya analyzed two distinct classical problem solving processes in 1926 and 1954, respectively. Wallas suggests that steps of creative problem solving are comprised of identifying the problem, incubating, sudden enlightenment and justification (cited Aslan, 2001). These steps emphasize that problem solving requires disturbing of the existing situation and seeking new and different solutions, and points out that creativity should be one of the intellectual skills needed for problem solving.

Creativity can be defined as a cognitive skill "which emerged as a new, authentic and skill-based product or has not been turned into a product yet, includes a unique problem solving process, and in which the individual employs intelligence components in an authentic and production-oriented way (cited Aslan, 2001). Creative thinking is not synonymous with problem solving; rather, it is a way of thinking which is used for producing a number of uncommon solutions for problems. It is known that many factors including thinking styles, personality traits, family work and guidance affect the choice of a profession. It is intriguing which procedures those with social and mathematic sciences as a profession follow in problem solving and whether there is a relationship between creative thinking skills they use and problem solving. In this study, the procedures used by two groups with opposing ways of thinking are investigated in the face of different problematic cases.

Problem

The main purpose of the study is to determine whether university students studying Social and Mathematical Sciences show differences in the problem solving process which requires social and mathematical thinking skills. The following sub-problems are proposed in this scope:

Sub-problems

1. Are there any differences between candidate teachers in social sciences and mathematical sciences considering their approaches to analytic and social problem solving?
2. Do candidate teachers studying social sciences and mathematics differ by gender in their approaches to analytic and social problem solving?

Method

Population and sample

Population of the study is comprised of students at Marmara University Ataturk Education Faculty departments of Secondary Education Mathematics Teaching, Elementary Mathematics Teaching, Social Sciences Teaching, and History Teaching. Classroom level to be used for both pilot application and the main application is appointed at random. While pilot study was carried out on sophomore and junior students, the main sample is comprised of freshmen students (N=243).

Table 1: Distribution of Participant Students by Department

Groups	N	%	Female	%	Male	%
Elementary math. teach.	70	29	37	36	33	23
Secondary math. teach.	34	14	14	14	20	14
Mathematical sciences total	104					
Social sciences teach.	66	27	23	23	43	30
History Teach.	73	30	28	27	45	32
Social sciences total	139					
Total	243		102		141	

Instrument of Data Collection

Problem Cases

In the study, it is aimed at observing thinking process used by students in direct problem solving, and thus a scale comprised of two problem cases and related 10 open-ended questions were prepared. Section one contains a problem status requiring analytic thinking, figures and colors; whereas section two contains challenges and complexities which require social reasoning, interpersonal relationships and conflict resolution. The problems were devised by a research group of six. One of the group members was a specialist on educational psychology, while the remaining five people were studying masters in mathematics teaching department.

To ensure parallelism between the problem cases, the problem analysis is built as in Annex 1, and the problem cases were reviewed by the group that built the cases. Parallelism was ensured between the problems which were used as an instrument for data collection requiring social and analytic thinking against criteria such as “number of persons, complexity of the problem, available overt data, hidden data, limitations, skills necessary for problem solving, critical facts needed for the solution and inference”. For the scale comprised of problem cases, validity and reliability analysis was carried out by means of obtaining expert opinion and quantitative trial via pilot scheme. A jury comprised of twelve individuals specialized on various subjects was asked to assess grading criteria of the scale and questions. Besides, the problem scale requiring analytic and social thinking was given to a sample group of 118 (31 people from elementary mathematics teaching, 25 people from secondary mathematics teaching, 33 people from social sciences teaching, and 29 people from history teaching). Responses to the scale were assessed against 13 criteria during the pilot scheme.

On the basis of the feedback obtained from both the jury and pilot scheme, the scale and the assessment methods were revised as follows: (1) Five open-ended questions were added to each of the analytic and social problem cases in order to trace the route followed for solving problem cases. (2) Three of the criteria applied for assessing the thinking process used in problem solving were annulled, and remaining ten criteria were established. These criteria are “determination, correct answer, redefining, noticing overt data, noticing hidden data, noticing asked data, reasoning, using strategy, and authenticity”.

