African Journal of Physics Vol. 2 (1), 13 pages, January, 2014. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Pre-service instructors' application of self-directive approach in physics problem solving: Effects of gender and educational achievement

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Accepted 13 July, 2013

The purpose of this study was to determine the extent which pre-service teachers use self -regulation strategies when solving physics problems, to establish the effects that gender and academic achievement have on the use of self-regulation strategies and to examine the factors determining the cases in which pre-service teachers use these strategies qualitatively. The research data were collected by "self-regulation strategies scale" and semi-structured interview methods were used. A total of 482 pre-service teachers who enrolled in the General Physics class in the Buca Education Faculty of Dokuz Eylül University, were involved in this research. In the quantitative analysis of the data, descriptive statistics and one-way MANOVA and univariate ANOVA were used. In the qualitative analysis, phenomenographic analysis method was used. The results of the research indicate that there were not significant differences in pre-service teachers' use of strategies according to their gender; however, in the planning aspect some differences occur. There were statistically significant differences between the groups according to the academic achievement variable. Furthermore, the data obtained from the results of the interviews and the factors that determine the pre-service teachers' use of strategies were discussed due to the importance of the self-regulation strategies in solving physics problems and the necessity of teaching them.

Key words: Problem solving, self-regulation strategies, strategy usage, gender, academic achievement.

INTRODUCTION

The analysis of cognitive processes in problem solving has been a crucial part of cognitive researches since the 1960s (Hestenes, 1987). Thus, one can conclude that problem solving includes high-level cognitive skills that require regulation and coordination, such as "comprehension, visualization, abstraction, questioning, analysis, synthesis and generalization" (Garofalo and Lester, 1985). In this sense, problem solving can be defined as a process that entails the use of high-level cognitive skills, and it involves various activities ranging from trial and error, gaining insight and establishing cause-effect relationships (Demirel and Ün, 1987).

'Problem solving strategies' are a significant element of problem solving procedure. Weinstein and Mayer (1986) explain that while some cognitive psychologists define 'problem solving strategies' as cognitive or learning strategies, others describe them in terms of inner metacognitive processes such as high- level thinking, metacognition, metacognitive strategies or self-regulation strategies (Armour-Thomas et al., 1992).

From this standpoint, one can say that problem solving strategies include both cognitive and metacognitive strategies (Montague, 1992). To exemplify, while strategies like "visualizing the problem" or "summarizing the problem" are known as cognitive strategies used for processing the information, metacognitive strategies like "self -evaluation" after solving the problem are the ones that are superior to cognitive strategies and have the function of execution (Açikgöz, 2000). Furthermore, these strategies enable a higher level of thinking. For this reason, cognitive strategies are applied to achieve a cognitive process; whereas, metacognitive ones are used to monitor the process (Flavell, 1992).

Flavell (1979) states "metacognition" is a person's

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experience and knowledge about his own cognitive processes. Simply put, “metacognitive” means thinking about thinking (Ibe, 2009). On the other hand, Hofer et al. (1998) believe that the term “metacognition” covers the knowledge about cognition and the way an individual makes use of that knowledge to regulate it.

Metacognition is divided into two components: (a) knowledge of cognition and (b) regulation of cognition (Nietfeld et al., 2005; Pintrich, 2002).

‘Knowledge of cognition’ concerns a person’s awareness of how much he knows about his own cognition or cognition in general (Pintrich, 2002). It comprised three components such as explanatory information (what a strategy is, for instance), practical information (how a strategy must be applied, for example) and conditional information (to illustrate, when a strategy must be employed) (Carrell et al., 1998). Regulation of cognition, on the other hand, takes into account the extent to which learners self-regulate (Sperling et al., 2004). They are also known as metacognitive skills or self-regulation strategies in literature.

Self-regulation is a person’s ability to control his cognitive activities underlying the executive processes related to metacognition (Flavell, 1976). According to Zimmerman (1989), self-regulation strategies are the activities that students believe to be helpful and they carry them out to acquire the knowledge or skills they would like to learn.

The most well-known elements of metacognitive skills (that is, self-regulation strategies) in literature are planning, self-monitoring and self- evaluation (Annevirta and Vauras, 2006; Meijer et al., 2006; Najar, 1999). Besides, unlike the former, Nielsen and his colleagues (2009) have emphasized that metacognition has six key constituents. These are awareness, control, evaluation, planning, monitoring and self- sufficiency (an individual’s perception of his own capacity of learning). Among these, planning, monitoring, control and evaluation are the fundamentals of the metacognitive skills or self-regulation strategies examined in this study. These skills are described in detail as follows:

i. Planning: It covers planning the use of cognitive strategies such as a learner’s regulation of the material he is reading or activation of his prior knowledge (Annevirta and Vauras, 2006). This strategy involves setting an objective, task analysis, planning, selection and organization of the related material (Zimmerman, 1989).

ii. Self-monitoring: It is the monitoring of the degree of effectiveness of the learning methods used as well as the strategies (Montague et al., 2000). In a manner of speaking, self-monitoring is regularly controlling the process to see if the material heard or read has been comprehended or not (Candan, 2005). In this sense, this metacognitive ability encourages the student to check the results of his own cognitive activities as well as monitoring his overall performance.

iii. Controlling: It is checking the validity of every step taken and the result achieved to explain whether it is reasonable or not (Reif et al., 1976). In addition, it covers assessing the accuracy of the mathematics used and the steps taken. Usually, masters make use of this step (Dhillon, 1998). Checking the metacognitive process is related to the self-monitoring process. In this context, checking corresponds to deliberately or indeliberately taking decisions at the end of the self-monitoring process (Perfect and Schwartz, 2002).

iv. Self-evaluation: This is based on comparing the observed behaviour with the objective or a standard (Perels et al., 2005). It is all the activities concerned with the quality and development of a student’s studies. So to speak, it is the student’s appraisal of his own learning products and regulation process (Schraw and Moshman, 1995).

