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Investigation of Effects of Theoretical and Applied Education on Success and Recall Level in Analytical Chemistry

Ayşen Demir Mülazımoğlu[1]

[1]*Necmettin Erbakan University, Ahmet Keleşoğlu Education Faculty, Chemistry Department, Konya, Turkey*
Email: admulazimoglu@konya.edu.tr

Abstract

In this study, a true-false test, selected from Analytical Chemistry textbook, was applied to investigate the effects of lesson learned in theoretical and applied in Analytical Chemistry to students' achievement and recall levels. A 30-item test, selected from the basic subjects, was applied to a group of 81 students as the Secondary Chemistry Education Program of Faculty of Education. This group was selected from the 2nd, 3rd, 4th and 5th grades and tried to apply to the groups of approximate twenty students to compare female and male students in every class. As a result of the study, it has been determined that analytical chemistry topics are easier to understand and remember when they are thought as applied in the laboratory. Another result of this study was found that female students were more successful than male students. When the overall female students are taken into account along with the other lessons this is an expected result. One of the expected results of this study is that 2nd grade students were more successful than the other grades due to Analytical Chemistry and its application are given at the 2nd grade in the program. Besides all these results 4th graders are found to be more successful than 5th graders due to teaching of the pedagogical lessons at the last three terms of the program.

Keywords: Analytical chemistry, Applied education, Gender difference.

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1. Introduction

It is an indisputable fact that many theoretical studies have supported the theoretical lesson with its application has positive effects on the level of learning and remembering. In addition, it should be known that the theory and the implementation must overlap one another. On the basis of the theoretical teaching give regularly, the reinforced teaching constructed by repeating the application is placed in the memory in an unforgettable way and makes it easier to remember again when it is necessary.

Chemistry is an active subject which involves principles that are essential to both the realms of nature and society. It deals with the composition of matter and its features (Mailumo *et al*., 2009). In addition, it is seen as a center of science that unifies the other science subjects (Agogo and Otor, 2013; Hanson *et al*., 2016). Chemistry is a difficult lecture to learn because students mostly encounter physical phenomena in their daily lives rather than chemical ones (Hand and Treagust, 1991). Although there are many methods offered by researchers in order to learn chemistry well (e.g., laboratory activities, multimedia, IT etc.), for the permanence of this knowledge, namely to become an expert in chemistry, a cognitive structure of the basic knowledge, problem-solving skills and expert-like attitudes and approaches are required (Duran, 2016).

The researches that have been performed for a long time show that the laboratory studies increase the interest and the abilities of the students towards science subjects (Bryant and Edmunt, 1987; Bekar, 1996; Bayrak *et al*., 2007).

If we list the benefits of applied education, especially given laboratory practices are crucial as theoretical training support, we would reach the following results.

-In theoretical teaching, students may not comprehend the subject very well. This problem may be overcome in applied teaching that would be interesting to the students.

-Laboratory applications are much more enjoyable because they are student centered compared to theoretical lessons.

-An application performed with interest focused affects the motivation of the students positively.

-Appropriate equipment for the purpose of practice strengthens learning.

-Learning becomes faster and more reliable because the students make observation and take measurement by themselves.

-All pre-acquired information is transferred to practice through applications.

- Since the final results are achieved, the knowledge learned by the applications performed is better placed in the permanent memory and is easily remembered when it is necessary.

- The report prepared at the end of the performed experiment makes it possible to review and reinforce the interpretation of the results obtained.

The scientific researches clearly state that use of the laboratory at the stage of chemistry education in general according to the knowledge acquired during the practice provides;

-understanding the essence and method of science

-improving problem solving ability

-reviewing daily life events with more conscious

-improving the ability to analyze and generalize.

In addition to these skills,

-increasing the interest and motivation for the lecture

-gaining positive attitude towards scientific research and being a scientist

-better understanding in grouping and organizing ideas by exchanging the ideas with each other (Whisnant, 1982; Rigano and Ritchie, 1994; Nakiboğlu and Sarıkaya, 1999; Coştu *et al*., 2005).

The widespread practice of students' practical work in the laboratory to wonder how they have contributed to the understanding of the topics taught in the theoretical lessons, and high practical cost of doing so has widened the scope of research on the learning environment in classroom and learning environments in science laboratory lessons have also been addressed (Tobin, 1990; Woolnough, 1991).