Table 2: Criteria for Making Parallel the Social and Analytical Problems

Criteria-Phenomena	Analytical content	Social content
Number of person	Number of person (5)	Number of persons (5)
Number of variables of consideration	Number of color Requirement to collect much	Number of characters Day/duration of being together
complexity	Maximum rings with different colors Given conditions More than one color more than one variable relationship between number and color of rings and persons	Conditions of being/not being together Given conditions More than one character More than one variable
Available data- clear	Total number of rings Number and color of rings of each person has	Character of persons Number of persons Intensification of the conflict by the same character
Available data- potential	Necessary condition (e.g three times more)	That three different characters do not create any conflict
Restrictions- limitations	Collecting maximum number of rings more than one color Given conditions Total number of fixed Given conditions	Persons with same characters can not stay together. That the group is of 3 persons 2 day-period (time) That the groups are different Given conditions
Necessary ability/information for solution	Analytical thinking Reasoning Reading comprehension 4 mathematical operations	Analytical thinking Reasoning Reading comprehension
Critical point		That each group has father for certain
Unnecessary information		Monthly income, social status, gender
Inference	Understanding potential relationship Understanding clear relationship	Understanding potential relationship Understanding clear relationship

Methods of Data Analysis

After the application, 12 tests were graded by two different assessors, and results were compared. Rank correlation coefficients were used to check if there are any differences between the assessors. Since there is significant difference between these two, grading was done by using the two assessors.

Fifteen types of scores were derived from the scale comprising problem cases. The first five of them are “Scores for following steps of problem solving”, and are related with if open-ended questions were answered. The questions were: (1) What are the problem data? (2) What is asked for in the problem? (3) What do you think the problem asks? Explain it. (4) What data is needed for solving the problem? (5) What is the result?

As for the second type for following the the problem solving steps, there are 10 questions, and scores are derived by grading responses given to above mentioned questions against 10 criteria. These scores are called "criteria scores for problem solving". Scores (0,1 and 2) were applied to both following solution steps and problem solving criterion scores. For questions without any answers, (0) point was given. If the answer is not correct or it does not include items asked by the question, (1) point was given; and if the answer entirely corresponds to the question and is correct, (2) points were given. This grading was repeated for both analytic and social problem cases. In addition, all scales were graded and coded in charts according to the 10 problem assessment criteria in order to make equal the two problem cases detailed under the instrument of data collection (making parallel forms). Afterwards, the scores calculated were uploaded to the computer for both analytic and social problem cases. Data was analyzed by using the department type, problem solving performance of participants by gender, chi-square analysis, and variance analysis (ANOVA). LSD was used for post hoc analysis.

Findings

Findings Regarding Department Type and Problem Solving Skills

Purpose of the study was to determine whether there is a difference between students in mathematical and social sciences in terms of their problem solving processes and creative thinking skills. Departing from it, sub-problem one was written: "Are there any differences between candidate teachers in social Sciences and mathematical sciences considering their approaches to analytic and social problem solving?" For this sub-problem, chi-square analysis was conducted between variables coded as 'department type' and 'steps of solution' and between predetermined 10 'problem solving criterion scores' in order to find out if participants followed the steps of solution organized as open-ended questions.(see Table 2, 3 and 4).

Table 3: Results of Chi-Square Analysis on Analytic Problem Solving Steps Followed by Students in Mathematical and Social Sciences

Analytic problem	Department Type	0	1	2	$\chi 2$	df	Sig.	Social problem	0	1	2	$\chi 2$	df	Sig.
CA1	Soc.Sc.	12	59	33	1,276	2	0,528	CS1	12	59	33	1,276	2	0,528
	Math.Sc.	17	87	35					17	87	35			
CA2	Soc.Sc.	27	43	34	6,123	2	,047*	CS2	27	43	34	6,123	2	,047*
	Math.Sc.	21	77	41					21	77	41			
CA3	Soc.Sc.	21	62	21	3,957	2	0,138	CS3	21	62	21	3,957	2	0,138
	Math.Sc.	36	65	38					36	65	38			
CA4	Soc.Sc.	20	68	16	3,017	2	0,221	CS4	20	68	16	3,017	2	0,221
	Math.Sc.	23	82	34					23	82	34			
CA5	Soc.Sc.	12	46	46	5,689	2	0,058	CS5	12	46	46	5,689	2	0,058
	Math.Sc.	8	81	50					8	81	50			

Note $*p<.05$ *Abbreviations*: CA1.. CA5: Analytic problem solving steps from 1 to 5. CS1 …CS5: Social problem solving steps from 1 to 5.