Montague (1992), in his research about the teaching of mathematical problem solving strategies, defines self-regulation strategies slightly differently than those expressed above. In his study, he correlates cognitive strategies (reading, paraphrasing the problems, visualization, making solution plans, prediction, calculation and checking) with metacognitive strategies; thanks to direct strategy teaching methodology, for every cognitive strategy, a new strategy teaching method has been developed that connects with the three-step metacognitive processes named SAY-ASK-CHECK. Here, SAY, ASK and CHECK steps correspond to self-instruction, self-questioning and self-monitoring self-regulation strategies, respectively.

Metacognition is a strong determinant of academic achievement and problem- solving strategies (Theide et al., 2003). In literature, as a result of various levels of learning, it has been proved that there is a strong relationship between academic achievement and the use of self-regulation strategies (Camahalan, 2006; Chye et al., 1997; Malpass et al., 1999; Pintrich, 2000; VanZile et al., 1999; Young and Vrongistinos, 2002; Zimmerman and Martinez-Pons, 1986). To illustrate, Zimmerman and Martinez-Pons (1986) have shown that successful students use self-regulation strategies more commonly than unsuccessful ones. Pintrich (2000) thinks that students’ target success, that is, their questioning of doing an academic task, is directly related to some metacognitive strategies. In addition to this, metacognitive strategies are absolutely needed for effective problem-solving. Also, they have to be taught together with cognitive strategies. The reason for this is that in this way, problem solvers acquire strategic knowledge better and faster, they learn how to apply it appropriately and it helps them to see the details when solving problems. Those strategies can be used either “explicitly (by thinking aloud)” or implicitly (Montague et al., 2000). Lester (1994) has set forth that good problem solvers are the ones who regularly monitor their own efforts throughout the problem solving process, and that they are aware of their strengths and weaknesses in problem solving. In other words, they exploit metacognitive skills.

While researching material in this field, it became evident that there are several researches concerning the effects of teaching self -regulation strategies in solving mathematical problems (Case et al., 1992; Chung and Tam, 2005; Montague, 1992; Mevarech and Kramarski, 1997; Schoenfeld, 1985). In the field of science, on the other hand, as far as it is known, there are a number of studies regarding the solving of science problems (Rozencwajg, 2003), the relationship between success in science and learning by using self- regulated strategies (Eilam et al., 2009; Ibe, 2009) and also the effects of teaching metacognitive skills (Beeth, 1998; Gauld, 1986; Georghiades, 2004). On the other hand, unfortunately, there are few studies carried out to set the frequency of students' use of metacognitive abilities or self-regulation strategies in the field of physics by using a scale and analyzing the extent to which those strategies change with the use of some cognitive or affective variables (Çali kan et al., 2008; Neber et al., 2008; Neto and Valente, 1997) . In a research conducted by Çali kan et al. (2008), the relationship success in physics between the modern strategies that the experimental group students utilized when solving physics problems and the traditional ones that the control group exploited, was analyzed. The outcomes have proved that more successful students made more frequent use of self-evaluation and self-regulation strategies in comparison with the others. A study by Neber et al. (2008) revealed the affiliation between the self-regulation strategies, which students of different genders and levels of knowledge use, and motivation. Furthermore, Neto and Valente (1997) performed an experimental study in which they compared a modern group of high school students equipped with metacognitive strategies to solve physics problems and a traditional group. In this survey, the use of self-regulation strategies was described by using a scale especially designed for it. After the research, it was shown that the metacognitive group was much better than the traditional one in terms of solving both quantitative and qualitative problems.

We know that most of the studies, with respect to problem-solving strategies in physics, are about the differences between the experts (good) and novices (weak) (Dhillon, 1998; Larkin et al., 1980), and that they teach strategies to novices in order to help them acquire expert skills (Huffman, 1997; Mestre et al., 1993). The findings of some of the studies concerning the former one have demonstrated that there are significant differences between the expert and novice problem solvers in terms of their metacognitive abilities. It has been proven in these studies that masters have better metacognitive abilities (Ferguson-Hessler and de-Jong, 1990), act in a more planned way in comparison with novices (Larkin et al., 1980; Reif and Heller, 1982) and assess the result of the problem at the end (Dhillon, 1998; Reif and Heller, 1982). While masters assess their answers considering different alternative solutions, novices usually stick to one way of solving problems (Leonard et al., 2002).

Above and beyond, surveys about self-regulation strategies have a very recent history in Turkey; the majority of which are about mathematics (Alci and Altun, 2007; Alci et al., 2010; Çilta and Bekta , 2009; Polat and Bulut, 2009; Üredi and Üredi, 2005), and the rest are about different fields such as science education (Arsal, 2010), biology (Yumu ak et al., 2007) and computer programming (Ha laman and A kar, 2007).