It is a known fact that males and females have different interests of subjects. This applies to all Analytical Chemistry and laboratory as well as to the theoretical and practical lessons. For the education to be effective for all students in the class to be successful, the teacher should remember that each student has its own characteristics while considering the common characteristics of the students in preparing the curriculum and should offer alternative activities appropriate to the individual characteristics of the students (Coşkun *et al*., 2007; Mülazımoğlu *et al*., 2008).

The present study is very important in terms of applying the Analytical Chemistry lesson in chemistry education and the students who have already seen the laboratory practice and assessing the results according to the gender differences as well as between the classes.

2. Purpose

The aim of this study is to examine the contribution and effects of learned knowledge to the level of learning and remembering in theoretical and its application which is given as separate lessons in the undergraduate program.

3. Method

3.1. Sample

The sample of this work consists of a group of 81 students consisting of 2nd, 3rd, 4th and 5th grades who are educated in Chemistry Education Department of Selçuk University, Education Faculty, Department of Secondary Education Science and Mathematics Education. The distribution of this sample by classes and genders is given in Table 1.

Table-1. Distribution of student numbers by class and gender

Class	Female	Male	Total
II	13	5	18
III	9	11	20
IV	12	12	24
V	7	12	19

Source: Selçuk University, Education Faculty

3.2. Data Collection Tool

In the study, a total of 30 questions were selected for the sample group, 15 questions from the theoretical background and 15 questions from the practical background along with the theoretical basis. Correct or incorrect markings were required. The groups were given 15 minutes to answer these questions. There are two reasons for limiting the time; the first one is to ensure that the learners give the first thought of answer to the questions, thus preventing the question from returning again, and the second is to prevent them from cheating. The questions and the answers directed to the students in the study were given as Annexes.

3.3. Application

The 30-item test, which was directed to the students in the study, was classified according to the degree of difficulty and it was tried to determine which questions were more difficult. Although higher accuracy rate was expected from the application basis questions in some theoretical basis questions higher accuracy was observed. The test results were evaluated among the classes and success rates were compared. Females and males were compared within their groups and in general. In some questions, males were found to be more successful. But it is seen that females in all grades and in total were found to be more successful generally.

Table-2. Classification of questions according to difficultness

Grade	Difficulty Level and Questions				
	0,00-0,10	0,11-0,30	0,31-0,60	0,61-0,90	0,91-1,00
2	---	3, 23	2, 7, 9, 11, 14, 19, 22, 27, 30	1, 4, 5, 6, 10, 12, 13, 15, 16, 17, 18, 20, 21, 24, 25, 26, 28, 29	8
3	7	3, 23, 27	2, 5, 10, 14, 15, 18, 19, 22, 28, 29, 30	1, 4, 6, 8, 9, 11, 12, 13, 16, 17, 20, 21, 25, 26	24
4	7	22, 23	1, 2, 3, 9, 14, 19, 21, 27, 29	4, 5, 8, 10, 11, 12, 13, 15, 16, 18, 20, 24, 25, 28, 30	6, 17, 26
5	---	3, 7, 14, 22, 27	1, 2, 8, 9, 13, 19, 23, 29	4, 5, 6, 10, 11, 15, 17, 18, 20, 21, 24, 25, 26, 28, 30	12, 16

Source: Author's field work

The distribution of the 30 questions asked to the students in theory and practice in the study is given in Table 3.

Table-3. Classification of questions directed to students according to the topics taught in theory and practice

Question No	Theory	Theory + Practice	Question No	Theory	Theory + Practice
1		x	16	x	
2		x	17	x	
3	x		18		x
4		x	19		x
5	x		20	x	
6		x	21		x
7	x		22		x
8		x	23	x	
9	x		24	x	
10	x		25		x
11	x		26		x
12		x	27		x
13		x	28	x	
14	x		29		x
15	x		30		x

Source: Author's field work

The distribution of the 30 questions in the Analytical Chemistry curriculum according to the subjects is given in Table 4.

