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# Effect of 5E Learning Cycle and V Diagram Use in General Chemistry Laboratories on Science Teacher Candidates' Attitudes, Anxiety and Achievement

By

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## Abstract

*The most important characteristic that distinguishes physical sciences from other disciplines of science is the emphasis on experimentation, observation and discovery. The significance of using methods that focus on this characteristic in chemistry laboratory classes is obvious. Current research was aimed to investigate the effects of teaching method implemented in General Chemistry Laboratory II class on academic achievement, attitudes towards chemistry, chemistry anxiety and attitudes towards chemistry laboratory of science teacher candidates who attended a state university. Two groups were randomly selected for this purpose. Research data were obtained through quasi-experimental method. A total of 34 students participated in the study. Paired sample t-test, independent sample t-test, one way ANOVA, MANOVA, ANCOVA and one way ANOVA for repeated measures analyses for used for data analysis. According to study results, it was identified that academic achievement of the treatment group who were taught with 5E learning cycle was significantly different compared to the comparison group who were taught with V diagram; that anxiety towards chemistry laboratory disappeared in the group taught with V diagram; that the implemented methods did not affect chemistry laboratory and chemistry lesson attitude scores based on post-test scores; that male students were more successful compared to female students in the chemistry laboratory and an inverse correlation existed between anxiety towards chemistry laboratory and attitude.*

**Keywords:** *5E learning cycle, achievement, chemistry attitude, chemistry laboratory attitude, gender, laboratory anxiety, V diagram.*

## 1. Introduction

The most important characteristic that distinguishes physical sciences from other disciplines of science is the emphasis on experimentation, observation and discovery, development of students' inquiry and research skills and provision of opportunities for students to form hypotheses and interpret obtained results. Laboratory work affects reasoning, critical thinking and understanding of science; it is an effective method to teach students the methods to produce knowledge. Also, it allows students to construct information meaningfully. Laboratory method has been regarded as one of the fundamental elements of teaching science since the middle of the 19$^{th}$ century. Laboratory work which was used at first to prove the topics that were theoretical explained can transform into environments today in which students discover information either individually or in groups (Çepni & Ayvacı, 2006).

Although laboratory work is crucial in teaching science, it is also noted that students rarely focus on goals through traditional laboratory methods (Hart, Mulhall, Berry, Loughran & Gunstone, 2000). In other words, students only focus on the observation of expected results they investigate in laboratory environments. Therefore, it can be claimed that laboratory methods that use deduction approaches are inadequate. Understanding laws, concepts, principles and theories that form the scientific knowledge is rather important in using scientific knowledge and in identifying the problem, forming hypotheses, designing experiments and interpreting results.(Ergin, Şahin-Pekmez, Öngel Erdal, 2005). The concept of falsification of hypotheses by making experiments like scientists has also become one of the principles of laboratory teaching in recent years (Shuh, 2002). In that sense, heuristic tools that support the solution of the problem or construction of knowledge have been in use with the paradigm change based on approaches that focus on constructivism and research and inquiry in science and chemistry teaching

(Stuart & Henry, 2002). Although it is important to focus on laboratory skills in teaching science, it is more important to provide the development of scientific process skills in students which can be expressed in basic skills such as identification of the problem, development of experimental designs and assessment (Shimizu, 1997). 5E model and V diagram can be two of the methods used in laboratories to provide students with these skills.

V diagram was first introduced to educational literature by Gowin and his students in the 1970’s in order to support understanding and constructing knowledge in laboratories (Novak & Gowin, 1984). Gowin argued that this diagram ensures forming relationships between theoretical knowledge and laboratory work for students and it makes laboratory reports more understandable and useful. Nakhleh (1994) emphasized that the main purpose of “General Chemistry Laboratory” classes is “increasing meaningful learning, having students actively participate in constructing knowledge and giving students responsibility and encouragement for their own learning” and therefore tools such as V diagram should be utilized. Nakiboğlu, Benlikaya & Karakoç (2001) noted that use of V diagrams in laboratory work in chemistry topics will help students to mentally construct theoretical information and achieve meaningful learning in addition to providing learning opportunities for students in psychomotor contexts. Muscat & Pace (2013) emphasized that metacognitive learning tools such as concept maps and V diagram contribute to meaningful learning in students. Roehrig, Luft & Edwards (2001) observed that students comprehend how scientific knowledge is constructed during the formation of V diagrams and their communication skills also develop as a result of collaborative work.