In the light of such information, it is believed that discovering the metacognitive skills and self-regulation strategies that students use in problem solving, which is of crucial importance in physics education, showing the relationships between the way they use them and their genders and academic success, and especially, describing the factors affecting their decisions to use those strategies qualitatively, have great importance in bringing their methods of problem -solving and levels of awareness to light. Concordantly, it is thought that the findings of this study will shed light on other studies on physics education specifically on the ones about problem-solving teaching and skills. In addition, it is believed that this study may contribute to new studies to improve the effectiveness of science teaching and learning.

Aim of the study

In this study, the aim is to determine the extent to which pre-service teachers use self- regulation strategies in problem-solving, to show the effect of gender and academic achievement on their use of self-regulation strategies and to analyze the factors that have an effect on their use of self-regulation strategies qualitatively. Considering all these, we tried to find answers to the following research problems:

(1) To what degree do pre-service teachers employ self-regulation strategies in solving quantitative physics problems?
(2) Does their degree of use of self-regulation strategies differ according to the gender variable?
(3) Does their degree of use of self-regulation strategies differ according to academic achievement variable?
(4) What are the factors affecting pre-service teachers' use of self-regulation strategies during the problem-solving process?

METHODOLOGY

Participants

The scale has been applied to n = 482 pre-service teachers taking "Introduction to Physics" at a Turkish State University. Taking the

Table 1. Distribution of the participants according to their genders, academic achievement and departments.

Gender	**n**	**%**
Male	204	42.3
Female	278	57.7
Academic achievement		
Unsuccessful	65	13.5
Averagely successful	351	72.8
Successful	66	13.7
Department		
Physics Education	40	8.3
Elementary School Science Education	113	23.4
Mathematics Education	57	11.8
Elementary School Mathematics Education	131	27.2
Biology Education	39	8.1
Computer and Education Technologies Education	102	21.2

Note: n, the number of the participants in groups; %, the percentage of the participants in groups.

University's teaching and exam procedures into account in this study, according to a 4 point scale, the pre-service teachers with a General Point Average (GPA) of 3.0 and higher than that have been considered to be successful, the ones with a GPA of between 2.9 to 2.0 as averagely successful and finally, the ones who have a GPA of 1.9 and below as unsuccessful. The distribution of the students according to their genders, academic achievement and departments is presented in Table 1.

Design of the study

In this cross-sectional research, we have used survey and semi-structured interviewing methods. The survey is a non-experimental, descriptive research method (Karasar, 2000). In this study, we have described when and how pre-service teachers utilize self-regulation strategies in problem-solving with the survey method.

The scale has been tested on pre-service teachers that have already taken the general physics course. The data has been collected from volunteered senior teacher candidates and took 8 min to collect during a one hour class in the normal classroom environment.

After applying the scale, the first author of this study initiated semi-structured interviews with 6 of the pre-service teachers, taking the average of their genders, academic success and levels of use of those self-regulation strategies. The face-to-face interview with each student took approximately 15 min to execute and their statements were written down by the researcher.

The dependent variables of the survey are problem-solving and self-regulation strategies (planning, checking, self-monitoring and self-evaluation), whereas, academic success and gender are the independent variables of the research. Finally, the senior teacher candidates' department is the control variable.

Evaluation instruments

In this study, the data were collected by means of the "self-regulation strategies scale" (SRSS).

Self-regulation strategies scale (SRSS)

SRSS is a 5-point Likert-type scale with 18 items. It includes the pre-service teachers' problem-solving behaviours (for example, "to make sure, the solution of the problem is checked repeatedly) used for determining their levels of use of self- regulation strategies. The scale has five alternatives namely, "always", "frequently", "sometimes", "rarely" and "never". The items on the scale are graded as 5, 4, 3, 2 and 1, starting from "always". In order to ensure structural validity of the scale, item and factor analyses have been made. As a result of the item analysis, it was found out that the item-total correlation of the scale is between 0.30 and 0.58. In the factor analysis process, on the other hand, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy that shows the eligibility (KMO>0.70) of applying factor analysis to the scale was first computated as 0.87. After that, we applied the Varimax Rotation Technique on the scale.

Finally, it has been concluded that the load factors of the scale are between 0.41 and 0.86. The scale can be categorized into four dimensions with an eigen value of higher than 1.0 and these dimensions explain 55.49% of the total variability. These dimensions are named planning (P), checking (C), self-monitoring (SM) and self-evaluation (SE), respectively. Dimension P includes the items evaluating the students' behaviours before they start solving a problem (for example, "While reading a problem, the student thinks about how to start the solution;" "Before solving a problem, he always note what is asked"). Dimension C embraces the items that assess the method employed by a student when solving a problem as well as checking if the result is a reasonable one or not (for example, "he always think if the solution he has reached is logical in physics or not"; "he always check the unit of the solution"). Dimension SM consists of the evaluation of the items concerning a student's self-monitoring throughout the whole problem-solving process (for example, "While solving a problem, he always ask himself if he is on the right track or not;" "he always question if the method he is using when solving a specific problem is a rational one or not"). Finally, dimension SE comprises the assessment of items that a student uses to question the solution he has reached and the formulas he has used (for example, "At the

Table 2. Subscales, number of items and Cronbach's Alpha Reliability Coefficient regarding SRSS.

Subscales	Number of items	Cronbach's Alpha Reliability Coefficients
P	4	0.66
C	4	0.72
SM	4	0.70
SE	6	0.81
SRSS	18	0.86

Table 3. Descriptive statistics concerning problem-solving self-regulation strategies.