In order to trace the route followed by students for solving problems, answers given for the five open-ended questions were analyzed. As a consequence, significant findings were obtained in favour of the students in mathematical sciences (f correct answer = 41) only for the scores regarding the second step ($\chi 2$=6,123) p< .05. As a consequence of the independent group t test conducted between total scores of students in mathematical and social sciences regarding following analytic problem solving steps, no significant results were found.

As for social problems, scores regarding following the steps of problem solving, statistical difference were found in chi-square between students of mathematical and social sciences in terms of CS2 correct answers. Such difference is in favor of those studying mathematics and giving correct answer (2) Ncorrect= 41).

Table 4: Results of Chi-Square Analysis on Analytic Problem Solving Criterion Scores of Students in Mathematical and Social Sciences

Criteria	Department Type	(0) No answer	(1) answered; incorrect	(2) correct answer	df	Chi-Square	Sig
Determination	Math.Sc.	3	59	42	2	9,986	,007**
	Social Sc.	21	69	49			
Correct answer	Math.Sc.	7	45	52	2	4,376	0,112
	Social Sc.	21	59	59			
Analyzing	Math.Sc.	17	38	49	2	2,02	0,364
	Social Sc.	33	45	61			
Redefining	Math.Sc.	16	63	25	2	0,135	0,935
	Social Sc.	23	81	35			
Overt data	Math.Sc.	22	33	49	2	0,383	0,826
	Social Sc.	31	48	60			
Hidden data	Math.Sc.	30	27	47	2	4,68	0,096
	Social Sc.	39	53	47			
Unnec. data	Math.Sc.	58	26	20	2	0,951	0,622
	Social Sc.	69	38	32			
Reasoning	Math.Sc.	40	20	44	2	0,621	0,733
	Social Sc.	60	23	56			
Strategic plan	Math.Sc.	43	33	28	2	2,212	0,331
	Social Sc.	56	55	28			
Authenticty	Math.Sc.	69	19	15	2	7,376	,025*
	Social Sc.	71	46	22			

Note ** *p<.01* * *p<.05*

As seen in Table 2, in connection with scores derived from “showing determination” for solution ($\chi 2$= 9,986), significant findings were obtained in favour of students in social sciences at significance level of p<.01 (correct answer f=49), similar results were found for “authenticity” ($\chi 2$=7,376) in favour of social sciences at p<.05 significance level (correct answer f= 22).

Table 5: Results of Chi-Square Analysis on Social Problem Solving Criterion Scores of Students in Mathematical and Social Sciences

Criteria	Department Type	(0) No answer	(1) answered; incorrect	(2) correct answer	df	Chi-Square	Sig
Determination	Math.Sc.	4	57	43	2	4,739	0,094
	Social Sc.	9	57	73			
Correct answer	Math.Sc.	9	44	51	2	1,412	0,494
	Social Sc.	9	69	61			
Analyzing	Math.Sc.	20	40	44	2	0,344	0,842
	Social Sc.	31	52	56			
Redefining	Math.Sc.	14	63	27	2	6,078	,048*
	Social Sc.	26	62	51			
Overt data	Math.Sc.	24	38	42	2	2,077	0,354
	Social Sc.	28	42	69			
Hidden data	Math.Sc.	49	29	26	2	10,163	0,006**
	Social Sc.	41	39	59			
Unnec. data	Math.Sc.	58	21	25	2	1,172	0,557
	Social Sc.	70	27	42			
Reasoning	Math.Sc.	53	27	24	2	5,59	0,061
	Social Sc.	67	23	49			
Strategic plan	Math.Sc.	63	24	17	2	0,672	0,715
	Social Sc.	85	36	18			
Authenticty	Math.Sc.	81	13	10	2	2,229	0,328
	Social Sc.	97	21	21			

Note ** *p<.01*, * *p<.05*

As a consequence of chi-square analysis regarding social problem solving criterion scores of students in mathematical and social sciences, significant findings were obtained in favour of mathematics at $\chi 2$=6,078 p<.05 significance level (correct answer f=51) for redefining the problem, and $\chi 2$= 10,163 p<.01 significance level (correct answer f= 59) for noticing covert data. Significant results were not found in independent (t) test results between total scores obtained from following steps of social problem solving. In chi-square analysis on social problem solving criteria applied by students in mathematics, significant findings were obtained from chi-square analysis between problem solving criterion scores obtained from determination, correct answer, analyzing, noticing overt data, noticing unnecessary data, reasoning, strategic plan, and authenticity.