V diagram is regarded as one of the metacognitive tools that provide acquisition of information through implementations in science and chemistry laboratories and development of meaningful learning and scientific process skills in students by helping them learn about the nature of knowledge and its structure (Aydoğdu & Kesercioğlu, 2005; Nakiboğlu, Benlikaya & Karakoç, 2001; Tatar, Korkmaz & Şaşmaz-Ören, 2007).

Another method that can be used in chemistry laboratories is 5E learning Cycle. This model was developed and used by Bybee (1989). Experiences in learning are divided into five phases and listed in this model. Sufficient time is crucial for students to use concepts as materials shaped appropriately in constructing their minds (Smerdon, Burkam & Lee, 1999).“Exploration” phase of 5E learning cycle greatly contributes to the realization of meaningful learning since it allows activities such as hands-on and minds-on inquiry (Bybee & Landes, 1988; Bybee et al., 2006; Stamp & O’Brien, 2005). Various researches have shown that 5E learning cycle is an effective science teaching method. Namely, Ceylan & Geban’s (2009) stated that 5E learning cycle based teaching is more effective compared to traditional methods in their study on teaching state of matter and solubility concepts Artun & Coştu (2013) also found the positive effects of 5E learning cycle on students’ understanding of osmosis and diffusion concepts. Similarly, Yalçın & Bayrakçeken (2010) identified that 5E learning cycle is an effective method to teach science teacher candidates about acids-bases.

**Purpose of the Study**

It can be argued that V diagram and 5E cycle are two effective methods in teacher training that can be used to catch up with the transformation towards recent approaches based on construction of knowledge and inquiry in educational systems. With the aim to present the effectiveness of general chemistry laboratory practices, current study intended to find out the effects of chemistry laboratory practices based on V diagram and 5E learning cycle methods on science teacher candidates’ academic achievements, attitudes towards chemistry classes, laboratory anxiety and attitudes towards chemistry laboratory. With this aim in mind, the effects of different teaching methods implemented to Science teacher candidates in General Chemistry Laboratory II class on their anxiety towards chemistry laboratories (CLAn), their attitudes towards chemistry laboratories (CLAt), their attitudes towards chemistry classes (CCAt) and their academic achievement (CLAA) were investigated. Implementation was carried out for a 12-week period during the spring term of 2011-2012 academic year. A total of 34 students, 16 females and 18 males, participated in the study.

Problem statements of the study are as follows:

- Are there meaningful differences in science teacher candidates' anxiety towards chemistry laboratories (CLAn), their attitudes towards chemistry laboratories (CLAt),their attitudes towards chemistry classes (CCAt) and their academic achievement (CLAA) when different teaching methods are implemented?
- Are there significant differences in science teacher candidates' posttest CLAn, CLAt, CLAA and CCAt scores when different teaching methods are implemented?
- Are there meaningful differences in pretest-posttest CLAA, CLAt, CLAn and CCAt in-group scores of treatment and comparison group science teacher candidates?
- Does gender have an effect on science teacher candidates' CLAA scores?
- Are there meaningful differences in posttest CLAA scores of science teacher candidates taught with different methods when their pretest CLAA scores are controlled?
- Are there meaningful differences in posttest CLAA scores of science teacher candidates taught with different methods when their pretest CLAA scores and posttest CLAt, CLAn and CCAt scores are controlled?
- Are there meaningful relationships between CLAt, CLAn and CCAt scores of science teacher candidates taught with different methods?

## 2. Method

5E Learning Cycle (treatment group; N=17) and V Diagrams (comparison group; N=17) were used in the research as teaching methods. Unequal control group design, a type of quasi-experimental design, was used in the study. Groups were assigned randomly.

Prior to the implementation, teacher candidates in each group were given information for a week to familiarize them with the methods that would be implemented. Students in the treatment and comparison groups were asked to prepare their laboratory reports according to 5E learning cycle and V diagram respectively and the groups were presented with sample reports related to another subject. A week later teacher candidates were given pretests and the same tests were implemented as posttests at the end. Table 1 presents the experimental design of the study.

