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The Effects of Gender and Grade Levels on Turkish Physics Teacher Candidates' Problem Solving Strategies

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ABSTRACT

The aim of this research is to determine how much physics teacher candidates use problem solving strategies and to investigate the effects of gender and grade levels on it. Research data was collected by a Likert-type "Problem Solving Strategies Scale". It has 35 items and its Cronbach Alpha reliability coefficient was found 0,82. 141 students from all grade levels had participated into the research voluntarily. The data has been analyzed by using some statistical techniques as frequency, percentage, mean, Standard deviation, t-test, variance analysis and Scheffé Test. It was concluded that there was a statistically significant difference among groups according to the variables of gender and grade levels. It was also found that female teacher candidates use the problem solving strategies more frequently than the male ones; as the class level increased, the frequency of candidates who use problem solving strategies were also increased.

Keywords: *Problem Solving, Problem Solving Strategies, Physics Education, Gender, Grade Level*

INTRODUCTION

One of the most important targets of modern education is to educate individuals who are able to overcome problems which they would encounter in their daily and social life, and in other words, to educate individuals who can easily solve the problems which they would encounter.

A problem is defined as a situation which one organism could not solve by the present responses (Açıkgöz, 2003). And, the problem solving is an activity which requires choosing and using both the subject area information and the cognitive strategies that are convenient for the situation (Senemoğlu, 1998).

Gagné (1985) stated that the most important ultimate duty of the education programs are to teach students to solve all kinds of problems related to mathematics, physics, health, social areas. Serway and Beichner (2002) explained by referencing to a famous Nobel laureate physicist, Feynman's own sentences as "you can not know anything until you

have practiced it". The problem solving skills in physics constitute the fundamental resource of the physics knowledge, and students have to solve problems as much as possible.

Problem solving is a process which requires high-level cognitive skills. This process includes some procedures from trial and error to gaining innervision, and finding a relationship of cause and effect (Demirel & Ün, 1987). The problem solving is a complex process, thus, experts suggest to separate this process into various stages. This makes easy of both teaching and learning processes (Senemoğlu, 1998). Outterside (1993) believes that students have already used this process and the skills of this process unconsciously.

The well-accepted process related to problem solving had been set forth by a famous mathematician, Polya (1997). Steps of this process are as follows:

1. Comprehending the problem
2. Choosing the strategy related to the solution (planning for the solution)
3. Implementing the selected strategy (applying the plan)
4. Assessment of the solution

Whereas each of these steps is considered as separate skills, each step is categorized into subskills. These skills can be considered as the analytical parts of the problem solving process, which requires defining, investigating, reviewing and processing of the information concerning the problem. Each of these subskills is defined as problem solving strategies in the literature. Mayer (1983) defines the problem solving strategy in general as a way which do not guarantee a definite result, but to help students in the problem solving strategy as guidance. The students use not only one strategy, but also many strategies together in this process as well.

Literature shows that individuals who use the problem solving strategies effectively and consciously were called as "expert problem solvers" and who can not use it sufficiently were called as "novice problem solvers". Differences among experts and novices had constituted a well foundation for the researchers who studied on problem solving in the subject areas in physics, mathematics, chemistry, etc.

It has been seen that one group of the abroad researches done in physics were devoted to comparing the strategy usage of the experts and novices (Larkin, McDermott, Simon & Simon, 1980; Chi, Feltovich & Glaser, 1981; Reif & Heller, 1982; de Jong & Ferguson-Hessler, 1986; Hardiman, Dufresne & Mestre,1989; Veldhuis, 1990; Zajchowski & Martin, 1993; Dhillon, 1998), and the researches in the other group were devoted to teaching of strategy (Larkin & Reif, 1979; Mestre, Dufresne, Gerace & Hardiman, 1993; Huffman, 1997; Heller, Keith & Anderson, 1992).

It can be put forward according to the results obtained from the researches of the first group as:

- Experts have a tendency to analyze the problem qualitatively based on the fundamental physics concepts before starting to solve the problems by means of mathematical equations. Whereas, novices mostly start to solve the problem by means of mathematical equations, substitute the given variables, and then investigate the other equations where they can substitute the other quantitative variables.
- Experts are more planned than the novices while solving the problems. They think alternative solutions, and develop plans before starting to use the equations.
- Experts categorize the physics problems depending on the underlying principles and concepts, however, novices categorize the problems according to their superficial characteristics (such as objects existing in the problem, and terminology).
- Experts solve problems more logically and systematically when compared to novices.

❖ Experts organize their knowledge in a gradual structure as passing from general to specific. Whereas novices have a tendency of gathering their knowledge disorderly, and organizing it badly.

On the other hand the results obtained from the researches of the second group show that teaching about the problem solving strategy had positive effects on the problem solving performance.