Table 6: Results of Chi-Square Analysis on Social Problem Solving Criterion Scores of Students in Mathematical and Social Sciences

Criteria	Department Type	(0) No answer	(1) answered; incorrect	(2) correct answer	df	Chi-Square	sig
Determination	Math.Sc.	4	57	43	4,739	2	0,094
	Social Sc.	9	57	73			
Correct answer	Math.Sc.	9	44	51	1,412	2	0,494
	Social Sc.	9	69	61			
Analyzing	Math.Sc.	20	40	44	0,344	2	0,842
	Social Sc.	31	52	56			
Redefining	Math.Sc.	14	63	27	6,078	2	,048*
	Social Sc.	26	62	51			
Overt data	Math.Sc.	24	38	42	2,077	2	0,354
	Social Sc.	28	42	69			
Hidden data	Math.Sc.	49	29	26	10,163	2	,006*
	Social Sc.	41	39	59			
Unnec. data	Math.Sc.	58	21	25	1,172	2	0,557
	Social Sc.	70	27	42			
Reasoning	Math.Sc.	53	27	24	5,59	2	0,061
	Social Sc.	67	23	49			
Strategic plan	Math.Sc.	63	24	17	0,672	2	0,715
	Social Sc.	85	36	18			
Authenticty	Math.Sc.	81	13	10	2,229	2	0,328
	Social Sc.	97	21	21			

Note **p<.05*

As seen in Table 5, significant findings ($\chi 2$= 10,163, p<.01) were obtained from chi-square analysis on scores obtained by students of mathematics and social sciences for redefining the problem, and ($\chi 2$= =6,078, p<.05) for noticing hidden data.

Results of Comparison of problem Solving Skills by Gender

Sub-problem three of the study was "Do candidate teachers studying social sciences and mathematics differ by gender in their approaches to analytic and social problem solving?

No significant results were found by gender in chi-square analysis applied to the scores obtained by students from mathematics and social sciences regarding following the steps of analytic problem solving. Likewise, no significant results were found by gender in independent group (t) tests conducted on total solution scores obtained by students in mathematics and social sciences in analytic problem solving. Finally, independent group (t) test conducted on total solution scores obtained by students from mathematics and social sciences did not produce any significant results in relation with following the steps of solution for social problems.

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Table 7: Results of Chi-Square Analysis on Analytic Problem Solving Scores of Students In Mathematical and Social Sciences

Criteria	Department Type	(0) No answer	(1) answered; incorrect	(2) correct answer	df	Chi-Square	sig
Determination	female	5	60	39	2	5,476	0,065
	male	18	65	52			
Correct answer	female	5	51	48	2	7,987	,018*
	male	21	51	63			
Analyzing	female	15	38	51	2	3,203	0,202
	male	32	44	59			
Redefining	female	9	64	31	2	7,306	,026*
	male	28	78	29			
Overt data	female	14	41	14	2	6,936	,031*
	male	36	39	36			
Hidden data	female	25	36	43	2	1,459	0,482
	male	42	42	51			
Unnec. data	female	54	26	24	2	0,215	0,898
	male	71	36	28			
Reasoning	female	37	20	47	2	2,279	0,32
	male	61	21	53			
Strategic plan	female	40	37	27	2	0,671	0,715
	male	56	50	29			
Authenticty	female	56	29	19	2	1,392	0,499
	male	81	35	18			

*Note *p>.05, **p<.01*

According to the chi-square analysis carried out regarding analytic problem solution scores collected by students in mathematics and social sciences by gender, significant results were found for correct answer ($\chi2$= 7,987 p<.*5) , redefining ($\chi2$= 7,306 p<.05*), and noticing overt data ($\chi2$ = 6,936 p<.05). The results were in favor of males for correct answers (f correct answer =63), females for redefining (f correct answer = 31), and males again for noticing overt data (f correct answer = 36).