**Table1.Experimental Design**

| Experimental Process | Duration |
|---|---|
| Providing Information | 1 week |
| PRE-TESTS<br>Pre-(CLAA),Pre-(CLAt),Pre-(CLAn),Pre(CCAt) | 1 week |
| IMPLEMENTATION | 12 weeks |
| POST-TESTS<br>Post-(CLAA), Post-(CLAt), Post-(CLAn), Post-(CCAt) | 1 week |

Results of statistical analyses showed data was homogeneous with normal distribution, therefore it was decided to apply parametric analyses. Arithmetic means, total scores and standard deviation were identified for the analyses and independent samples t-test, dependent samples t-test, one way ANOVA, MANOVA, ANCOVA and one-way ANOVA for repeated measures analyses were used in comparisons.

**Experimental Process**

Two groups were formed in the general chemistry laboratory in the framework of the study and 5E learning cycle was implemented in the first group while V diagrams were used in the comparison group.

Subjects provided below were utilized during the experimental work undertaken in the laboratory: States of matter and its granular structure, Physical and chemical transformation, Normal distillation and water steam distillation, Purification techniques, Chemical reactions, Acid-base reactions, Water purification, Solubility and factors that affect solubility, Effect of concentration and temperature on reaction velocity, Electrolysis, Soap synthesis.

Classes were taught with the same content and by the same instructor in both groups. Activities were implemented by the students under the guidance of the instructor who provided directions. Sample lessons are provided in the Appendix.

## Data Collection Tools

### *Attitude and Anxiety Scales*

The scale developed by Yeşilyurt (2003) to identify student attitudes towards physics laboratories was adapted in the current study to determine students' CLAt scores and implemented to teacher candidates. The scale is a five point Likert type scale with a total of 33 statements: 17 negative and 16 positive. Higher scores point to positive attitudes towards chemistry laboratories. Cronbach Alpha reliability coefficient was found to be 0,89 during the development phase of the scale and it was calculated to be 0,85 during the implementation.

Students' CLAn scores were identified with the help of "Chemistry Laboratory Anxiety Scale" developed by Bowen (1999) and translated to Turkish by Azizoğlu and Uzuntiryaki (2006). CLAn scale is five point Likert type scale with a total of 20 statements [15 statements that support anxiety (positive) and 5 statements that do not support it (negative)] and four sub dimensions. Obtaining higher scores in the scale shows absence of anxiety towards chemistry laboratory. Based on dimensions, Cronbach Alpha reliability coefficients of the translated scale were found to be 0,88 in "using laboratory tools and implementing experimental procedures" dimension (items 2, 7, 12, 17); 0,87 in "working with other students" dimension (items 4, 9, 14, 19); 0,86 in "collecting data" dimension (items 3, 8, 13, 18) and 0,87 in "using the laboratory time" dimension (items , 10, 15, 20) (Azizoğlu & Uzuntiryaki, 2006). Cronbach Alpha coefficients of the current study were found to be 0,81; 0,78; 0,71 and 0,73 respectively for the dimensions.

Teacher candidates' attitudes towards chemistry lessons (CCAt) were examined with the help of "Attitude and Perception towards Chemistry Classes Scale" developed by Kavak (2004). The scale is a five point Likert scale and has 18 statements (9 positive and 9 negative) to identify students' attitudes and perceptions towards chemistry. Higher scores in the scale point to positive attitudes. Cronbach alpha reliability coefficient of the scale was found to be 0,84.

In the attitude and anxiety scale, positive statements were scored as 5, 4, 3, 2, 1 and negative statements were scored as 1, 2, 3, 4 and 5. Corresponding scores for each statement were added to separately identify total attitude and anxiety scores of students.

### *Achievement Test*

Achievement test developed by the author is composed of a total of 30 questions including multiple choice, fill-in-the blanks and true-false type questions about the subjects taught during the experimental process. Views of five instructors were sought for validity analysis of the achievement test and it was finalized based on these views. For reliability analysis, the test was implemented on 120 students who had taken the class previously. Item and test analyses were done following the trial implementation undertaken to identify test items. Item difficulty and item discrimination indexes were calculated for each item. 3 items whose item discrimination indexes were below 0,30 were removed from the test. For item discrimination, it was also checked to determine whether there were meaningful differences between lower and upper 30% segments by using dependent groups t-test and $p > 0,05$ was obtained. As a result of the analyses on 33 items, item difficulty and item discrimination indexes, item standard deviation and t-test values were found for the items appropriate for the achievement test. Kuder Richardson reliability coefficient (KR-20) of the test was found as 0,90 and consequently, the test was accepted as reliable.