Problem-solving self-regulation strategies (subscales)	N	Minimum	Maximum	$\overline{X}$	*SS*
Planning	482	5	20	14.07	3.02
Self-monitoring	482	6	20	15.28	2.63
Checking	482	4	20	12.82	3.17
Self-evaluation	482	6	30	21.77	4.14

end of the problem, he ask himself if there are other concepts, formulas and information he need to learn about the related subject;" "When he cannot solve a problem, he tries to see what he need to learn more about that specific subject"). The highest score one can get from this scale is 90 and the lowest is 18. The number of items belonging to the scale itself and its subscales and Cronbach's Alpha Reliability Coefficients which is a criterion of internal consistency of the scale are shown in Table 2.

Data analysis

The quantitative data obtained from SRSS has been analyzed using the one- way multivariate variance analysis (MANOVA) method in SPSS 11.0 program. Thus, the frequency (f), percentage (%) and standard deviation (SD) of the data have been calculated. After that, through a follow-up test, univariate ANOVA has been applied for each dependent variable. Whenever a meaningful result was obtained after the ANOVA analysis, in order to detect which group the discrepancy was caused, we applied the Bonferonni test which is an example of multiple comparison/post -hoc tests. The independent variables of the study are gender and academic success, the dependent variables are problem-solving and self-regulation strategies (planning, checking, self-monitoring and self-evaluation) and the control variable is the pre-service teachers' departments. Before examining the effects of each independent variable on dependent variables, the hypotheses of MANOVA had been tested. It was discovered that the scores of the dependent variables showed univariate and multivariate normal distribution. The homogeneity of each dependent variable has been assessed by means of the Levene test whose variances are homogenous. The homogeneity of variance-covariance matrices, on the other hand, was assessed by way of the Box's M test. The analysis of the data has been performed and a significance level of 0.05 has been established.

The data gathered from the semi-structured interviews with the pre-service teachers was analyzed by the phenomenographic method of data analysis. The phenomenographic research method studies how individuals express the cognitive structures they have formed in their minds concerning concepts. Through phenomenography, we make generalizations about an individual's expressions. In other words, phenomenography is used to categorize those expressions (Demirkaya and Tomal, 2008). In this survey, by means of the phenomenographic method, generalizations have been made in relation to the pre-service teachers' expressions explaining the factors affecting their use of self-regulation strategies when solving physics problems. In other words, the method enabled the study to classify those factors and situations.

FINDINGS

Levels of pre-service teachers' use of self-regulation strategies in problem-solving

To identify the levels of pre-service teachers' use of self-regulation strategies, we have computed the averages and standard deviations of the scores they got from each subscale of the SRSS. The results are presented in Table 3.

In order to describe the senior candidate teachers' frequency use of self-regulation strategies, we have assessed the results by an equal-interval scale. In this assessment, we have considered the minimum and maximum scores that one can get for each subscale. Moreover, the frequency of strategy use has been categorized equally as "always", "frequently", "sometimes", "rarely" and "never". This categorization is displayed in Table 4.

When the averages ($\overline{X}$) in Table 4 are examined, it is seen that the candidate teachers employ self-regulation strategies in planning, self-monitoring and self-evaluation

Table 4. Assessment of the frequency of use of self-regulation strategies used in problem-solving by means of an equal-interval scale.

Subscales	Score intervals				
	Always	Frequently	Sometimes	Rarely	Never
Planning	20.00 - 17.00	16.90 - 13.70	13.60 - 10.40	10.30 - 7.20	7.10 - 4.00
Self-monitoring	20.00 - 17.00	16.90 - 13.70	13.60 - 10.40	10.30 - 7.20	7.10 - 4.00
Checking	20.00 - 17.00	16.90 - 13.70	13.60 - 10.40	10.30 - 7.20	7.10 - 4.00
Self-evaluation	30.00 - 25.20	25.10 - 20.40	20.30 - 15.60	15.50 - 10.80	10.7 - 6.00

Table 5. Descriptive statistics of problem-solving self-regulation strategies according to gender.

Subscales	Female (n = 278)		Male (n = 274)	
	$\overline{X}$	*SS*	$\overline{X}$	*SS*
Planning	14.40	2.98	13.62	3.02
Self-monitoring	15.34	2.52	15.20	2.77
Checking	13.01	3.19	12.56	3.13
Self-evaluation	21.82	4.05	21.71	4.27

steps very frequently; whereas, they use them in the checking step rarely.

The effect of gender on pre-service teachers' use of self-regulation strategies in problem-solving

The "descriptive statistics" regarding male and female candidate teachers' SRSS subscales scores are shown in Table 5. The average scores belonging to the depen-dent variables of the self-regulation strategies used in this study have been compared with the results of one-way MANOVA analysis. When the results of MANOVA were studied, it was found that there is no significant discre-pancy between the average scores of students statistically in terms of SRSS subscales [Wilks' Lambda(λ) = 0.980, $F_{(4,\ 477)}$ = 2.383, p = 0.051]. Speaking for the dependent variables in general, we can say that MANOVA F value has no statistical significance. Accord-ing to the results of the one-way ANOVA test made for the subscales, on the other hand, a significant discre-pancy was discovered in the planning subscale respecting gender. Moreover, it was noticed that this discrepancy was to the advantage of female students [$F_{(1,480)}$ = 7.788 p = 0.005 $_p^2$ = 0.016]. In this analysis, so as to avoid I. type mistake (alpha mistake), we did the Bonferroni correction. Hereunder, has been taken as = 0.0125 (0.05/4). In the research, the influence quantity of gender on the self-regulation scores has been assessed by partial eta square (η_p^2). Stevens (1992) sug-gests that partial eta square values should be taken as small for $_p^2$ 0.01, average for $_p^2$ = 0.06 and large for $_p^2$ = 0.14. As indicated by these values, it is apparent that gender has a small influence on quantity on the planning subscale. As stated by the results of the one-way ANOVA, gender has no significant influence on self-monitoring, checking and self- evaluation [$F_{(1,480)}$ = 0.297 p = 0.586; $F_{(1,480)}$ = 2.430 p = 0.120; $F_{(1,480)}$ = 0.069 p = 0.792, respectively].