Table 8: Results of Chi-Square Analysis on Social Problem Solving Score Types of Students In Mathematical and Social Sciences by Gender

Criteria	Department Type	(0) No answer	(1) answered; incorrect	(2) correct answer	df	Chi-Square	sig
Determination	female	4	52	48	2	1,338	0,512
	male	9	60	66			
Correct answer	female	3	55	46	2	6,467	,039*
	male	14	56	65			
Analyzing	female	15	44	45	2	4,812	0,09
	male	35	47	53			
Redefining	female	10	56	38	2	6,928	,031*
	male	30	66	39			
Overt data	female	17	38	49	2	3,592	0,166
	male	35	39	61			
Hidden data	female	31	33	40	2	3,894	0,143
	male	57	35	43			
Unnec. data	female	46	22	36	2	6,683	,035*
	male	81	25	29			
Reasoning	female	41	25	38	2	7,328	,026*
	male	77	24	34			
Strategic plan	female	56	29	19	2	4,096	0,129
	male	89	31	15			
Authenticty	female	72	15	17	2	2,517	0,284
	male	103	19	13			

Note **p>.05, **p<.01*

According to the chi-square analysis of the types of social problem solution scores collected by students in mathematics and social sciences by gender, significant results were found for correct answer in favor of males (χ^2 =,6,467 $p<.05$) ($f_{correct\ answer} = 39$); for redefining in favor of females ($\chi2 = 6,928$, $p<.05$) ($f_{correct\ answer} = 39$); for noticing unnecessary data in favor of females ($\chi2 = 6,928$, $p<.05$) ($f_{correct\ answer}= 36$); and for reasoning in favor of females ($\chi2 = 7,328$, $p<.05$) ($f_{correct\ answer} = 38$).

Discussion

The research started off by giving a scale to a sample group of 241 students from departments of Social Sciences Teaching (N=66), History Teaching (N=73), Elementary Mathematics Teaching (N=70), and Secondary Mathematics Teaching (N=34). Scales of creative thinking and problem solving were given to (N= 243) participants in total. After grading the, test scores of 241 participants responding to all of the three tests requiring creative thinking, analytic thinking, and social reasoning, the data was entered into the SPSS 13.0 for statistical analysis. As a result, participants duly completed the three tests in social sciences (N=140) and (N=105) in mathematical sciences, and their answers were able to be graded. The figure shows that 58% of the students studying social sciences and 44% of those studying mathematics completed the task successfully.

The social problem solving model of D'zurilla and Goldfried (1971) points out that problem solving includes cognitive and behavioural activities. According to this model, human beings apply five different problem solving approaches: (1) Positive problem orientation, (2) Negative problem orientation, (3) Rational problem solving, (4) Impulsive/careless problem style, (5) Avoident style. Also, social problem solving allows predicting behaviours of decision making.

There are a number of factors that may hinder the process of problem solving (Matlin, 1998; Smith, 1991) such as: (a) mental set in which a fixed or improper method is adopted for a new problem while easier solutions could have been utilized; (b) meta-cognition in which a problem solving process may require the support of other metacognitive processes to achieve the solution goal; and (c) lack of knowledge in which either the problem or the goal could not be well represented or modeled, and no method or solution could be applied to the problem. In the context of these findings, although problem solving process is tried to be monitored by means of open-ended questions and problem solving criteria, we could not monitor all of the effecting factors.

Morera and et al. (2006) carried out a study on a group of 952 university students (N=387 males, 565 females) who consider themselves as Hispanic on the causal relationship between their social problem solving styles and decision-making styles. Present study is based on the social problem solving model by D’zurilla and Goldfried (1971). While there is a positive relation between intuitional and analytical decision-making skills and positive problem orientation, negative relation was found with regret-based decision-making.

In this study, a significant difference was found between scores of students regarding following the steps of social and analytic problem solution in favour of mathematics. However, no difference was found between social and mathematical branches in relation with answering the problem correctly. This result can be explained with an advantage of mathematical sciences students as they know problem solving methodology. In analytic problem solving process, students in social sciences perform better in showing determination and coming to a result by an authentic method. In connection with social problem solving, those studying mathematics performed better in redefining the problem and noticing hidden data. According to these findings, while there is not a difference between the departments for obtaining accurate results in analytic and social problems; students in different departments think somehow differently in the problem solving process. This can be interpreted as the members of different professions have different thinking styles.

In another study carried out by Ulucınar-Sagır (2011), 883 candidate teachers were taken as sample from departments of Physics, Mathematics, Turkish Language and Literature, and Classroom Teaching, and the relationship between the department type and perception regarding problem solving was examined. Hepner and Peterson’s problem solving inventory and information form was used on the same study. As is known, In Ulucınar-Sagır’s study, it was reported that there was a difference between departments in terms of problem solving perception and that science teachers had the highest problem solving perception, while the physical education teachers had the lowest problem solving perception.