## 3. Findings

This section includes data about the effects of teaching method on science teacher candidates' academic achievement and attitudes towards chemistry laboratory. Table 2 presents the findings regarding pretest CLAA results of science teacher candidates.

**Table2. Pre-test CLAA Scores for Groups**

| | | M | SD |
|---|---|---|---|
| **Pre-CLAA** | **5E** | 38,35 | 9,63 |
| | **V Diagram** | 37,41 | 11,53 |

No meaningful differences were detected in teacher candidates' pretest CLAA scores [t(32) = 0,258; p = 0,798 > 0,05]. This finding suggests that no differences existed between groups in terms of academic achievement scores and the groups were equal to one another in that regard. Table 3 displays the findings regarding teacher candidates' pretest CLAt, CLAn and CCAt results

**Table 3. Pre-test CLAt, CLAnandCCAt Scores for Groups**

| Dimension | Group | CLAt | | CLAn | | CCAt | |
|---|---|---|---|---|---|---|---|
| | | M | SD | M | SD | M | SD |
| **Pre-test Total** | **5E** | 3,94 | 0,51 | 3,65 | 0,77 | 4,06 | 0,37 |
| | **V Diagram** | 4,05 | 0,47 | 3,09 | 0,66 | 4,00 | 0,49 |

Comparison of teacher candidates' pretest CLAt scores shows no significant differences between groups [t(32) = 0,617; p = 0,541 > 0,05]. However significant differences were detected according to pretest CLAn scores of the groups [t(32) = 2,268; p = 0,030 < 0,05]. Arithmetic means for chemistry laboratory anxiety scores for the treatment and comparison groups were found to be M = 3,65 and M = 3,09 respectively. Results suggest that students in the comparison group had higher anxiety levels based on their pretest scores. No significant differences were found between CCAt scores based on the pretest scores of the groups [t(32)=0,415; p = 0,681 > 0,05]. Table 4 presents the findings for posttest CLAA results of the teacher candidates.

**Table 4. Posttest CLAA scores for Groups**

| Dimension | Group | M | SD |
|---|---|---|---|
| **Post-testTotal** | **5E** | 63,88 | 7,99 |
| | **V Diagram** | 53,35 | 12,28 |

As Table 4 shows, posttest CLAA mean scores for the treatment group and comparison group were M = 63,88 and M=53,35 respectively. When the value of p was examined to decide whether this result was statistically significant, level of significance for p value was found to be smaller than 0,05 and the difference identified as significant [t(32)=2,963; p = 0,006 < 0,05]. Accordingly, laboratory practices based on 5E learning cycle provided more successful outcomes compared to laboratory practices based on V diagrams. Table 5 displays the findings for posttest CLAt, CLAn and CCAt results of teacher candidates.

**Table 5. Post-test CLAt, CLAn ve CCAt Scores for Groups**

| Dimension | Group | CLAt | | CLAn | | CCAt | |
|---|---|---|---|---|---|---|---|
| | | M | SD | M | SD | M | SD |
| **Post-test Total** | **5E** | 4,03 | 0,55 | 3,21 | 0,81 | 4,10 | 0,48 |
| | **V Diagram** | 4,07 | 0,49 | 2,83 | 0,69 | 4,26 | 0,34 |

Comparison of posttest CLAt scores of teacher candidates shows no significant differences between groups [t(32)=0,221; p = 0,827 > 0,05]. Although there were significant differences between groups in pretest CLAn results at the beginning of the study, it was observed that this difference disappeared at the end of the study and no significant differences remained between groups based on posttest CLAn scores [t(32)=1,466; p = 0,152 > 0,05]. Also, no significant differences were found in the CCAt scores of the groups based on posttest values [t(32)=1,085; p = 0,286 > 0,05]. This finding suggests that the implemented method eliminates student anxiety towards chemistry laboratories however it does not affect their attitudes towards chemistry classes and chemistry laboratories. This finding was validated with MANOVA analysis as well.

