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The effects of students' problem solving skills on their understanding of chemical rate and their achievement on this issue

Fulya Öner Armağan[a*], Şafak Uluçınar Sağır[b], Ayşe Yalçın Çelik[c]

[a]*Education Faculty,Department of Primary Science Education, Gazi University, Ankara, 06500, Türkiye*
[b] *Education Faculty , Department of Primary Science Education, Amasya University, Amasya, Türkiye*
[c]*Education Faculty, Department of Secondary Science and Mathematics Education, Gazi University, Ankara, 06500, Türkiye*

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Abstract

Problem solving is a part of thinking. There are several steps of problem solving. The first thing which is necessary for solving personal and organizational problems is the knowledge of problem solving process. Students who have learned problem solving process can be successful in every stage of their lives by using these skills in finding solutions to the encountered difficulties and problems. In this study, the effect of students' problem solving skills on achievement in the chemical reaction rate and the effect of temperature and concentration on the reaction rate subjects is investigated; students are from several different departments. Quasy experimental design was used in this research. SPSS 11, 5 packet program was used to evaluate the data. Independent sample t-test was used to compare the post test scores of groups and it was not found a statistically meaningful difference. One-way ANOVA analysis is used to find out whether there is a difference in results of post-test, aimed to measure students' problem solving skills, with regard to departments where students are studying. According to the result of ANOVA test there was statistically significant difference in control groups' post-test scores considering the departments of students whereas there was not significant difference in the post-test scores of experimental group. Additionally, the effect of problem solving skills on achievements of female and male students was investigated and a situation in favor of females students was observed.

Keywords: Problem solving; chemistry education; chemical reaction rate.

* Fulya Öner Armağan. Tel.: +9 0312 2028102; fax: +9 0312 222 8483.
E-mail address: armaganf@gazi.edu.tr.

1. Introduction

Individuals consistently encounter problems in all fields. New methods and strategies should be developed to solve problems quickly and effectively (Posamentier, 1998). Individuals' skill of problem solving is related to their concentrating on the problem and self-evaluation (Heppner, Baumgardner and Jackson, 1985). Problem solving skill will help us to resolve problems in not only academic life but in all parts of the life. Researchers and educators need more information about problem solving process to help their students more efficiently. If problem solving skill is a cognitive activity then, improving problem solving skill through education should be a valuable goal (Seminara, 1996).

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Lumsdaine and Lumsdaine (1995) state that problem is not an assignment which requires completing missing parts. A problem has two characteristics; problem can involve a difficulty or can mean an opportunity. A problem can involve two or one of these characteristics. Problems are, generally, composed of ambiguity, relations and problems that contain difficulty and situations whose accuracy and truth are not certain.

The concept of problem solving was systemized firstly by American educator John Dewey and Russian educator Vygotsky. Individuals' skill of problem solving is related to their concentration on the problem and self-evaluation (Heppner, Baumgardner and Jackson, 1985).

Most of the people think that they are born with problem solving skill. However, there are not many people who receive training and perceive the importance of problem solving (Kneeland, 2001). When we face with a particular problem, analyzing and decision-making skills gain importance. Notwithstanding, individuals develop, unconsciously, their own methods of problem solving and decision making with their own personality, being brought up styles and things that they learn in school (Arnold,1992). In fact, problem solving skill is a skill that can be learned like other skills. Therefore, the first thing that is necessary in solving individual and organizational problems is knowing problem solving process. Problem solving process can be facilitated by using open ended materials and group projects to provide integrated learning even when the pressure of time is involved. Those who will do this are teachers (URL, 2006).

Studies have shown that many secondary and higher education students have problems based on deficiency of information and skill in problem solving stage. The first of these issues is that students could not show some skills such as comprehension and inference. However, students' understanding scientific events is very important for science education because problem solving skill is closely related to problems that students face in daily life. In this aspect, developing problem solving skill has a particular importance for success in other fields of science and learning many chemistry topics meaningfully.

Students apply previous information in new situations and this is an indicator of their problem solving skills. Fogler and Leblanc (1995) state that a problem does not have a single solution and different methods should be applied in different situations. Students that have learned problem solving process can be successful in all fields of life by using these skills and finding solutions to individual problems and difficulties.

Researchers have made some studies about the stages of problem solving. Findings in the researches have shown that there are some differences that take root from present theoretical information, problem used in the research or individual solving it. In the field of chemistry problems that people face take root from different reasons. These are: students can not perceive chemical concepts (Enoch and Gabel, 1984; Nurrenberg and Pickering, 1987), memory is overcharged (Frazer and Sleet, 1984), males' performances are better than the females' (Tobin and Garnett, 1987), interest in science is low and poor performance (Weinburgh, 1995).