The effect of academic achievement on pre-service teachers' use of problem-solving self-regulation strategies

The "descriptive statistics" regarding male and female candidate teachers' SRSS subscales scores according to their academic achievement are exhibited in Table 6. The average values regarding the dependent variables measured in the study have been compared with one-way MANOVA by accepting the level of academic achievement as a fixed variant. However, the multivariate effect appears meaningful [Wilks' Lambda (λ) = 0.934, F (8, 952) = 4.139 p = 0.000]. Besides, the influence of success on the dependent variables is small (ηp2 = 0.034) . The differences between the variables according to the level of achievement was determined by one-way ANOVA analysis. In that analysis, so as to avoid alpha mistake, was taken as = 0.0125. When the results are examined, it was realized that there were meaningful differences with respect to self-monitoring, checking and self -evaluation [$F_{(2,479)}$ = 4.921 p = 0.008; $F_{(2,479)}$ = 13.383 p = 0.000; $F_{(2,479)}$ = 9.255 p = 0.000, respectively], while there was no significant difference in terms of planning [$F_{(2,479)}$ = 1.644 p = 0.194].

The level of success bound differences diagnosed in self-monitoring, checking and self-evaluation have been

Table 6. Descriptive statistics of problem-solving self-regulation strategies according to the level of academic achievement.

Subscales	Level of academic achievement	n	$\overline{X}$	SS
Planning	Unsuccessful	65	13.48	2.82
	Average	351	14.12	3.04
	Successful	66	14.38	3.09
Self-monitoring	Unsuccessful	65	14.70	2.72
	Average	351	15.23	2.58
	Successful	66	16.10	2.61
Checking	Unsuccessful	65	11.37	2.75
	Average	351	12.84	3.15
	Successful	66	14.17	3.14
Self-evaluation	Unsuccessful	65	19.94	3.77
	Average	351	21.90	4.05
	Successful	66	22.89	4.46

Table 7. Bonferroni test results according to the level of academic achievement.

Subscales	Level of academic achievement	Unsuccessful	Average	Successful
Self-monitoring	Unsuccessful		0.409	0.007*
	Average	0.409		0.039
	Successful	0.007*	0.039	
Checking	Unsuccessful		0.001*	0.000*
	Average	0.001*		0.004*
	Successful	0.000*	0.004*	
Self-evaluation	Unsuccessful		0.001*	0.000*
	Average	0.001*		0.212
	Successful	0.000*	0.212	

Note: *$p < 0.05$.

researched using the Bonferroni test. We have made Bonferroni correction on the significance level for average discrepancy. The results of mutual comparison have been given in Table 7. The use of self- regulation strategies by successful candidate teachers for self-monitoring and self-evaluation was significantly more frequent than the unsuccessful ones. Furthermore, it was evident that successful candidate teachers use self-regulation strategies far more frequently than both unsuccessful and averagely successful ones during the controlling stage.

The factors affecting pre-service teachers' decisions to use self-regulation strategies during problem-solving process

As a result of the phenomenographic analysis made on the data concerning semi-structured interviews, we have come up with seven categories in the qualitative factors affecting the degree of pre-service teachers' use of self-regulation strategies in solving physics problems. These categories are known as planning, self-monitoring, checking and self-evaluation. In accordance with the findings obtained from the first three sub-problems during the interviews, the reasons for candidate teachers' seldom use of the "checking" strategy, the reason why male pre-service teachers are less planned than the females and why unsuccessful candidates make less use of self-monitoring, checking and self-evaluation strategies in comparison with the successful ones, and vice versa, were researched. In line with this criterion, the candidate teachers selected for interview were asked questions considering the average scores they got from the scale.

"A" stands for "the researcher." Successful male-female candidate teachers, averagely successful male-female candidate teachers and unsuccessful male-female candidate teachers are abbreviated as “SFCT-SMCT”, “ASFCT - ASMCT” and “USFCT - USMCT”, respectively.

Below, one can find some of the striking explanations made by the interviewed candidate teachers, which have been very helpful in the setting of those categories.

Planning

A: By looking at your data concerning the scale, we have noticed that you seldomly use planning strategies during the problem-solving process. What can you state as a reason? Could you please explain it to us, please?
USMCT: “...when I start reading a problem, first, I think about the related formulas...if I can write down the right formulas, then I would not need a plan..”
A: Do you think that only writing down the formulas would be good enough to solve a problem?
USMCT: “...well, it may not be, but...some problems do not require long answers. I mean, one or two formulas could be adequate. To tell you the truth, I do not need to make any plans...and I have never seen anyone making a plan before solving a problem...or, perhaps I could not realize that some people are making plans for that”;
ASMCT: “...I have never been told to use such a strategy in the physics classes I have taken before. I do not know much about strategies, anyway…and frankly, I have never realized that I use them rarely..”
A: Alright, how do you start solving a problem, then?
SMCT “...I always underline what has been given in the problem and what I am required to find...I draw figures if needed...I try to understand the problem very well before I start solving it...”
SMCT: “ ...plus, I never make an extra plan...I only think carefully about what the subject of that specific problem is, what the inputs are, what steps to follow..”
A: From your scale average, we have observed that you frequently use the planning strategy. Do you often make plans before solving physics problems? What could be the reasons for that? Could you explain that to us, please?
ASFCT: “...our physics teacher at high school used to tell us that before solving a problem, the first thing that one has to do is identify what is given and what is asked...I always note down what is given and what is asked, and think of a solution accordingly...and I simplify the information in the problem and organize it.”
SFCT: “...First, I have to understand what is going on in the problem very well.. I ask myself what is wanted here, otherwise I cannot solve it, no way...and to understand the problem better, I think out a solution plan in my mind, that is, it looks too complicated to me without a plan. First, I definitely have to write a simple summary of the problem...for example, if there are no figures (shapes), I immediately draw one to comprehend it better.”