When researches done in Turkey were reviewed, unfortunately, very few researches were found about physics area (Sezgin, Çalışkan, Çallıca, Ellez & Kavcar, 2000; Ünsal & Moğol, 2003; Selçuk Sezgin, Çalışkan & Erol, 2005; Çalışkan, Selçuk Sezgin & Erol, 2006); and it was seen that the other researches mostly had focussed onto the mathematics (Altun, 1994; Altun, 1995; Altun, Dönmez, İnan, Taner & Özdilek, 2001; Baki, Karataş & Güven 2002; Erden, 1984; Seçil Özkaya, 2000; Sarıtaş, 2002; Karataş, 2002; İsrael, 2003; Arslan, 2002; Kılıç, 2003; Karataş & Güven, 2004; Yıldızlar, 1999).

Thus, it is thought that more researches are required especially in physics. Physics among other science areas is a fundamental science in which problem solving is mostly used.

In the current research, it was intended to determine how much physics teacher candidates use problem solving strategy and the effects of the gender and grade levels on it.

For this purpose, following sub questions were also examined:

1. How much do the physics teacher candidates use the problem solving strategies?
2. Is there a significant difference between the physics teacher candidates' problem solving strategies and their gender?
3. Is there a significant difference between the physics teacher candidates' problem solving strategies and their grade levels?

METHODOLOGY

A-Subjects

Subjects of the research are the physics teacher candidates at Physics Education Department of Buca Education Faculty from Dokuz Eylül University. 141 students from all grade levels had participated into the research voluntarily. 53,9 % (n=76) of the subjects was female and 46,1% (n=65) of them was male. 22,7% of them was in their first, 22% of them in second, 17,7 % of them in their third, 19,1 % of them in their fourth, and 18,4 % of them in their fifth years.

B-Data Collection Tool

In the research, data were collected by "Problem Solving Strategy Scale (PSSS)" developed by Sezgin, Çalışkan, Çallıca, Ellez and Kavcar (2000). Its Cronbach Alpha reliability coefficient was found as 0,82. It has 35 Likert-type items. The factor loads of all items in the scale are over 0,40, and items are collected in following seven dimensions as comprehending (7 items), planning (6 items), outlining (4 items), visualizing (4 items), creative expression (4 items), solution (6 items), and assessment (4 items). The items in the scale are scored as 5, 4, 3, 2, 1 relatively starting from "Very Frequently to Never".

C-Data Analysis

Data were analyzed by using frequency, percentage, mean (M), Standard Deviation (SD), t-test, variance analysis and Scheffé Test at SPSS 10.0 program.

To determine the usage frequency of each strategy, equal interval scale assessment had been performed. According to this, distribution of the scores according to the choices are as follows: Very Frequently (5,00–4,20), Frequently (4,19–3,40), Sometimes (3,39–2,60), Rarely (2,59–1,80) and Never (1,79–1,00).

FINDINGS

In order to answer to the first sub problem of the research, means and standard deviations for each item were calculated based on the answers of the teacher candidates of each strategy expression existing in the scale. The results are presented in Table 1.

Table 1. *Means and Standard Deviations Results for the Scale Items*

Scale Items	M	SD
Rereading the problem	3,82	0,95
Trying to comprehend the problem	4,68	0,48
Thinking of concept/concepts about the problem	3,99	0,83
Expressing the problem by his/her own sentences	3,60	1,15
Writing the given variables about the problem	3,66	1,27
Expressing the problem by figures and diagrams	3,69	1,02
Reviewing the rules and principles about the problem	3,64	0,85
Thinking of whether he/she encountered a similar problem before.	3,31	1,11
Charting the given variables about the problem	2,66	1,16
Writing the asked variables about the problem	3,46	1,31
Using the trial and error method in order to find a solution	2,73	1,03
Concretizing abstract concepts about the problem	3,10	1,21
Thinking aloud the problem	2,48	1,30
Finding possible solutions for the problem	3,47	0,98
Estimating the solution of the problem	3,36	1,11
Reviewing the solution of the problem	3,63	0,99
Checking the operation steps used in the solution of the problem	3,60	1,04
Dividing the problems into sub problems	2,85	1,07
Writing the remembered formulas related to the problem	3,51	1,16
Thinking of whether the answer given to the problem was logical.	4,07	0,86
Tabling the given variables in the problem	2,41	1,12
Applying the first remembered solution	3,46	1,11
Visualizing the problem by drawing	3,78	1,02
Thinking of the correlation among the given variables in the problem	4,10	0,78
Trying different ways for the solution	3,02	1,01
Visualizing the problem	4,02	0,97
Thinking of what about the problem was.	4,21	0,79
Thinking of the different aspects of the problem from the similar problems	3,33	1,09
Categorizing the information in the problem	3,02	1,16
Defining the problem in more simple language	3,90	0,93
Underlying the important points in the problem	3,94	1,16
Focusing onto the solution of the problem	3,78	1,06
Interpreting the results obtained from the problem	3,73	1,07
Thinking of the limitations in the problem	3,13	1,05
Planning for the solution	3,37	1,12

It is seen from the Table 1 that all strategies which are included in the scale above were used by the candidates, and the mean usage frequency of each strategy was intensify on the choices of “Very Frequently”, “Frequently”, “Sometimes”.

In order to answer the second sub problem of the research, means and standard deviations for the SPSS score of female and male candidates were calculated. A t-test was applied to check the significance of the difference between the means of female and male candidates. The results of the analysis are in Table 2 below.