Chemistry is seen as a difficult field by students, teachers and researches. Students have difficulty in this field because chemistry topics are very brief (Ben-Zvi et al., 1988) and there is a chemistry language that is different from the language used in daily life (Bergquist and Heikkinen, 1990). Science education in schools causes big problems owing to students' misunderstandings (Johnstone and Kellett, 1980; Nussbaum, 1981). In a research about chemical rate it has been observed that students have some misunderstandings in this topic. Misunderstandings are: misunderstanding expressions under the headline of "reaction rate" show that rate law equation, reaction length and reaction process are confused with reaction rate and a particular concentration criteria is considered in explaining the reaction rate. Misunderstanding expressions under the headline of "reaction rate-temperature relation"; show that increase in reaction rate and temperature is explained with the increase of molecules' kinetic energy and average speed, although it does not give any information about whether increase in the experiment is endothermic or exothermic, it is thought that increase in temperature affect the rates of endothermic and exothermic reaction in a different way (Nakiboğlu et al., 2004).

2. Purpose Of The Study

In this study our aim is to examine the effect of gender and the method which developed problem solving skills on the success of students, in Science, Chemistry and Mathematics Education Departments, in the field of reaction rate.

Methodology

Sampling

Sampling of this study is composed of 122 students in the department of Science (39), Chemistry (37) and Mathematics (46) Education Departments in Gazi University, Gazi Education Faculty during 2005-2006 education year; these students are taking General Chemistry Laboratory (Table 1).

Table 1. Distribution of the Sampling According to Groups and Gender

	Science Teaching				Chemistry Teaching				Mathematics Teaching			
	Control		Experimental		Control		Experimental		Control		Experimental	
Gender	**n**	%	**n**	%	**n**	%	**n**	%	**n**	%	**n**	%
Female	11	57,9	12	60,0	12	70,6	13	65,0	14	63,6	13	54,2
Male	8	42,1	8	40,0	5	29,4	7	35,0	8	36,4	11	45,8
Total	19	100	20	100	17	100	20	100	22	100	24	100

3. Method

Before the practices Scientific Process Skill Test and Logical Reasoning Skill Test were applied to students. Since students have been taken Chemical Kinetics in General Chemistry Course in the first term of the school year, mean of the General Chemistry course marks have been considered as pre-test score. A test including information about chemical kinetics has been arranged as post- test and it has been applied after the activities. Opinions of experts have been taken to prove validity. Quasy experimental desing was used in the research. In these three departments a control group and an experimental group have been selected randomly. Experimental group students have been given information about problem solving strategies and two verbal problems has been arranged and applied to determine students' problem solving skills. In control groups, course is conducted with traditional methods.

Instruments

Logical Reasoning Test (LRT): The original test was developed by Tobin and Capie (1981). This test is composed of ten questions; 8 of the questions are multiple choice questions and 2 of them are open ended questions. The test measures determining and controlling variables, proportion probability and synthesis skills of students. The reliability of the test has been determined as $\alpha = 0, 79$.

Scientific Process Skill Test (SPST): The original test was developed by Burns, Okey and Wise (1982). Translation to Turkish and adaptation of this test was formed by Özkan, Aşkar and Geban (1991). This test contains 36 multiple choice questions (with 4 choices). Five subsections that form the test aim to test different view points of scientific process skills. The reliability of the test has been determined as $\alpha = 0, 82$.

Achievement test

A test composed of 7 open-ended questions was applied by researches to measure students' knowledge on chemical rate. This test consists of questions related to writing chemical rate equations, factors affecting the rate (temperature, concentration and catalyst effect), determining rate and constant rate. The opinions of chemical instruction experts regarding validity and reliability of the test have been applied.

Application:

A week before the related experiment, students in experimental group were given questions related to the effects of concentration and temperature on reaction rate and they were asked to define, analyze and evaluate the problem. During the experiment week, it was considered that which factors can be related to chemical reactions under the

light of the data presented in the problem. In addition, discussion among students about the research method and experiment findings was provided. At the end of the two-week period, students' observation of the experiment and their responses to the questions were controlled and feedback was given. During two weeks classes were conducted traditionally in control group (explanation, question-response) and at the end of the lesson a test was applied to both of the groups.

Analysis of data:

Responses given by students were evaluated in SPSS 11.5 Packet Program. Descriptive analysis was made to determine the distribution of students according to their gender, department and group. Scores of the pre and the post tests were used in analyzing variables; independent samples t-test was used to examine differences between control and experimental group and examine differences between females and males. One way ANOVA test was used to examine the effect of the department on problem solving skill.

Results and Discussion

Statistical analysis have been done by comparing the data of experimental group, in which we aimed at developing problem solving skills, with the data of control group in which the traditional teaching method was used .

Table 2. Comparison of LRT, SPST and pre-test scores before instruction

Test	Group	n	$\overline{X}$	S	df	t	P
LRT	Control	58	7,83	1,74	117	,483	,630
	Experimental	61	7,67	1,75			
SPST	Control	58	26,22	3,73	120	-,056	,955
	Experimental	64	26,26	4,36			
Pre-test	Control	57	46,57	16,63	119	,990	,324
	Experimental	64	43,64	15,99			

As it is seen in Table-2 there is not a meaningful difference among the LRT, SPST and pre-test scores of control and experimental groups (p>.05). This case has shown that control groups and experimental groups were equal before the instruction.

After the application independent sample t- test was applied to compare the post-test scores of control and experimental groups (Table 3). Comparison of post test scores was showed in Table-3.

Table 3. Comparison of post-test scores between groups after the instruction

Group	N	$\overline{X}$	Sd	Df	t	p
Control	58	36,81	19,26	118	-,985	,327
Experimental	62	40,53	21,95			

According to results in Table 3, there is not a meaningful difference between groups post-test scores after the instruction of chemical reactions' rate [$t_{(118)}$= -0,985; p> .05] Average of control groups' post-test score was 36,81 and average experimental groups' post-test score after instruction was 40,53.

One way ANOVA was applied to examine whether there is a meaningful difference between on post-test results and departments at which students receive education (Table 4).

Table 4.a. Desciptive statistics of post-test results according to departments and groups

Group	Department	N	$\overline{X}$	Sd
Control	Mathematics	22	28,82	16,19
	Science	19	32,47	20,17
	Chemistry	17	52,00	12,80
	Total	58	36,81	19,26
Experimental	Mathematics	23	36,13	20,95
	Science	20	45,45	24,89
	Chemistry	19	40,68	19,76
	Total	62	40,53	21,95

Table 4.b. ANOVA results of post-test scores according to departments

Group	Sources of Variance	Sum of Squares	Df	Mean Square	F	p
Control	Between Groups	5684,904	2	2842,45	10,117	,000
	Within Groups	15452,010	55	280,94		
	Total	21136,914	57			
Experimental	Between Groups	929,772	2	464,88	,964	,387
	Within Groups	28463,664	59	482,43		
	Total	29393,435	61			

According to these results there is a statistically meaningful difference ($F_{2\text{-}57}$= 10,117 ve p< .05) between departments and post-test results in control groups. Scheffe test applied to find which department causes this difference showed that there is a meaningful difference between average post-test scores of chemistry and mathematics students and chemistry and science students. Average post-test scores of mathematics students was 28,81 while average post-test scores of chemistry students was 52,00 and science students score was 32,47. There is not a meaningful difference between the average post-test scores of departments' experimental group (p> .05). However science experimental groups' average is higher than others (45,45).

It was examined that whether there is a meaningful difference between students' gender and achievement according to groups with independent sample t-test (Table 5). It was found that there is a meaningful difference between average post-test scores of males and females. This meaningful difference is in favor of females.

Table 5. Comparison of post-test scores according to group and gender

Group	Gender	n	$\overline{X}$	Sd	df	t	p
Control	Female	37	42,46	19,30	56	3,196	,002
	Male	21	26,86	14,94			
Experimental	Female	37	52,27	18,66	60	6,729	,000
	Male	25	23,16	13,25			

The average post-test scores of female students in control and experimental groups are higher. It has been found that there is not a meaningful difference between the average post-test scores of female students in control group (52,27) and in experimental group (42,46). Independent sample t-test was used for this analysis (Table 6).

Table 6. Comparison of female students' post-test scores in control and experimental groups.

Group	n	$\overline{X}$	Sd	df	t	p
Control	37	42,46	19,30	72	-2,223	,029
Experimental	37	52,27	18,66			

It has been found that the average of female students in control group is 52,27, on the other hand the average of female students in experimental group is 42,46. It has been determined that the difference between them is meaningful [$t_{(72)} = -2{,}223$; $p < .05$]. Also, it has been determined that female students that have learned problem solving method and chemical rate are more successful than male students and than other students to whom the traditional method was applied.

4. Conclusion and Suggestions

Problem solving is a process rather than a result (Kneeland, 2001). Therefore, it is wrong to decide by considering only last product (solution). Problem solving is all the processes during the problem solving efforts (Blum and Niss, 1991). Determining and evaluating what kind of efforts students make and how they find a solution is very important because problem solving process begin with recognizing the problem. People gain information about the problem, apply to sources and gather data. Person that solves the problem develops some hypothesis according to obtained data; makes appropriate elections among them and finds a solution.

In this study as a result of feedbacks of students is understood that students have some misunderstandings about chemical rate and these misunderstandings can be corrected. The students sometimes can not relate data and findings and this is the factor that causes misunderstandings. For example the biggest mistake in this study what kind of relation there is between chemical reaction rate and reaction time was not determined. Another misunderstanding is about the relation between temperature and reaction rate. However at the end of this study it was observed that if students are given opportunities, their problem solving skills can be developed. Planning the course with the activities such as narration technique and scenarios affects the attitude of the course positively. This fact should not be ignored while planning the course. Also this develop students' problem solving skills.

In this study it was observed that students discuss their findings on their own before open sessions and this provide cooperation and positive attitude in the course. Also students' responsibility, self-confidence and self-proficiency can be developed.

Students that use brain storming in problem solving processes, gain practicability in speaking, agreement and cooperation. Reasoning on the results and making elections provide that students gain empathy, compromise and they share the responsibility of the decision. In conclusion children can be independent evaluator in their jobs by evaluating their errors and elections.

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