Checking

A: On the examination of your data, we have seen that you seldom utilize checking strategies during the problem- solving process. Why do you think you use checking strategies less? Could you explain that to us, please?
SFCT: “...I sometimes think of checking after I solve a problem ...but, if I am not so sure about the result...I mean, if the problem is a complex one, I check what I did as solution ...other than that, I think that it is a waste of time...after all, if the solution is a short one and I did solve it correctly, then I would not need to go over it again and again...”
A: So, you mean that you check it if you had hard times solving it, do you not?
SFCT: “…yes...if there are not many operations, to tell the truth, I do not need to check it...if it makes sense...after all, I can see that it is correct as a whole”
SMCT: “...if I could solve the problem and reach a solution, I feel like it is a waste of time to get back to the beginning once again and go through all those operations again...”
A: What if you have made a mistake?
SMCT: “ ...of course, I may make a mistake. Well, if it is a complex one, if I tried hard to reach a solution, I absolutely check it... yet, if it took only a few operations, then I am not saying that my answer is 100% correct, but I just would not spend time checking it.”
ASMCT: “...if the problem is kind of a difficult one, or if I strived hard to find a solution, then I would definitely check it...”
A: So, you mean that you would check it only if it has been a hard slog, do you not?
ASMCT: “Absolutely...other than that, I think that it is a waste of time...if the solution looks correct anyway, then there is no need to check anything..”
ASFCT: “...I absolutely check up on the result, I mean to see if it is a strange one.. but, I do not necessarily go over the solution entirely...if I have a problem in the middle of it or else, then I start over, but this does not necessarily mean a “complete check”...apart from that, when I doubt the result, I check the unit of the result to make sure if it is a reasonable one or not..”

Self-monitoring

A: We understand from your scale average that you sometimes use self-monitoring strategies when solving a physics problem. What could be the possible reasons for not using those strategies more often? Could you explain that to us, please?
USFCT: “...I have never heard of self-monitoring strategies before...so, I have never realized that I have not been using them often enough...”
A: Let me put it this way: Do you ever ask yourself

questions when solving a problem, or start over to monitor what you have been doing?
USFCT: "...not really...I only focus on formulas and operations…that is, I do not ask many questions... I would rather try to reach a conclusion"
ASMCT: "It is the first time I have heard a strategy called self-monitoring..."
A: Well, what I am trying to ask you is "Do you ever check yourself when solving a problem?" Or, do you ever think about what procedure you should follow or ask yourself questions concerning that during the solution process?
ASMCT: "Not much…perhaps I am doing that unwittingly...but, I have never been taught such strategies.."
A: We have observed in your scale data that you make use of self-monitoring strategies frequently. What are your reasons for using those strategies frequently? Could you explain that to us, please?
SFCT: " ...I might be using them, but not knowingly, I guess… Could you give me an example to those strategies, please?"
A: Well, like judging your method of solution to see if it makes sense or not.
SFCT: "...am I on the right track, I ask myself..." A: Why do you do that?
SFCT: "Because I would like to be sure of myself... "now, I must solve this," I tell myself…I believe that we should do that not to make a mistake."
A: So, your purpose is to be of yourself, or not to make mistakes... So, can we say that you have noticed that you do not make mistakes in this way?
SFCT: "Well, I have realized it myself.. and I was in the 9th grade in high school, I guess.. I used to study with a friend of mine and she used to solve physics problems in this way..she was talking to herself as if she was teaching how to do it to someone else. "
ASFCT: "...while solving a problem, from time to time I check what I have done...I mean, I ask myself if I am doing it right..."
A: Why?
ASFCT: " ...to be/make sure, of course...not to make a mistake, I talk to myself.."
SMCT: "..I have a quick look at what I have written so far when solving a problem...check if I could understand the related notations and the correlations among them well.."
A: Why do you that?
SMCT: "...not to make a mistake, of course... "