**Table 6. MANOVA**

| Dimension | Group | M | SD | df | F | p |
|---|---|---|---|---|---|---|
| Post-CLAA | 5E | 63,88 | 7,99 | 1-32 | 8,777 | 0,006 |
| | V Diagram | 53,35 | 12,28 | | | |
| Post-CLAn | 5E | 3,21 | 0,81 | 1-32 | 2,150 | 0,152 |
| | V Diagram | 2,83 | 0,69 | | | |
| Post-CCAt | 5E | 4,10 | 0,47 | 1-32 | 1,178 | 0,286 |
| | V Diagram | 4,26 | 0,34 | | | |
| Post-CLAt | 5E | 4,03 | 0,55 | 1-32 | 0,049 | 0,827 |
| | V Diagram | 4,07 | 0,49 | | | |

The results of MANOVA conducted on post-CLAA, CLAn, CCAt and CLAt scores present significant differences between treatment and comparison group teacher candidates based on scales that were implemented [Wilks' Lambda (Λ) = 0,696, F(4,29) = 3,171, p < 0,05]. This shows meaningful differences in post-CLAA, CLAn, CCAt and CLAt for students in the research group. Examination of Table 6 to find out which score types generated the differences shows significant differences between the post CLAA scores of teacher candidates in favor of treatment group [F(1-32) = 8,777; p = 0,006 < 0,01].

Current study also examined the differences between pretest and posttest scores of science teacher candidates in treatment and comparison groups based on CLAA scores. Table 7 presents the obtained data.

**Table 7. In-group pretest-posttest CLAA scores**

| Group | | M | SD |
|---|---|---|---|
| 5E | pretest | 38,35 | 9,63 |
| | posttest | 63,88 | 7,99 |
| V Diagram | pretest | 37,41 | 11,53 |
| | posttest | 53,35 | 12,28 |

As Table 7 shows, statistically significant differences were found in the pretest and posttest scores of teacher candidates in both groups [Treatment group t(16)=15,291; p = 0,000 < 0,01; Comparison group t(16)=8,310; p = 0,000 < 0,01]. The finding suggests that the implemented teaching method had positive effects on teacher candidates in both groups.

Current study also investigated whether there were significant differences between pretest and posttest scores of teacher candidates in treatment and comparison groups based on CLAt, CLAn and CCAt scores. Results are provided in Table 8.

**Table 8. In-group pretest posttest CLAt, CLAn andCCAt scores**

| Dimension | Group | CLAt | | CLAn | | CCAt | |
|---|---|---|---|---|---|---|---|
| | | M | SD | M | SD | M | SD |
| 5E | pretest | 3,94 | 0,51 | 3,65 | 0,77 | 4,06 | 0,37 |
| | posttest | 4,03 | 0,55 | 3,21 | 0,81 | 4,10 | 0,48 |
| V Diagram | pretest | 4,04 | 0,47 | 3,09 | 0,66 | 4,00 | 0,49 |
| | posttest | 4,07 | 0,49 | 2,83 | 0,69 | 4,26 | 0,34 |

Findings show no significant differences between teacher candidates' pretest posttest CLAt [Treatment group t(16)=0,460; p = 0,651 > 0,05; Comparison group t(16)=0,149; p = 0,884 > 0,05], CLAn [Treatment group t(16)=1,351; p = 0,196 > 0,05; Comparison group t(16)=1,065; p = 0,303 > 0,05] and CCAt [Treatment group t(16)=0,276; p = 0,786 > 0,05; Comparison group t(16)=1,746; p = 0,100 > 0,05] scores.

Current study also investigated possible relationships between teacher candidates' posttest CLAA scores and their gender. Findings are presented in Table 9.

**Table 9. Posttest CLAA scores based on gender**

| | *M* | *SD* |
|---|---|---|
| **Female** | 54,06 | 13,16 |
| **Male** | 62,67 | 8,23 |

Statistically significant differences were identified between the posttest CLAA scores of male science teacher candidates (M=62,67) and female science teacher candidates (M=54,06) [t(32)=2,313; p = 0,027 < 0,05]. Table 9 shows that this difference was in favor of male students. This finding suggests that male teacher candidates are more successful in the chemistry laboratory.

Through ANCOVA analysis, the current study investigated the relationship between the academic achievement of teacher candidates and the implemented method when teacher candidates' pretest CLAA and posttest CLAn scores were controlled. Table 10 presents the obtained data.