The type of high school graduated does not bring significant difference, whereas gender and grade level does, and we see that female students and fourth grade students have higher problem solving perception. It was observed that those having a hasty and avoider problem solving style also have a negative problem solving perception, while those who think, have an organized approach and are self-confident, have a higher positive problem solving perception. In Ulucınar-Sagır’s study, females have a more negative problem solving perception. In our study as well, girls and boys differ from each other to a certain extent in problem solving. The finding supports the research. What distinguishes our study from others is its direct focus on achievement and thinking process involved in the problem solving process rather than the problem solving perception. There is no difference by gender in terms of solving the problem accurately. The type of department makes a difference in both studies. Our study is supported from this aspect too, which makes us think that individuals with different thinking styles choose different professions. Another explanation might be that education on different occupations affect thinking processes.

In the study of Merrin, Kinderman and Bentall (2007), the idea emerged from the hypothesis that illusions that give pain to someone would make him/her inclined towards focusing on the result when encountered a problem. It is claimed that before making decision, departing from relatively tiny information would lead to biased observations in relation with making references. Our study sheds light onto what kind of a process people with a normal thinking style and showing abnormal behaviours react to events and what kind of a decision-making process they employ in face of problems in real life. For this, 24 people with hurtful illusions were compared with another 24 people that are not mentally ill. The subjects were given the task of oriented deductive thinking. They were asked what references they made to ordinary social events. The clinical group not only jumped to the conclusion, but also supported themselves with tiny evidences while making decisions. Such a tendency was predominantly seen among those with painful illusions. Also the difference was observed in relation with asking for internal, external and situational information. However, no difference was observed between groups in terms of referring to results. Present study demonstrated that hurtful illusions cause restriction in cognitive research strategies, and effect making references. Another probability inferred from this finding is that mental health disorders decrease an individual's chance for coping with problems in real life. It might also have some consequences such as wrong references made by individuals to events or wrong cognitive strategies used by the same.

In a study published by Dutoglu and Tuncel in 2008, the relationship between critical thinking and emotional intelligence (quotient) factors of candidate teachers was examined. Study participants were composed of 374 senior grade candidate teachers studying in Abant İzzet Baysal University Education Faculty during 2006-2007 Academic Year. California Critical Thinking Test and Bar'on Emotional Quotient Test were used for the study. A significant positive relationship was found between subscales of participant teachers' tendency to critical thinking and subscales of emotional quotient at significance level of $p<.01$. Furthermore, positive significant relationship was seen between total scores of participant teachers from critical thinking scale and emotional quotient test at significance level of $p<.01$.

Secondly, no difference was found by gender for following the steps of analytic and social problem solving with the exception that gender makes a difference in the thinking processes for analytic problem solving. Males perform better than females at finding the *correct* answer and noticing the overt data while solving analytic problems. On the other hand, females are found better at redefining the problem for analytic problems. As for social problem solving, females are more successful than males in connection with finding the correct answer, redefining, noticing unnecessary data and reasoning.

Sardogan, Karahan and Kaygusuz (2006) carried out a study on University Students' Indecisiveness Strategies in Problem Solving Skill, Gender, Level of Class, and Type of Faculty. The study was carried out on 992 students from various faculties of Ondokuz Mayıs University, and the participants were identified by means of proportional group sampling. In order to measure the students' problem solving skills, the "Problem Solving Inventory" developed by Heppner and Petersen in 1982 and adapted to Turkey by Taylan (1990 cited by Sardogan, Karahan and Kaygusuz, 2006) and Sahin, Sahin and Heppner in 1993 (Savasır and Sahin, 1997, cited by Sardogan, Karahan and Kaygusuz, 2006) was used. Indecisiveness strategies were measured by using the "Indecisiveness Scale" developed by Bacanlı (2000,cited by Sardogan, Karahan and Kaygusuz, 2006). For analyzing data, a two-factor ANOVA test was used for independent samples. It was demonstrated that problem solving skill, level of class and type of the faculty all have a common significant effect on hasty and researcher indecisiveness strategies. The students with low levels of problem solving skills use researcher indecisiveness strategy more. Data results show that use of researcher indecisiveness strategy is influenced by level of problem solving skill. As for differences by gender, it does not have significant influence on hasty and researcher indecisiveness strategies. Common influence of gender and problem solving skill on use of researcher indecisiveness strategy was not found as significant. In other terms, we can say that students mostly using researcher and hasty indecisiveness strategies and have lower levels of problem solving skills need psycho-social support more in terms of individual achievement, and personal and social harmony.