Self-evaluation

A: We have observed in your scale average that you sometimes use self-monitoring strategies when solving a physics problem. What could be the possible reasons for not using those strategies more often? Could you explain that to us, please?
USFCT: I do not know exactly how I should evaluate myself about problem-solving... but, when I cannot solve a problem, I believe that I have not studied hard enough; and if I can solve it, then everything is fine...
A: Why?
USFCT: "Because if I could, it means I do not need that...I mean, I have comprehended the subject well enough... so, I do not think of anything...and if I cannot solve it, it is no use evaluating myself about a problem that I could not solve.
ASFCT: "if I cannot solve a problem, I try to evaluate myself once in a while…and, sometimes, I tell myself "you have no idea about this subject, so you had better revise it"...other than that, I do not know if I am using these strategies knowingly..."
A: Why?
ASFCT: "Because what we have learnt so far is to write down the formula, do the related mathematical operations and find the result in the shortest way possible...unlike me, my physics teacher at high school used to make a very short comment on the result, that is all..."
ASMCT: " ... I try to evaluate myself. Yet, I do it only if I have time and tried hard but could not solve the problem …"Why can I not do it?" I ask myself... I would think that I do not know much about this subject, or that there are some formulas I do not know.... if I can solve a problem, then there would be no need for self-evaluation...because I would think that I know that subject very well..."
A: We have noticed in your scale average that you use self-evaluation strategies very frequently. Could you explain the reasons for using them so often, please?
SFCT: "...even though I do not use it for every single problem, if I strived hard to solve a problem, I definitely question myself at the end of the problem... have I done it right? I would think about what knowledge I have used... I go over my solution, at least once."
A: Why do you do to that?
SFCT: "depending on my experience... because if I do not revise the solution or think over it, I might make a mistake …"
A: But you are doing that for the ones you have tried hard to solve, right?
SFCT: "Exactly…you know, I would need to evaluate myself more if I could not solve it or if it needs a comment ..."
SMCT: "…I evaluate myself...I would ask myself what more I need to learn to solve the problem. Not for every problem, but whenever I have hard times or make a mistake, I think over it…"
A: Have you learnt that from someone else, or by yourself?
SMCT: "By myself, I guess…I mean, I question what I could not do and why...I do not do that only when solving physics problems, it is a habit..."

After analyzing the interview data, we classified pre-service teachers' statements into the following categories (common situations):

(1) Considering it necessary/unnecessary (or not needing it): The situation when a candidate teacher expresses that he finds self-regulation strategies necessary or unnecessary, or that he does not need them.
(2) Waste of time: The situation when a candidate teacher thinks that strategies are a waste of time.
(3) Not knowing how to do it: The situation when a candidate teacher does not know how to use a specific self-regulation strategy.
(4) Influence of teachers: The situation when a candidate teacher says that he has learnt how to use self-regulation strategies by observing his teacher.
(5) Influence of peers: The situation when a candidate teacher says that he has learnt how to use self-regulation strategies by observing his peers.
(6) Knowing/not knowing the strategy: The situation when a candidate teacher says that he does not know anything about self-regulation strategies.
(7) Awareness: The situation when a candidate teacher says that he is not aware if he is using self-regulation strategies knowingly.

DISCUSSION

In this study, it has been inferred that generally, pre-service teachers use self-regulation strategies included within planning, self -monitoring and self -evaluation subscales frequently, whereas, they use the self-regulation strategies concerning checking subscale sometimes. Likewise, in the study that was carried out by Çali kan et al. (2006) to identify pre-service physics teachers' problem-solving behavior, it was inferred again that they use planning strategies frequently, while checking strategies sometimes.

According to these findings, one can notice that although pre-service teachers use checking strategies sometimes, they make very frequent use of self-monitoring strategies which are closely related to the former one. It means that besides checking their operations throughout the problem -solving process from the inside rather more frequently, pre- service teachers often do not go over the solution as a whole finally, or check whether their results made sense or not. One possible reason for this might be the fact that some pre-service teachers see checking as unnecessary or a waste of time. Another reason could be that they have not got the habit of using this strategy.

As an answer to the effect of gender on pre-service teachers' use of self-regulation strategies, we have come to the conclusion that in all of the three subscales excluding planning, there is no important difference between the males and females. On the other hand, it has been observed that, when compared to the male pre-service teachers, females utilize planning strategies far more frequently. Various surveys carried out in this field (Ablard and Lipschultz, 1998; Alci and Altun, 2007; Pokay and Bluemenfeld, 1990; Zimmerman and Martinez-Pons, 1990) demonstrate that female candidate teachers take more advantage of self-regulation learning strategies (Pajares, 2002). In the same way, in another research by Zimmerman and Martinez-Pons (1990), it was determined that the female candidate teachers employ planning strategies more often than the male candidate teachers. The fact that female candidate teachers plan more beforehand, shows that they care more about the problem-solving procedure than the males (Israel, 2003). In addition to this, some surprising research results have also been obtained. For example, in a survey conducted by Üredi and Üredi (2005), it was spotted that male pre-service teachers have higher motivation to use self-regulation strategies than the female ones.

As far as it is known, in the single study performed about the effect of gender on the use of self-regulation strategies in physics (Neber et al., 2008), it was discovered that high school-level male students are more active and willing to use them when compared to the same level of female students. Although we have not encountered any studies regarding the effect of gender on the use of self-regulation strategies when solving physics problems, in similar studies about problem-solving strategies by Selçuk et al. (2006, 2007), the findings support the present study's findings in the way that there was again significant differences in the frequency of use of problem-solving strategies in physics problems solving and also, that this situation is mostly to the advantage of female pre-service teachers. Unlike the previous one, Sezgin et al. (2000) did conduct a research on the use of self-regulation strategies during physics problem solving among university level students. As a result, they put forth that the usage of self- regulation strategies does not differ depending on gender. Therefore, we need more studies analyzing the effect of gender on the use of self-regulation strategies.