Table-4. Distribution of questions by subject area

Question No	Subject
1, 2, 3, 4, 5, 6, 7, 11, 16, 17, 21	Gravimetric analysis methods
1, 3, 8, 9, 10, 11, 12, 18, 19	Titrimetric analysis methods
4, 10, 11, 13, 14, 15, 18, 19, 22, 23, 25, 26, 29	Aqueous solution chemistry
17, 20, 24, 28	The impact of ionic balance
10, 18, 22, 25, 26, 29	Application of equilibrium calculations to complex balances
10, 22, 23, 29	Theory of neutralization titrations
12, 13, 14, 15, 19, 25, 26, 27	Titration curves for complex acid / base systems
13, 19, 25, 29	Applications of neutralization titrations
6, 10, 12, 19	Precipitation titrations
21, 30	Complex formation titrations

Source: Author's field work

4. Conclusions

The data obtained in the study were evaluated with SPSS 15.0 package program. Through this program, the difficulty ratings of the questions were determined, comparisons were made between male and female students and among the classes, and the results were given in the Figures. As a result of the study, it was determined that the 2nd grade students were more successful than the other classes, but the success rates of the 4th grade students were similar to the 2nd grade students. It is commented that the majority of the 4th classes are taking these two lessons again, which might have a positive effect on the success of the test. However, it is an unexpected result that 4th grade students should be more successful than 3rd grade students and it is necessary to work on them. Such that the majority of third grade students take these two lessons again. In this case, the success of 4th grade students may arise from their experience and their approaches to the topics with more consciousness.

When Table 2 is examined, it is seen that the questions 3 and 23 are difficult to answer while there are no questions that are very difficult for 2nd grade students. This situation is confronted as seventh question in 3rd grade students, and it is seen that the 3rd grade students are difficult to answer the questions 3, 23 and 27, and 4th grade students are difficult to answer the questions 22 and 23. While there were not very difficult questions for 5th grade students, it was seen that they were difficult to answer the questions 3, 7, 14, 22, 27. It is seen that 2nd grade students answered very easily to question 8 and 3rd grade students answered very easily to question 24. When Table 2 is examined, it is seen that 4th grade students answered the questions 6, 17 and 26 and 5th grade students answered the questions 12 and 16 very easily.

In Table 3, it is seen that the questions that are very difficult for the 3rd and 4th grades are given only theoretically in Analytical Chemistry lesson. According to Table 3, it was determined that the level of correct answer and remembering is higher for the questions about the subjects that students usually learned in practice following the theory. This is very important in terms of revealing how important Analytical Chemistry needs to be practiced in the laboratory as well as theory.

Furthermore, when the answers given by the students to these questions were examined, it was determined that they gave false answers to the questions. Due to the fact that even though the graders had been thought theoretically, they couldn't have visualized the topics in their mind. This case can be understood when the answer to the seventh question is examined. For this question although the students are well aware of the theoretical aspect of precipitate formation, they couldn't have visualized this formation in their mind. The same reason is valid for the answers of the questions 3, 14, 23 and 27. Students are quite successful answering the questions number 6, 8, 12, 16, 24 and 26, as the practice on these questions is performed in the laboratory and they observe the real application about the topics in the laboratory.

When the right and wrong answers given to the questions were examined statistically, it was found that seventh question was the most correct answer by 2nd grade. There is a significant difference between the results of 2nd grade and the other grades. In addition, it was determined that eighth and thirteenth questions were the most wrongly answered by 5th grade and the found difference was significant. The thirtieth question was the most wrongly answered by 2nd grade students and thus a significant difference was calculated. Statistically, no significant difference was calculated among all grades.

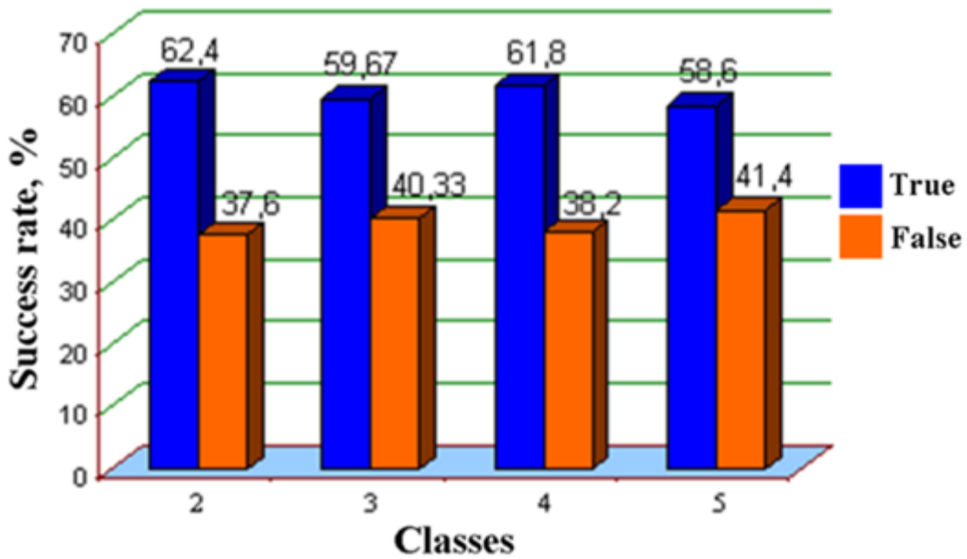

Figure-1. Overall success rates between classes.