Tumkaya, Aybek and Aldag (2009) conducted a research on university students' critical thinking skills and perceived problem solving skills with 204 volunteer students from social sciences and 149 from applied sciences totalling to 353 students. 50% of the study participants were female, while the other 50% male. Facione and Facione's (1992) "California

Critical Thinking Disposition Inventory" and Heppner and Petersen's (1982) "Problem Solving Skill" scale and the "Personal Information Form" developed by researchers for socio-demographic features (such as age, gender, level of class and type of faculty) were used as instruments for collecting data. For analysis of collected data, Pearson moment correlation and multivariate analysis of variance (MANOVA) was used. Correlation analysis showed significant relationship between students' critical thinking disposition and their problem solving skills. In the study, it was understood that gender does not make a significant difference in terms of students' tendency to critical thinking and problem solving skills. There is significant difference between problem solving scores by common influence in gender and field of study, whereas it is the opposite in the case of critical thinking scores. It was understood that common interaction of gender, level of class and field of study does not bring significant difference onto problem solving and critical thinking scores. Average scores reveal that female students in social sciences have a higher problem solving skills than the females in applied sciences. The opposite is applicable for males. In other words, males studying applied sciences have a higher problem solving skills than males in social sciences. It was seen that common interaction of gender, level of class and field of study does not introduce a significant difference on problem solving and critical thinking scores.

As may be remembered in this study, males performed better than females in producing the correct answer in the event of social and mathematical problems, and gender is influential in different thinking styls in problem solving process. Findings of our study regarding gender are partially parallel with literature findings on problem solving. In the study of Sardogan, Karahan and Kaygusuz (2006), it was found that gender and problem solving skill does not have a significant common effect on using researcher indecisiveness strategy. Researcher indecisiveness strategy is important for problem solving, as students with poorer problem solving skills use researcher indecisiveness strategy more. In the study of Tumkaya, Aybek and Aldag (2009), gender was found to have no significant effect on students' critical thinking disposition and problem solving skills. According to the common effect on gender and field of study, there is significant difference between solving scores, while it is not the case for critical thinking scores. The studies of Sardogan, Karahan and Kaygusuz (2006) and Tumkaya, Aybek and Aldag (2009) were measured by using scales built on the perception regarding problem solving. As already known, perception can be deceptive. Unlike other studies, we focused on the real problem status instead of problem solving perception, and thinking processes employed by individuals in problem solving process are directly measured. Such a measurement method and research pattern is thought to generate different findings than literature. These results show that current education systems do not contribute to problem solving skills, including critical thinking and creative thinking. Even though this finding is mostly related with findings from the Turkish education system, education programs developed by specialists all over the world can also be useful for developing thinking and problem solving skills. Such development is one of the essential values to be gained by individuals while preparing for real life.

In their paper regarding problem solving process employed by human beings, Zhong, Wang and Chiew (2010) list typical psychological factors assisting the problem solving process:

- Defining problem objectives correctly
- Being determined
- Using effective strategies while carrying out research
- Tracing the solution process so as to go back to the special step taken previously

In cognitive psychology, what differentiates an expert from a novice problem solver is studied. It is observed that not everyone possesses the same ability for problem solving. The most significant traits between experts and novices in problem solving are identified as follows (Payne & Wenger, 1998; Polya, 1954; Smith, 1991)

- Scope of knowledge on accumulated information
- Problem solving schemas
- Skills
- Expertise
- Memory capacity
- Problem representation ability
- Analysis, and synthesis skills
- Abstraction, and categorization abilities
- Long-term concentration ability
- Motivation
- Efficiency
- Accuracy

These information shows that, the problem solving process is as important as the result and requires a separate study. The problem solving skills of students may only be increased by acting on these study results. Both Merrin, Kinderman and Bentall (2007) and our study show that the problem solving process is influenced by many factors such as cognitive, emotional and social factors. However, even though it is assumed that in the current education systems the curriculum content can improve thinking and problem solving skills, it is not certain to what extent it is influential. Nevertheless, problem solving is a skill that can be improved, and special education programs developed by specialists and education materials are needed for this purpose. Both creative thinking skill and problem solving processes and using the right solution strategies can be taught. In Bilgin's study (1987), the relationship between individuals in late adolescence (average 18.5 years) and perceived parental attitudes, loyalty to peers and family, and problem solving was examined. Social self-sufficiency inventory, problem solving inventory, and learned ingeniousness inventory were used. According to the structural equality model analysis, family loyalty styles are directly related with social self-sufficiency. Additionally, authoritarian family attitude has an indirect effect on social self-sufficiency and loyalty to peers. Also there is relationship between social self-sufficiency and problem solving skills, and between problem solving skills and learned ingeniousness.

The aim of the study by Tok and Sevinc (2010) is to identify effects of thinking skills training program candidate pre-school teachers' perception regarding creative thinking skills and problem solving skills. The program for developing thinking skills built on Sternberg's Theory of Successful Intelligence was applied to 101 senior students in pre-school teaching of Marmara University during 2006-2007 autumn academic year.. It is a semi-experimental pretest- posttest research with a control group. On that study, Watson Glaser Critical Thinking Appraisal Test (YM form) and Problem Solving Inventory were used as measurement instruments. According to the study results, Education group got higher post-test scores than pre-test in all dimensions except for "Interpretation" as well as total scores on the Appraisal Test. Post-test scores of the education group on the Critical Thinking Appraisal Test were recorded significantly higher than post-test scores of both groups in total score. Problem solving inventory post-test scores of the education group were found significantly lower than the other groups' post-test scores.

In his article, Aksoy (2003) claims that problem solving skills can be acquired by means of teaching curriculum content by means of different teaching methods. A problem is an obstacle thrown before an individual. The individual is expected to remove the obstacle. In other words, the problem refers to the current status, and problem solving to required situation. Thanks to the problem solving method, students are able to cope with real life problems outside school. Students can acquire following skills by means of problem solving:

1. Scientific thinking skills,
2. Responsibility and collaborative working skills,
3. Communication skills,
4. Attention building and prediction skills,
5. Time management skills,
6. Skills of comparing the real world with school life,
7. Skills of visualizing information and reporting,
8. Skill of expressing and assessing oneself before the community.

In problem solving process used in classroom environment as a teaching method, problem solving skills can be taught by means of showing step by step to students' ways of coping with the problematic case through course topics. The investigation of Canturk-Gunhan and Baser (2009) "*Effects of Problem Based Learning on Students' Critical Thinking Skills"*proves that problem solving skills can be taught by specialists in the field and by means of special methods. As a thinking style underscored in teaching mathematics, critical thinking today is necessary for an individuals' success in any area. An experiment model with pre-test and post-test and control group was used on the study. The experimental method used in the study is the "Problem Based Learning" (PBL), whose effect on experiment group was investigated. On the other hand, "Traditional Teaching Methods" were used in the control group. The study investigated effects of applied methods on students' critical thinking skills. The research was carried out with 46 students attending the 7^{th} grade in a private school. The "Scale for Critical Thinking Skills regarding Angles and Polygons" was developed in order to measure critical thinking skills of the 7^{th} grade students in mathematics lesson. As a consequence of the study, PBL was found more effective than traditional methods in developing students' critical thinking skills in mathematics lesson. These findings reveal that both problem solving skills can be improved by means of educational practices directed at problem skills and various lessons can be developed with certain methods for improving the skill.

Recommendations

- Considering the benefits of acquiring thinking and problem solving skills by young generations at both national and individual level, further research is needed on these topics and education programs need to be developed accordingly. Also those studies must be replicated in all other areas.
- Studies, in which performances of problem solving skills and thinking styles are compared in the event of perceived and real problem situations, should be carried out. We

expect that such studies can provide considerable data for developing training programs that will help develop problem solving and thinking skills.

- It is suggested to researchers to try in different professional groups the problem solving processes and individuals' thinking strategies by research methods employing both qualitative and quantitative research techniques, by involving other variables in the research.
- As psychological factors in problem solving and thinking process is important, they should be studied.
- The relation of thinking and problem solving processes with metacognition processes should be studied.
- Programs should be developed and implemented as a separate applied course for all levels from pre-school to higher education.

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