Table 2. *Means, Standard deviations, and t-test Results of Problem Solving Strategy Scale Scores according to Gender*

Gender	n	M	SD	df	t-Value	Significance Test
Female	76	125,42	15,60	139	2,30	Difference is significant p<.05
Male	65	119,49	14,71			

From the Table 2, it is clear that means of female teacher candidates (M=125,42) are higher than the means of males (M=119,49). Based on the t-test results, it is detected that there was a significant difference between female and male candidates in favor of the female candidates.

In order to answer the third sub problem of the research, means and Standard deviations for the SPSS score of teacher candidates from each grade level were calculated. These results are below in Table 3.

Table 3. *Means and Standard Deviations Results of Problem Solving Strategy Scale Scores of Teacher Candidates according to Class Level*

Class Level	n	M	SD
1st class	32	116,00	12,32
2nd class	31	116,15	14,83
3rd class	25	122,92	14,84
4th class	27	129,18	15,35
5th class	26	131,73	13,48

From the Table 3, it is seen that the lowest mean according to grade level was belonging to first year candidates (M=116,00), and the highest mean was belonging to fifth year ones (M=131,73).

Variance analysis was applied to determine whether there was a statistically significant difference between the means of teacher candidates according to grade levels. The results of the variance analysis are below in Table 4.

Table 4. *Variance Analysis Results of Problem Solving Strategy Scale Scores of Teacher Candidates according to Class Level*

Source of Variation (SV)	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F	Significance Test
Inter group (IG)	6019,02	4	1504,75	7,48	Difference is significant p<.05
Inner group (IG)	27339,25	136	201,02		
General (GN)	33358,27	140			

From the Table 4, it is found out that there were significant differences among groups according to the grade levels. In order to determine in which groups there were significant differences, A Scheffé Test was applied. The results of the analysis showed that there were significant differences between first and fourth-fifth year candidates, and there were also significant differences between second and fourth-fifth year ones.

DISCUSSIONS

1- In the research, it was detected that all strategies in the scale were used by the teacher candidates. Main strategies which are used in general by all grade levels and the usage frequencies of them can be summarized as follows:

The strategies used by teacher candidates "Very Frequently" are as follows:

"Trying to comprehend the problem", "Thinking of the correlation among the given variables in the problem", "Thinking of what about the problem was".

It has been found that many strategies used by teacher candidates "Frequently", and the main strategies having higher mean scores are given below:

"Rereading the problem", "Thinking of concept/concepts in the problem", "Visualizing the problem by drawing", "Defining the problem in more simple language", "Underlying the important points in the problem", "Reviewing the rules and principles related to the problem", "Interpreting the result obtained in the problem".

The strategies which are used by the teacher candidates "Sometimes" are as follows:

"Charting the given variables in the problem", "Using the trial and error method in order to find the solution", "Thinking aloud the problem", "Tabling the given variables in the problem", "Dividing the problems into sub problems".

It is thought that strategies used "Very Frequently" and "Frequently" were the strategies which are used by the teachers mostly at lectures, and the strategies used "Sometimes" were the strategies not used much or not emphasized to be used by the teachers. "Dividing the problems into sub problems" is a strategy used by the expert problem solvers in general, and in this study, it has been found that it was used by the candidates "Sometimes". It is thought that the teacher candidates need a special training about usage of this strategy.

2. It has been detected that there was a statistically significant difference between female and male teacher candidates in favor of the female candidates in their usage of the problem solving strategies. According to the scale in general, female teacher candidates use the problem solving strategies more frequently than the male ones. For the reason of this result, it is thought that the females had more tendency to model their teacher at lectures than the males, and they observed and tried to internalize the strategies which their teachers used at lectures even implicitly.

3. In the research, it has been determined that there were statistically significant differences among the groups according to the grade levels. Higher grade level candidates use the problem solving strategies more frequently. It is thought that reason of this is based on their earlier experiences in which they had more opportunity to observe the thinking and problem solving processes of different lecturers during their educations.

CONCLUSION AND SUGGESTIONS

It is thought that the results obtained from this research would give clues to the lecturers have active roles in teacher educating process, and the researches devoted to developing problem solving strategy skills. In the direction of the results obtained from the research, the following suggestions were developed:

1. Lecturers should determine the problem solving strategies which their students used, and they should encourage their students to get to know these strategies, and to use them. At the beginning of the academic year, problem solving strategies which the students used must be determined by scales or by one-to-one interviews is required. The lecturer of that course should constitute a model for the students in using of the important

strategies which the students did not use by solving sample problems containing strategy usage.

2. Lecturers should be acquainted with their students better, and by reviewing their methods which they followed, and teaching activities which they applied in their teaching processes, they should rearrange them according to the needs of their students; and they must definitely involve the activities which would develop the problem solving skills of the students in their lectures.

3. More researches are required to determine the effects of gender on problem solving strategy usage.

4. The effects of grade levels on problem solving strategy usage must be deeply investigated.

5. Problem solving strategy usage and the effects of students' characteristics (age, socio-economical and socio-cultural level, graduated school, etc.) on this must be investigated in different subject areas and in different grade levels.

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