**Table10. Results of ANCOVA Analysis When Pretest CLAA* and CLAn* Scores are Controlled***

| DATA SOURCE | MS | F | p | DATA SOURCE | MS | F | p |
|---|---|---|---|---|---|---|---|
| **Model** | 2878,147 | 29,743 | 0,000 | Model | 1098,950 | 5,195 | 0,011 |
| **CLAA (Pretest)**** | 1935,764 | 40,009 | 0,000 | Post CLAn ** | 156,567 | 1,480 | 0,233 |
| **Group** | 821,373 | 16,976 | 0,000 | Group | 706,338 | 6,678 | 0,015 |
| **Error** | 1499,883 | | | Error | 3279,080 | | |
| **Corrected Total** | 4378,029 | | | Corrected Total | 4378,029 | | |
| * $R^2$= 0,657 | | | | * $R^2$= 0,251 | | | |

**Controlled variables

According to Table 10, the model implemented in ANCOVA analysis is meaningful (p for the model=0,000) and it explains 66% of the conceptual achievement in the chemistry laboratory (R2 = 0,657). It is observed that the difference between the posttest CLAA scores is significant when the pretest CLAA scores are controlled (F = 16,976; p < 0,01). Based on ANCOVA results, it can be suggested that posttest academic achievement of the treatment group students is higher than that of comparisons group students. Based on the values obtained after having controlled posttest CLAn scores of teacher candidates, significant differences are observed between the posttest CLAA results of the groups [$F=6{,}678$; $p = 0{,}015 < 0{,}05$]and the implemented teaching method affects achievement.

Current study investigated the relationship between the implemented method and academic achievement when teacher candidates' posttest CLAt and CCAt scores are controlled with the help of ANCOVA analysis. Findings are presented in table 11.

**Table11. Results of ANVOVA Analysis When PostCLAt andCCAt Scores are Controlled***

| DATA SOURCE | MS | df | F | p |
|---|---|---|---|---|
| **Model** | 1391,860 | 3 | 4,661 | 0,009 |
| **Post Chemistry Att.**** | 274,042 | 1 | 2,753 | 0,107 |
| **Post lab**** | 351,520 | 1 | 3,531 | 0,070 |
| **Group** | 1071,825 | 1 | 10,768 | 0,003 |
| **Error** | 2986,170 | 30 | | |
| **Corrected Total** | 4378,029 | 33 | | |

* $R^2= 0{,}657$ **Controlled variables

Significant differences are observed between the academic achievement of the groups when teacher candidates' posttest CLAt and CCAt scores are controlled [$F = 10{,}768$; $p = 0{,}003 < 0{,}01$]. Table 11 shows that the implemented model is meaningful [$F = 4{,}661$; $p = 0{,}009 < 0{,}01$] and it explains 66% of the academic achievement in the chemistry laboratory. Current study also focused on the difference between the posttest CLAA scores of the groups when teacher candidates' pretest CLAA and posttest CLAt, CCAt and CLAn scores are controlled. Findings are presented in Table 12.

**Table12. Results of ANCOVA analysis when post CLAt, CCAt, CLAn and pretestCLAA scores are controlled***

| DATA SOURCE | MS | df | F | p |
|---|---|---|---|---|
| **Model** | 3226,601 | 5 | 15,693 | 0,000 |
| **Post Chemistry Att.**** | 161,001 | 1 | 3,915 | 0,058 |
| **Post lab**** | 269,996 | 1 | 6,566 | 0,016 |
| **Postanxiety**** | 22,222 | 1 | 0,540 | 0,468 |
| **Pretest**** | 1677,218 | 1 | 40,786 | 0,000 |
| **Group** | 905,226 | 1 | 22,013 | 0,000 |
| **Error** | 1151,429 | 28 | | |
| **Corrected Total** | 4378,029 | 33 | | |

* $R^2= 0{,}737$ **Controlled variables

Relationship between the teaching method and academic achievement was investigated when teacher candidates' posttest CLAt, CCAt and CLAn scores and pretest CLAA scores were controlled. According to table 12, the model used in ANCOVA is meaningful [$F = 15{,}693$; $p = 0{,}000 < 0{,}01$] and it explains 74% of the conceptual achievement in the chemistry laboratory ($R2 = 0{,}737$). The difference between the posttest CLAA scores of groups was found to be significant when their pretest CLAA scores and posttest CCAt, CLAt and CLAn scores were controlled [$F = 22{,}013$; $p = 0{,}000 < 0{,}01$]. This finding suggests that academic achievement of the students in the treatment group was higher than that of comparison group when pretest CLAA scores and posttest CCAt, CLAt and CLAn scores were controlled.