With respect to their levels of academic achievement, it has been proved that successful pre- service teachers make far more use of self-regulation strategies while solving physics problems. Moreover, the successful senior candidate teachers once again employ self-regulation strategies considerably more often during the self-monitoring and self-evaluation stages in comparison to the unsuccessful candidates. Furthermore, at the checking subscale, the successful ones use these strategies significantly more frequently than both the unsuccessful and averagely successful pre-service teachers. During planning, on the other hand, no considerable difference have been spotted in the use of self-regulation strategies in terms of pre-service teachers' levels of academic achievement.

In this fashion, we can conclude that there is a meaningful relationship between the levels of academic achievement of pre-service teachers and their rate of use of self-regulation strategies. Both in Turkey and abroad, we have come across various researches supporting this specific finding.

Üredi and Üredi (2005) explained that 8th grade students' use of self-regulation strategies is a strong predictor variable of male students' success in mathematics. In the same way, Alci et al. (2010) put forward that metacognitive self-regulation strategies have a critical power on the prediction of mathematical success.

Similarly, Young and Vrongistinos (2002) have demonstrated that successful pre-service teachers make more use of metacognitive strategies in comparison with the less successful ones. Chye et al. (1997), in their study, put forward that there is a considerably high correlation between university students' use of self-regulation strategies and their academic achievement. Ee et al. (2003), in their study on high-achieving sixth-graders in Singapore, demonstrated that the use of self-regulated learning strategies had a direct positive effect on academic achievement. Malpass et al. (1999) also claimed that there are meaningful relationships between mathematical success at secondary school level and using self-regulation strategies. Ablard and Lipschultz (1998) believe that as the number of students' learning objectives increase, they make more use of self-regulation strategies. Besides, Camahalan (2006) in his studies at elementary school level, VanZile-Tamsen and Livingston (1999) at university level and Zimmerman and Martinez-Pons (1990) both at elementary and secondary school level, proved that there is a significant relationship between students' use of self-regulation strategies and their academic achievement. In additional, Ibe (2009) claimed that the metacognitive strategies were effective in enhancing science academic achievement.

Although there is no study that directly analyzes the relationships between the use of self-regulation strategies and physics problem -solving, in a study about the relationship between the use of problem- solving strategies and success in physics (Çali kan et al., 2008), it was demonstrated that, both in the experimental and control groups, after teaching the strategies, there was a considerable statistical difference between the successful pre-service teachers and the unsuccessful ones in terms of use of self-evaluation strategies. Likewise, in a study about the use of problem-solving strategies in physics by Selçuk et al. (2006), it was observed that the successful senior candidate teachers use problem-solving strategies noticeably more often than the unsuccessful ones.

Based on the interview results in this specific research, we have found various factors influencing the candidate teachers' use of self-regulation strategies when solving physics problems. It has been discovered that some of the reasons why they use checking and planning strategies are seldom due to the fact that they think it is unnecessary, a waste of time and not knowing those strategies. On the other hand, some of the reasons why some teachers use those strategies frequently are either because they have seen or learnt them from their teachers or peers who use them, or know of them. In addition to that, the majority of the candidate teachers employing these self-regulation strategies have admitted that they use them only when the problem is a complex one. In this fashion, we can say that excluding the situations when candidate teachers do not know the explained strategies or do not use them knowingly, one cause of considering these strategies as a waste of time or unnecessary could be due to their belief that the problems being solved do not require long solutions, or that they are not challenging. From this judgment, we think that it is of crucial importance to create conditions that would require the use of these strategies.

Conclusion

This study shows that pre-service teachers use self-regulation strategies at planning, self-monitoring and self-evaluation stages when solving physics problems frequently, whereas, they rarely utilize them at the controlling stage.

Broadly speaking, no significant discrepancy has been found between the use of self-regulation strategies by female and male pre-service teachers. However, it has been observed that female senior candidate teachers are more planned. Moreover, it has been noted that the successful pre-service teachers employ self -regulation strategies far more frequently than both the averagely successful and unsuccessful ones. Furthermore, based on the interview results of the frequent strategy-users, it has been discovered that they prefer to use the strategies when the problem is a complex one.

Schoenfeld (1985) explains that most studies prove that the majority of students cannot develop perfect checking strategies, and for this reason, their problem-solving skills deteriorate in time. According to Sungur (2007), metacognitive skills are commonly regarded as a function that enables students to become active individuals in societies after they graduate from school. These skills have a critical role in improving "learning to learn". From this point of view, a learner that uses planning, self-monitoring and self- evaluation abilities to his advantage in the best way can make effective decisions when learning something or looking for the right sources of information by applying the appropriate cognitive strategies. What is more, those learners are aware of their performance, comprehension and can judge their way of thinking, learning and its consequences. In this sense, it is believed that pre-service teachers must be provided with learning activities that will enable and support them to utilize self-regulation strategies.

Particularly, educators, academicians or teachers must introduce these strategies to students and determine the levels of their usage. During classes, rather than practicing short and simple solution- requiring problems, they should deal more frequently with high-level cognitive problems that allow students to think and question. They should be encouraged and supported to use these strategies.

Since this study is a cross-sectional one, there are some limitations. However, it is a snap shot study. For this reason, if the same survey is repeated at another time, one might obtain different results. Another limitation of the study is that because we implemented the qualitative interview method and talked to a few students, it is not possible to make exact inferences based on any reason.

A recommendation for future research on this subject matter would be to analyze (a) the relationships between students' use of self-regulation strategies and time-bound changes, (b) the effects of different teaching methods such as problem- based learning and cooperative learning on students' use of self-regulation strategies and (c) the relationships between students' use of self-regulation strategies and their affective behaviors like their attitude towards the course, solving problems and motivation to learn.

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