Source: Author's field work

When Figure 1 is examined, the success rates of the classes over the totals of male and female students are determined as 2nd, 4th, 3rd and 5th grades, respectively. This result supports what is initially expected. The low success of both males and females in the 5th grade is a situation that needs more attention and caution.

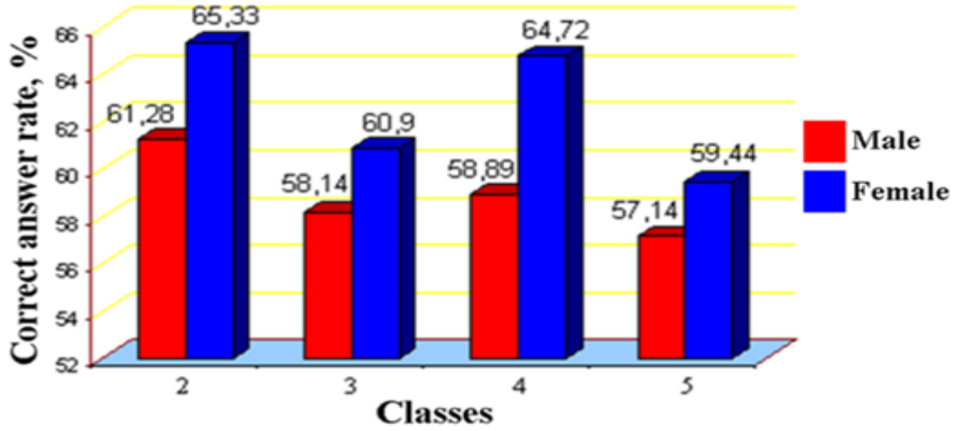

Figure-2. Comparison of correct response rates between male and female students among classes.
Source: Author's field work

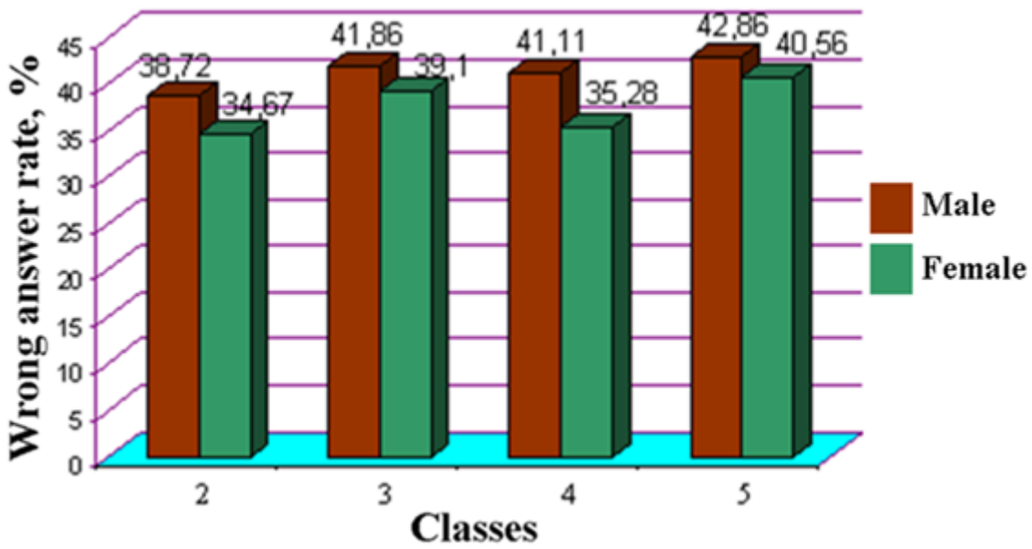

Figure-3. Comparison of wrong answer rates between male and female students among classes.
Source: Author's field work

When Figure 2 and Figure 3 are examined, there is no significant difference between the male and female students according to the answers given to the questions in general. Despite this, it is seen that females are more successful in all classes in Figure 1. This situation overlaps with the fact that female students have higher student selection and placement test scores and their success rates are higher than male students in the classroom environment they are studying.

5. Discussions

When the conducted study and the evaluated data are taken into account, the following results have been reached.

-The Analytical Chemistry is a quite difficult lecture for the students when they consider the wrong answer rates.
-The knowledge acquired in practice for students is more permanent as well as more accurate.
-Even if students have seen some subjects in theory or practice, they cannot learn the notions that they cannot recall easily in their minds or they forget very easily.
-It is more permanent and easier to remember information that students learn by visualizing.
-Female students who were found to be more successful in their undergraduate studies were successful as a result of evaluating the answers given to the questions.
-The student selection and placement test scores they receive when entering the Chemistry Education Program are important indication of the success of students in their undergraduate studies.
-The high number of students who repeat both Analytical Chemistry and Analytical Chemistry laboratory lessons should be considered as a factor that reduces their success due to the prejudices of the students taking this course for the first time.

6. Recommendations

It is obvious from this study that Analytical Chemistry lesson should be given with its more intense application. It is necessary for the students to be taught that each lesson is easy and understandable and that no lesson should be approached with prejudice. The idea that every work approaching with prejudice will be lost from the beginning must be known by the students. Since more regular and planned female students are more successful, male students should have the same behavior. One of the reasons for the low level success of the students is that they are worried about not being able to do their profession after completing the chemistry program. One recommendation could be a better correlation between the theoretical and application basis. The application of the theoretical knowledge in the laboratory should be a good representative of daily life and environment.

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Examination test asked to students for "Investigation of Effects of Theoretical and Applied Education on Success and Recall Level in Analytical Chemistry"

Description: *The following is a true-false answer questions thirty blended from selected some topics in Analytical Chemistry. Please give all questions the answers that come to you first and that you know correctly or that are most reasonable to you.*

			T	F
1	Gravimetric analysis also be consulted while the titration process.		x	
2	We measure the mass in lab also the fact that we say we measure we use weights and weight in the calculations.			x
3	Stoichiometry refers to the qualitative relationship between the amount of product with reactants.			x
4	Gravimetric analysis methods are based on an analytical balance to measure mass.		x	
5	A colloidal particle is a solid with a diameter ranging from 10^{-4} to 10^{-7} cm.		x	
6	The supersaturated solution is an unstable solution and tends to collapse.		x	
7	Precipitates; nucleation, grain growth, mechanical drift, and entrapment.			x
8	The solutions prepared from primary standard materials are called standard solutions.		x	
9	Secondary standard substances can also be used as reference substances in titrimetric analyzes.		x	
10	In particular, when no suitable indicator is found, the back titration procedure is used.		x	
11	The formula that shows the simplest integer ratios of the atoms in a chemical compound is the molecular formula.			x
12	Actually; a turning point is an interval, the equivalence point is a theoretical point.		x	
13	In order for the buffer solution to form, the compounds must have an analytical concentration.		x	
14	Conjugate acid-base pairs can react in some cases.			x
15	Perchloric acid and hydrochloric acid are stronger in perchloric acid if they are ionized in methanol, although the acidity forces are the same in ionized form in water.		x	
16	Surface adsorption in the formation of precipitates is a contamination event.		x	
17	The common ion in the dissolution of solids reduces the solubility.		x	
18	When preparing an acid solution, the addition of some water is due to the fact that the ionization of the acid is endothermic.			x
19	Although the equivalence point is known as the point at which the number of moles of the analyte is equal to the standard reagent added in the titration, it is actually the point where the concentrations are equal to each other.			x
20	Neglect in analytical chemistry problem solving can be done only in equations of addition and subtraction.		x	
21	EDTA solutions are prepared from the disodium salts due to the fact that the primers are standard.		x	
22	They can be used as titrant in weak acid and base in some cases in titration process.			x
23	In some cases, the pH may be negative, such as near zero.		x	
24	A kind of activity is a measure of the effective concentration.		x	
25	An acidic salt consists of a mixture of a weak acid with a slight amount of a strong base.			x
26	In the solution environment, both proton-accepting and proton-yielding species are called amphiprotic species.		x	

27	The carbonate defect is the presence of excess carbonate ions in the solution environment.			**x**
28	In order for Debye-Hückel Equality to be available, the solvent must be water.		**x**	
29	The use of a buffer solution having a pH of 4.74 in a desired solution having a pH of 3.50 is not suitable.		**x**	
30	Since the Eriochrome Black-T indicator is a basic indicator, it is more suitable to use for solutions with a pH lower than 7.00.			**x**