Current study investigated whether there were significant differences between teacher candidates' posttest CLAt, CLAn and CCAt scores by using one way ANOVA for repeated measures. Table 13 presents the findings.

**Table 13.PosttestCLAn, CLAt andCCAt scores**

| Source of Variance | Sum of Squares | df | F | p | Difference |
|---|---|---|---|---|---|
| **Between Subjects** | 15,173 | 33 | | | post CLAn LE-CLAt, post CLAn -CCAt |
| **Measurement** | 27,767 | 2 | 49,547 | 0,000 | |
| **Error** | 18,494 | 66 | | | |
| **Total** | 61,434 | 101 | | | |

Significant differences were detected between students' posttest CLAt, CCAt and CLAn scores [F(2,66)=49,547 p = 0,000 < 0,01]. Their posttest CLAn, CCAt and CLAt scores were M = 3,0162, M = 4,1814 and M = 4,0535 respectively. On the other hand, difference between the posttest CLAn scores and posttest CCAt and posttest CLAt scores was found to be significant whereas no meaningful differences were detected between the posttest CLAt and posttest CCAt scores. This finding may suggest that students' positive attitudes towards chemistry laboratory and chemistry classes meaningfully increase while their anxiety decreases.

## 4. Results and Discussion

Current study investigated the effect of different teaching methods implemented in the chemistry laboratory on students' academic achievement, attitudes towards chemistry classes, laboratory anxiety and attitudes towards chemistry laboratory. In the treatment, two groups were selected and one group was taught with laboratory activities designed on 5E learning cycle whereas the other group was taught with laboratory activities based on V diagram.

After the implementation, it was found that academic achievement of the group who were taught with laboratory activities based on 5E learning cycle was significantly higher than the group who were taught with laboratory activities based on V diagram. It was identified that the implemented method explained 74% of the academic achievement when the students' attitudes towards chemistry laboratory, attitudes towards chemistry classes and their chemistry laboratory anxiety scores were controlled. This finding may suggest that 74% of student achievement in the chemistry laboratory was originated from the implemented method since their CLAt, CCAt and CLAn scores were controlled. Various studies note that 5E learning cycle contributes to student achievement and comprehension in science and chemistry (Akbulut, Sahin & Çepni, 2012; Aydin, Yilmaz, 2010; Hanuscin & Lee, 2008; Wilder & Shuttleworth, 2005). Ceylan and Geban (2009) reported the effectiveness of5E learning cycle in teaching "state of matter" and "solubility" concepts. Artun and Coştu (2013) designed activities based on 5E learning cycle to teach osmosis and diffusion concepts and identified that the method significantly increased students' conceptual achievement. Higher conceptual achievement scores of groups in which 5E learning cycle is implemented may be related to the fact that the method provides opportunities for students to associate their prior knowledge with the subjects that are taught and it allows them to engage in plenty of experiments. As a matter of fact, getting rid of misconceptions identified during Engagement phase by undertaking many trials and experiments during Exploration phase is regarded as a strong element of 5E learning cycle (Snajdr, 2011). Also, students play active roles in associating new information with prior knowledge and constructing mental images in 5E learning cycle.

It was observed that chemistry laboratory anxiety identified in the group taught with V diagram before the implementation disappeared, hence, it was found that V diagram removes students' chemistry laboratory anxiety. Since students need to work collaboratively during the phases of the V diagram, a highly interactive environment is developed. Such an environment can be said to contribute to socialization of students. As a matter of fact, Karışan and Yılmaz-Tuzun (2013) emphasize that socialization may be instrumental in removing laboratory anxiety in students. Kurbanoğlu and Akın (2010) identified that self-competence is an effective predictor of laboratory anxiety. No efforts were made in the current study to identify the relationship between students' laboratory anxiety and their self-competence beliefs. However, it is observed that individual and group work help remove students' laboratory anxiety. Jegede (2007) also stated that laboratory anxiety of students disappeared when they were taught in well-equipped laboratories with qualified chemistry teachers.

Current study identified that attitudes towards chemistry and academic achievement increased when laboratory anxiety decreased. The most important affective components that affect students' laboratory achievement are attitude and anxiety (Kurbanoğlu, 2014). Findings regarding the inverse relationship between laboratory anxiety and attitudes towards chemistry are also observed in Kurbanoğlu and Akın's (2010) study. Koballa and Crawley (1985) defined attitudes towards science as an individual's like or dislike of science or the negative or positive feelings towards science. Therefore, the decreases in laboratory anxiety along with the increases in attitudes towards chemistry laboratory are expected outcomes. Keeves and Morgenstern (1992) also expressed that students' interest towards the class would decrease when they experienced feelings of anxiety towards chemistry. On the other hand, Deboer (1987) suggested that students' academic achievement were directly related to positive feelings towards the subjects taught in classes. It was found in the study that implemented teaching methods did not affect students' CLAt and CCAt scores. It is known that attitudes are affective characteristics that are hard to change in a short time frame (Tavşancıl, 2005). It can be argued that duration of the implementation was not sufficient to develop related attitudes.

An important finding of the study is the change in academic achievement according to gender. It was identified that male students were more successful in the chemistry laboratory. Greenfield (1996) reported that male students were more successful in physical science activities compared to female students.

Current study presented that 5E learning cycle method is more effective than V diagram in the chemistry laboratory. The importance of laboratory work cannot be denied since it allows students to practice the theoretical information they receive in classes. Therefore, it is crucial to implement methods that will remove laboratory anxieties in the chemistry laboratory. According to the findings of the current study, it is suggested that effects of 5E learning cycle method in chemistry laboratory should be investigated by comparing it with other methods based on constructive learning approaches and to the correlation between perception of self-confidence and anxiety towards chemistry laboratory should be examined.

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## APPENDIX

**Sample Lesson Plan in the First Group (Treatment Group)**
5E learning cycle was implemented in the first group. The lesson plan was created according to the steps below:

**1. Engagement**
Students are asked the questions below by the instructor to arouse their interest, to activate their prior information and to motivate them:
What is a galvanic cell? What are its working principles?

Is it possible to produce an electrochemical battery under this condition: Eobattery< 0? How can it be produced if it is possible to produce it? Why cannot it be produced if you think it is not possible to produce it?

What do you associate electrolysis with?
Can a watch be coated with gold? Explain the process.

**2. Exploration**
Students in small groups are asked to discuss how batteries are charged and what happens during the process.

Before moving on to the experimental process, a discussion takes place regarding how electrolysis occurs. EO values of copper, zinc, iron, silver and nickel are pointed out and electrodes that will be used in anode and cathode to carry out the electrolysis are selected. It is discussed to find out why a power source is connected to the system. Later, differences between galvanic cells and electrolyte cells are discussed and the changes that take place in the anode and cathode are observed by the students. After several trials, it is discussed to find out why the system stops after a while.

**3. Explanation**
In small groups, students are asked to present the results they have obtained from the experiments to the whole class. The facts are cited: electrolysis is a method of using a direct electric current to drive an otherwise non-spontaneous chemical reaction and electrolyte cells are electrochemical cells that use electric currents from an external source. After emphasizing the fact that electrolyte cells are different than galvanic cells, it is mentioned that especially two electrodes are generally in the same department, there is only one electrolyte and concentration and pressure are not standard.

The need is cited for a larger potential in electrolysis than the potential produced by inverse reaction called over current in order to drive an otherwise non-spontaneous chemical reaction. After citing that the potential applied on the electrolytic cell should be as big as the cell potential in the reversed cell reaction at the least, it is emphasized that the type with higher reducibility potential will be reduced first if there is more than one reducible type in the solution and the same is valid for oxidation.

It is discussed that electrolyte is used in the industrial production of aluminum and magnesium, extraction of metals form their salts, preparation of chlorine, fluorine and sodium hydroxide, purification of copper and electro coating.

**4. Elaboration**
In order to allow students to associate what they have learned at the class with their daily lives, discussions are undertaken about what corrosion is, why iron starts to corrode when it is left in the open, whether there is a relationship with this event and electrolysis and how coppers are purified.

**5. Evaluation**

In the evaluation phase, questions below are asked to assess whether students have comprehended the subject:

Why do we use electric energy to charge cell phone batteries?
Explain the differences between galvanic cells and electrolyte cells.
What kind of electrolysis cell do you prepare to coat a metal with gold? Please explain by drawing figures.

**Sample Lesson Plan in the Second Group (Comparison Group)**

V diagram was used in the second group to implement laboratory lessons. The lesson plan was created according to the steps below: