# IMPLEMENTATION OF THE PEER-LED TEAM LEARNING (PLTL) MODEL TO TURKISH CONTEXT: ITS EFFECT ON UNDERGRADUATE ENGINEERING STUDENTS' ACADEMIC PERFORMANCES AND ANXIETY IN GENERAL CHEMISTRY COURSE

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# ABSTRACT

## IMPLEMENTATION OF THE PEER-LED TEAM LEARNING (PLTL) MODEL TO TURKISH CONTEXT: ITS EFFECT ON UNDERGRADUATE ENGINEERING STUDENTS' ACADEMIC PERFORMANCES AND ANXIETY IN GENERAL CHEMISTRY COURSE

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This study examined the effect of peer-led team learning (PLTL) model over traditional college instruction (TCI) on undergraduate engineering students' exam achievement, conceptual understanding, state anxiety, and social anxiety in general chemistry course. The sample of this study consisted of 128 freshman engineering students who participated in two sections of general chemistry taught by the same instructor at Atılım University. While the experimental group randomly determined from these sections was instructed through PLTL model, the control group was instructed through TCI. This study continued fourteen weeks with six peer-led chemistry workshops and eight leader training sessions. Before and after the treatment, General Chemistry Concept Test (GCCT), State-Trait Anxiety Inventory (STAI), and Social Anxiety Questionnaire for Adult (SAQ) were implemented to both groups. Throughout the study, two midterm exams and one final exam were also given to both groups while quizzes were only conducted at PLTL group. To evaluate the PLTL model, Student Survey, Leader Survey, and Critical Components Rubric were used after the intervention. Based on MANCOVA results, the PLTL model indicated significant and meaningful impact over TCI on improving engineering students' conceptual understanding and alleviating their situational anxiety, but not effective in reducing their social anxiety. The present study also revealed that low and medium achievers in the PLTL group performed better than those of the TCI group in terms of general chemistry exam achievement (GCEA). However, no statistically significant difference was found among the GCEA of high achievers in both groups. The findings of the general evaluation of the model supported the requirements of PLTL intervention proposed in the literature.

Keywords: Peer-Led Team Learning (PLTL), General Chemistry, Engineering Students, Conceptual Understanding, Anxiety

# ÖZ

## AKRAN LİDERLİ TAKIM ÖĞRENMESİ (ALTÖ) MODELİ'NİN TÜRK BAĞLAMINA UYGULANMASI: GENEL KİMYA DERSİNDE LİSANS MÜHENDİSLİK ÖĞRENCİLERİNİN AKADEMİK PERFORMANSLARI VE KAYGI ÜZERİNDEKİ ETKİSİ

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Bu çalışma, akran liderli takım öğrenmesi (ALTÖ) modelinin lisans mühendislik öğrencilerinin genel kimya dersindeki sınav başarısı, kavramsal öğrenme, durumluk kaygı ve sosyal kaygı üzerindeki etkisini geleneksel üniversite öğretimi ile karşılaştırarak incelemiştir. Bu çalışmanın örneklemini, Atılım Üniversitesi'nde aynı öğretim üyesi tarafından verilen genel kimya dersinin iki sınıfına katılım gösteren 128 birinci sınıf mühendislik öğrencisi oluşturmaktadır. Bu sınıflardan rastlantısal olarak belirlenmiş deney grubuna ALTÖ öğretim modeli uygulanırken, kontrol grubuna ise geleneksel öğretim yöntemi uygulanmıştır. Bu çalışma, altı akran liderliğindeki kimya çalıştayı ve sekiz lider eğitim oturumu ile on dört hafta sürmüştür. İki gruba da genel kimya kavram testi, durumluk-sürekli kaygı envanteri, ve erişkinler için sosyal kaygı anketi, uygulama öncesinde ve sonrasında uygulanmıştır. Çalışma sürecinde her iki gruba iki ara sınav ve bir final sınavı yapılırken, bireysel testler sadece ALTÖ grubunda gerçekleştirilmiştir. Uygulamadan sonra, ALTÖ modelini değerlendirmek için öğrenci anketi, lider anketi, ve kritik bileşen anketi kullanılmıştır. MANCOVA sonuçlarına göre, ALTÖ modeli geleneksel üniversite öğretimi'ne göre, mühendislik öğrencilerinin kavramsal öğrenmelerini geliştirmede ve durumsal kaygılarını azaltmada önemli ve anlamlı bir etki göstermiş ancak sosyal kaygılarını azaltmada etkili olamamıştır. Mevcut çalışma, aynı zamanda genel kimya sınav başarısı (GCEA) açısından ALTÖ grubundaki düşük ve orta düzeyde başarılı olanların geleneksel üniversite öğretimi grubundakilere göre daha iyi performans gösterdiğini ortaya koymuştur. Bununla birlikte, her iki gruptaki yüksek başarılıların genel kimya sınav başarıları arasında istatistiksel olarak anlamlı bir fark bulunmamıştır. Modelin genel değerlendirmesinin bulguları, literatürde önerilen ALTÖ uygulamalarının gerekliliklerini desteklemektedir.

Anahtar Kelimeler: Akran Liderli Takım Öğrenmesi (ALTÖ), Genel Kimya, Mühendislik Öğrencileri, Kavramsal Öğrenme, Kaygı

Dedicated to My Extended Family, Eren & Şişman

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## LIST OF ABBREVIATIONS

ABBREVIATIONS

| | |
|---|---|
| ACS | : American Chemical Society |
| CL | : Cooperative Learning |
| df | : Degrees of Freedom |
| DV | : Dependent Variable |
| FE | : Final Exam |
| GC | : General Chemistry |
| GC1 | : First-Semester General Chemistry |
| GC2 | : Second-Semester General Chemistry |
| GCCT | : General Chemistry Concept Test |
| GCEA | : General Chemistry Exam Achievement |
| HERI | : Higher Education Research Institute |
| IV | : Independent Variable |
| M | : Mean |
| MANCOVA | : Multivariate Analysis of Covariance |
| MONE | : Ministry of National Education |
| MKO | : More Knowledgeable Other |
| MT | : Midterm Exam |
| N | : Sample Size |
| NRC | : National Research Council |
| NSF | : National Science Foundation |
| PLTL | : Peer-Led Team Learning |
| SAQ | : Social Anxiety Questionnaire for Adult |
| SD | : Standard Deviation |
| SPSS | : Statistical Package for the Social Sciences Program |
| PLGI | : Peer-Led Guided Inquiry |

| | |
|---|---|
| PLTL | : Peer-Led Team Learning |
| PCK | : Pedagogical Content Knowledge |
| STAI | : State-Trait Anxiety Inventory |
| STAI-S | : State-Trait Anxiety Inventory- State Anxiety Scale |
| STAI-T | : State-Trait Anxiety Inventory- Trait Anxiety Scale |
| STEM | : Science, Technology, Engineering, and Mathematics |
| ZPD | : Zone of Proximal Development |

# CHAPTER 1

# INTRODUCTION

*"What a child can do today with assistance, she will be able to do by herself tomorrow."*

*(Lev Vygotsky, 1978)*

## 1.1. The Grounds of the Peer-Led Team Learning Model

Over the last decades, many countries have challenged with severe teaching and learning problems and concerns in their higher educational settings about the lack of engagement in the natural sciences and engineering. This important deterioration leads to diminishing enrollments in the sciences and decreasing the number of talented students who retain in the scientific fields. According to the Higher Education Research Institute (HERI, 2010), the number of high achievers who remain in science, technology, engineering, and mathematics (STEM) programs as well as pursue those professions drops day by day while the rates of student retention in these fields have remained steady or increased. In fact, there is evidence that forty percent of the freshman students selecting STEM fields change their majors to nonscience majors before their senior year regardless of their STEM fields (Astin & Astin, 1993). In this case, we need to answer the main question of what higher education institutions should do to prevent undergraduate from leaving their science programs. The first thing to do may be searching for the factors that could influence undergraduate students' learning and interest in STEM fields and the reasons why they could not maintain a science major and career choice. These reasons for the high rate of attrition or dropouts of undergraduates in higher education have been attributed to accusing students of their failures by faculties (Lovitts, 2001); having differences in the learning approach (Tobias, 1990); having problems concerning pedagogical knowledge, curriculum, and assessment (Seymour & Hewitt, 1997). Besides, Gafney and Varma-Nelson (2008) mentioned about some teaching and learning problems faced in universities and colleges and expressed by instructors as follows:

- Since rote memorization does not enable students to understand the concepts clearly, students need to be involved in more quantitative, conceptual, and challenging materials to solve the problems.
- Students have difficulty in communicating with scientific ideas and collaborating with others to solve the problems.
- Students do not look for academic help or do not use provided resources related to their courses.
- In their learning processes, students are not active. They are therefore required to participate in learning activities to enhance their cognitive and social development.

To handle these problems, numerous institutions of higher education have recommended and utilized many different philosophical approaches and methods such as summer programs, curricular changes focusing on active-learning techniques, structured research experiences for undergraduate students (Drane, Micari & Light, 2014). In other words, substantial programs are needed to advance undergraduate students' success and retention in these introductory courses.

College-level science courses generally consist of a traditional lecture, and laboratory sessions and in some cases supplemented by recitations. Thus, the problems of traditional or conventional teaching may be derived from the lack of scientific inquiries that aim to actively engage all students with materials, think critically by using their prior knowledge and to enhance a deeper understanding of concepts with vigorous discussions. For the requirements of sustaining students' achievement and retention, Tinto (1975) recommends improving the instruction in such a way that students feel a sense of belonging to a college community. He also (1975, 1987) mentions the importance of the students and the faculty relationship by focusing on the association of the students' needs and the academic and the institution's social setting. Another study reports that among the factors that affect the cognitive development and growth of undergraduate students are the interaction between student and faculty members outside the classroom, participation in different community-building activities on campus and participation in student peer groups, which are the most powerful determinant of success (Astin, 1993). Further, traditional teaching approaches fail to develop mentoring relationships that are crucial for students' cognitive development and careers (Tobias, 1992). Consequently, all these studies provide extensive evidence for the necessity of using student-centered pedagogies that focus on collaborative learning techniques.

Peer-Led Team Learning (PLTL) is an instructional model which has been implemented by hundreds of faculty instructor individually or/and by dozens of institutions across the US in STEM courses to overcome such problems through a peer-led workshop. PLTL creates an active learning environment where students have an opportunity to re-examine the content of the lecture, communicate and work together with each other efficaciously, think thoroughly, ask many questions easily and discuss their scientific views in a friendly environment and construct their knowledge by using higher-level reasoning and problem-solving skills (Tien, Roth, & Kampmeier, 2002; Varma-Nelson, 2006). It was first introduced in general chemistry courses named as "Workshop Chemistry" at The City College of New York (CCNY) in the early 1990s and this was followed by many institutions nationwide across all STEM disciplines (Gafney & Varma-Nelson, 2008; Gosser, Dreyfuss, & Bozzone, 2003). Within this model, lectures are primarily introduced by the course instructors and then supplemented with PLTL workshops where a successful undergraduate lead a student team to solve some structured problems in weekly meetings. This "PLTL Workshop" is different from a conventional recitation session since the main activity is the discussion of the scientific concepts and ideas that are required for solving the problems. Gafney and Varma-Nelson (2008) state that in a typical workshop session, a team of students consisting of six to eight undergraduates come together and discuss on team problems correlated with the course content in the supervision of a peer leader by contributing to a deeper understanding of the concepts and critical thinking during one or two hours per week. They also explain the dynamic of collaboration in the PLTL workshops in a way that students improve their individual performance to a higher level of understanding throughout cooperative discussions and proper supervision of peer leaders. Since they become more responsible for their learning in time, their individual performance will improve.

Unlike a teacher lecturing in the conventional classroom or a teaching assistant demonstrating how to solve a problem in a recitation session, “peer leader” is a facilitator or guide who previously received a high grade (at least a B) from the corresponding course. In addition to their high level of performance, peer leaders should have good communication skills and leadership potential. Concerning the nature of the model, they have a significant role in the implementation of PLTL workshop because students perceive them as role models rather than authority figures (Gafney & Varma-Nelson, 2008) and they are able to understand how their peers learn and describe the problems considering their situation since they have recently learned the materials (Gosser & Roth, 1998). Accordingly, the main role of the leader in PLTL is to occupy students with each other, as well as with problem-solving activities, to provide guidance for developing scientific discussions and conceptual understanding and reaching their full potential in solving problems. (Gafney & Varma-Nelson, 2008; Roth, Cracolice, Goldstein, & Snyder, 2001). The PLTL handbook for team leaders (Roth, Goldstein, & Snyder, 2001) explains the PLTL program, the selection, and the training process of peer leaders and related studies. Moreover, Gafney describes a theoretical framework for the implementation, instrumentation, and evaluation of the model (2001a, 2001b, 2001d) in the Guidebook of PLTL (Gosser et al., 2001).

### 1.2. Objectives of the Study

According to the extensive body of research on PLTL which forms a new pedagogy or approach to teaching and learning for undergraduate STEM courses at the college level, it is clear that this model is effective to improve students' performance across a wide variety of areas such as chemistry, physics, biology, and mathematics. In addition to improvements in students' achievement in the sciences, the PLTL model has positive influences on the affective and social dimension of students' learning. Although the PLTL model has been widely implemented in STEM courses in the US, its effect on the Turkish context has not been examined yet. In the light of such circumstances, the positive influence of PLTL model prompted this study to examine its effect over traditional college instruction (TCI) on the freshman engineering students' conceptual understanding, state anxiety, and social anxiety in general chemistry course and to investigate its effect on exam achievement of students having different academic abilities.

## 1.3. Problems and Hypotheses

The current study presented the problems, and hypotheses in the following sections.

### 1.3.1. Main Problems

The study has two main purposes to follow: (1) to examine the effectiveness of PLTL model over TCI on freshman engineering students' conceptual understanding, state anxiety, and social anxiety in general chemistry course and (2) to explore the effectiveness of PLTL over TCI on exam achievement of those with different academic ability levels. Accordingly, the following main problems were pursued in this study:

- Main problem 1: What are the effects of Peer-Led Team Learning (PLTL) model on undergraduate engineering students' conceptual understanding, state anxiety, and social anxiety in general chemistry course when compared to traditional college instruction (TCI) at Atılım University?
- Main Problem 2: How do PLTL and TCI influence exam achievement in a general chemistry course of undergraduate engineering students with different academic abilities at Atılım University?

### 1.3.2. Sub-Problems

Ten sub-problems (SPs) were pursued in this study within two main-problems as follows:

- SP1.1: What are the effects of PLTL and TCI on the means of collective dependent variables of undergraduate engineering students' posttest scores of conceptual understanding, posttest scores of state anxiety and posttest scores of social anxiety in general chemistry course when pre-existing differences (pre-test conceptual understanding, pre-test state anxiety scores trait anxiety, and college of engineering entry scores) were controlled?
- SP1.2: Is there a statistically significant mean difference in posttest conceptual understanding scores in general chemistry course between groups exposed to PLTL and TCI when pre-existing differences (pre-test conceptual understanding, pre-test state anxiety scores trait anxiety, and college of engineering entry scores) were controlled?
- SP1.3: Is there a statistically significant mean difference in posttest state anxiety scores in general chemistry course between groups exposed to PLTL and TCI when pre-existing differences (pre-test conceptual understanding, pre-test state anxiety scores trait anxiety, and college of engineering entry scores) were controlled?
- SP1.4: Is there a statistically significant mean difference in posttest social anxiety scores in general chemistry course between groups exposed to PLTL and TCI when pre-existing differences (pre-test conceptual understanding, pre-test state anxiety scores trait anxiety, and college of engineering entry scores) were controlled?
- SP2.1: Is there a statistically significant mean difference in general chemistry exam achievement scores of undergraduate engineering students between groups exposed to PLTL and TCI?
- SP2.2: Is there a statistically significant mean difference in general chemistry exam achievement scores of low, moderate, and high achievers?

- SP2.3: Is there a statistically significant effect of interaction between PLTL and TCI groups and academic abilities (low, moderate, and high achievers) of undergraduate engineering students on their general chemistry exam achievement scores?
- SP2.4: Is there a statistically significant mean difference in general chemistry exam achievement scores of low achievers in PLTL and TCI groups?
- SP2.5: Is there a statistically significant mean difference in general chemistry exam achievement scores of moderate achievers in PLTL and TCI groups?
- SP2.6: Is there a statistically significant mean difference in general chemistry exam achievement scores of high achievers in PLTL and TCI groups?

### 1.3.3. Null Hypotheses

The following ten null hypotheses were addressed to test the problems of this study:

- $H_o$1.1: There are no statistically significant effects of PLTL and TCI on the population means of collective dependent variables of undergraduate engineering students' posttest scores of conceptual understanding, posttest scores of state anxiety and posttest scores of social anxiety in general chemistry course when pre-existing differences (pre-test conceptual understanding, pre-test state anxiety scores trait anxiety, and college of engineering entry scores) were controlled.
- $H_o$1.2: There is no statistically significant population mean difference in posttest conceptual understanding scores in general chemistry course between groups exposed to PLTL and TCI when pre-existing differences (pre-test conceptual understanding, pre-test state anxiety scores trait anxiety, and college of engineering entry scores) were controlled.
- $H_o$1.3: There is no statistically significant population mean difference in posttest state anxiety scores in general chemistry course between groups exposed to PLTL and TCI when pre-existing differences (pre-test conceptual

understanding, pre-test state anxiety scores trait anxiety, and college of engineering entry scores) were controlled.

- $H_o$1.4: There is no statistically significant population mean difference in posttest social anxiety scores in general chemistry course between groups exposed to PLTL and TCI when pre-existing differences (pre-test conceptual understanding, pre-test state anxiety scores trait anxiety, and college of engineering entry scores) were controlled.
- $H_o$2.1: There is no statistically significant main effect of PLTL and TCI on population means of general chemistry exam achievement scores of undergraduate engineering students.
- $H_o$2.2: There is no statistically significant main effect of academic abilities (low, moderate and high) of undergraduate engineering students on population means of their general chemistry exam achievement scores
- $H_o$2.3: There is no statistically significant effect of interaction between PLTL and TCI groups and academic abilities (low, moderate and high) of undergraduate engineering students on population means of their general chemistry exam achievement scores
- $H_o$2.4: There is no statistically significant population mean difference in general chemistry exam achievement scores of low achievers in PLTL and TCI groups.
- $H_o$2.5: There is no statistically significant population mean difference in general chemistry exam achievement scores of moderate achievers in PLTL and TCI groups.
- $H_o$2.6: There is no statistically significant population mean difference in general chemistry exam achievement scores of high achievers in PLTL and TCI groups.

## 1.4. Significance of the Study

Despite coming with high scores, undergraduate students generally do not succeed in their STEM courses or fail to fit into the university environment due to rote learning of a body of knowledge or lack of enthusiasm to learn science and pursuit science-related careers. There is a growing need for the improvement of science education and remedy such problems in colleges and universities. For this reason, the PLTL model that has recommended and used various institutions in the US is considered to satisfy these needs by deepening students' content knowledge and increasing their motivation, and retention in higher education of Turkey. While students perceive introductory science courses as an obstacle to reach more important and more interesting courses, faculty members use such courses to identify which students are capable and are able to good at advanced courses (Gafney & Varma-Nelson, 2008). How could students and faculty members come to an agreement although they have different perspectives? With the help of the PLTL model, students participate in problem-solving activities and become more interested in the material while not concentrating on grades. Most importantly, as students are good at solving problems, and thinking scientifically and critically, they feel more confident and this provides them to get higher grades. With the increase in student interest and motivation as well as improvement in their performance, PLTL can bridge two stances that students and faculty have so that this will be a step to minimize the communication issues in Turkish Universities. Further, Gafney and Varma-Nelson (2008) pointed out that if PLTL has been successfully implemented, it supports the growing partnership between faculty members and peer leaders. Such partnership and collaboration among them assist to build a bridge between two stakeholders: faculty members and students. For example, they stated that leaders meet weekly with the course professors in training sessions and can make suggestions about the subject matter, workshop strategies, learning process, group dynamics, and student behaviors. Therefore, these meetings form a partnership when course professors and peer leaders have a mutual goal to solve the problems in the teaching and learning process and develop students' performance. In addition, course professor and peer leader collaboration through their workshop participation enable the views of professors and students to bring together and establish a dynamic equilibrium in both directions. Besides, they claim that students can be aware of professors' concerns about their learning and professional development through this partnership. Accordingly, it is clear that the collaboration of peer-leaders and professors supply many positive resources to solve the problems in the learning process and strengthen the relations.

Many faculty members expect their students to show greater interest in science and more competent ones to choose for majoring in STEM programs. Based on the study of Astin (1993), if you have a friend or a peer who is studying in a science discipline, it is more likely to maintain a science major and pursue a science career. Similar to these results, Light (2001) asserts the importance of having friends from science majors. In that case, such friends can help in making them increase their motivation and remain in studying science. In this manner, since PLTL promotes friendships by increasing students' sense of belonging to a community, it is a desired and recognized power within the higher education for the science and engineering majors in Turkey.

In business life, students will need to think creatively and critically, communicate effectively and work as a team with others who have different personality characteristics, is some cases, social or cultural backgrounds (Maxfield, 2001; Pink, 2005). To illustrate, Houston (2007) states that The National Research Council (NRC) planned and organized a workshop about the required skills of the future. Based on the results of the workshop, there is a high request for individuals having six core competencies: complex communication skills, creative problem-solving, self-management, self-development, adaptability, and systems thinking. Student-centered pedagogies such as PLTL program offer an active learning opportunity to not only construct new knowledge for themselves but also to acquire such skills required in their science-related careers. Consequently, the courses at the college level in Turkey should prepare them for careers by providing both academic content knowledge related to their discipline and an opportunity to acquire the required qualifications and skills.

PLTL chemistry workshops promote the cognitive, social, and epistemological development of the students (Gafney & Varma-Nelson, 2008) because students in teams communicate each other, listen to new evidence and discuss the paths and results of the problems, revise each other' opinions and wrong ideas, and give suggestions similar to the interaction of graduate students in the research groups (Varma-Nelson & Coppola, 2005). These kinds of interactions and negotiations in peer-led workshops have engineering students to develop and maintain partnerships and to have a deeper understanding than they ever had. Therefore, they will become multi-faced individuals who can enhance the development of Turkish society.

In addition to the cognitive, social, and epistemological development, individuals' affective growth, which refers to the development in a variety of concepts including feelings, attitude, enthusiasm, interest, emotions, anxiety, and motivations, etc., is so important for their learning process. Thus, professors should integrate different strategies into their instruction to emphasize the affective development of students. To illustrate, in their first year at college or university many students have anxiety about their knowledge and abilities in their STEM courses. Regardless of their gender, ethnicity or race, either a high level of anxiety can cause students' poor performance or higher anxiety levels of students is most likely attributable to their poor performance (Gafney & Varma-Nelson, 2008). In both cases, a high level of commitment should be provided to STEM courses regarding the strategies, methods or programs to be adopted so as to improve students' performance and to alleviate anxiety. Gafney and Varma-Nelson also report that among causes for not able to ask questions in undergraduate courses are feeling anxious about speaking in front of professors and peer in a crowd and fear of being perceived by others as asking stupid questions (2008). This reinforces students' reluctance to participate in class discussions and social anxiety. In order to handle these issues, PLTL workshops provide a very comfortable environment in which students can present their ideas and discuss their preconceptions about the particular topic under the guidance of leaders with substantially less situational and social anxiety. Therefore, this study offers empirical evidence that whether freshman students' anxiety can be reduced after the PLTL interventions.

The teacher in the primary and secondary levels of education generally are more open to change their instructional strategies than the professors, or administrators in higher education. They have difficulties in applying a new approach, handling its feedback, and exposing this process, mostly at universities where the majority of students are in STEM disciplines (Brainard, 2007; Connolly & Millar, 2006). Professors want to implement student-centered approaches rather than traditional ones to improve and inspire students; nonetheless, they express that they have a limited time to devote. Therefore, the PLTL model provides an atmosphere for instructors to share some responsibilities with peer leaders in discussing and preparing workshop materials for their instruction. Gafney and Varma-Nelson (2008) emphasize that if both faculty members' and institutions' educational priorities, orientation to and attitudes toward teaching and learning are compatible with the PLTL model, more desirable student outcomes are likely to be obtained. After the implementation of PLTL, many faculty members report significant improvements in higher education with the shift from an old paradigm to new ones as indicated in Table 1.1 adapted from Fink's work in 2003 (as cited in Gafney & Varma-Nelson, 2008, p.99). This study will provide an opportunity to implement this new paradigm in Turkish Universities too.

Table 1.1. *Old and new perspective for higher education*

| | **Old perspective** | **New perspective** |
|---|---|---|
| Student | Passive vessel to be filled by the faculty's knowledge | Active constructor and discoverer of knowledge |
| Student growth goals | Complete requirements, graduate with a major | Focus on lifelong learning in a broader system |
| Relationships | Impersonal relationships between faculty and students | Personal relationships between faculty and students |
| Context | Competitive, individualistic | Cooperative learning in the classroom and on faculty teams |
| Power | The faculty holds and exercises power, authority, and control | Power is shared among students and between students and faculty |
| Teaching assumption | Any expert can teach | Teaching is complex and requires training |

Due to having no implementation of the PLTL in the Turkish context, this study serves as an example in this area to develop, implement and disseminate the PLTL model for other universities in Turkey. Moreover, faculty members can use the materials and team problems in their instruction and add to their teaching repertoire. Finally, it offers a solution to the deficiencies, problems, or obstacles in higher education in Turkey.

## 1.5. Important Terms

The key terms of this study were defined as constitutively and operationally in the following section.

### 1.5.1. Peer-Led Team Learning

It is a structured form of team learning in which a team of undergraduate students meets each week with their peer leader for discussing and solving a set of carefully developed problems correlated with the course content (Gosser & Roth, 1998). PLTL forms an active learning environment where students have an opportunity to re-examine the content of the lecture, communicate and work together with each other efficaciously, think thoroughly, ask many questions easily and discuss their scientific views in a friendly environment and construct their own knowledge by using higher-level reasoning and problem-solving skills (Tien, Roth, & Kampmeier, 2002; Varma-Nelson, 2006).

### 1.5.2. Peer-Led Chemistry Workshop

Peer-led chemistry workshop is the discussion and debate session in which a group of students works on some cooperative activities and problems for one or two hours per week for deepening their conceptual understanding, problem-solving skills, and critical thinking (Gafney & Varma-Nelson, 2008).

### 1.5.3. Peer Leader

The peer leader is a successful undergraduate student who has previously completed the same course successfully (at least B). They guide a team of students to discuss the concepts and solve the problems collaboratively in PLTL workshops through weekly meetings. (Gafney & Varma-Nelson, 2008).

### 1.5.4. Traditional College Instruction

TCI is a kind of teacher-centered instructional method in which a faculty member introduces the topic by lecturing and then solve some problems about that topic. At the college level, course instructors explain the chemistry concepts to their undergraduates with comprehensive instructions by using textbooks, solve end-of-chapter problems and do not consider students' misconceptions during instruction while undergraduates listen to course professors, and memorize scientific terms and principles. In other words, in this kind of instruction, teachers try to transfer knowledge directly to the students and they passively receive the knowledge from the teachers and the course textbooks and do not actively participate in classroom discussion (Jonassen, 1991).

### 1.5.5. Anxiety

Anxiety refers to an emotional condition or feelings of unease, worry, nervousness, tension, or stress (Spielberger, 1972).

### 1.5.6. Trait Anxiety

It is a permanent personality characteristic that refers to a general feeling of anxiety or stabilizing individual differences characterizing their anxiety (Spielberger, 1983). In this study, State-Trait Anxiety Inventory-Trait Anxiety Scale (STAI-T) was used to measure the trait anxiety of undergraduates.

### 1.5.7. State Anxiety

It can be defined as a temporary emotional state or feeling that refers to the individuals' explanation of a particularly stressful situation at a specific period/moment in time. (Spielberger, 1983). In this study, it was measured by State-Trait Anxiety Inventory-State Anxiety Scale (STAI-S) with 20 items.

#### 1.5.8. Social Anxiety

Social anxiety is considered a powerful fear of shame, humiliation, or embarrassment in social settings and performance conditions (American Psychiatric Association, 2003). Social Anxiety Questionnaire for Adult (SAQ) was implemented in the current work to measure the social anxiety construct.

#### 1.5.9. Conceptual Understanding

The definition of conceptual understanding can change based on the subject. The conceptual understanding in general chemistry refers to the profound understanding of core chemistry concepts, theories, practices, and relationships. A student is more likely to show a higher conceptual understanding if s/he can

(1) apply core chemistry ideas to chemical situations that are novel to the students,

(2) reason about core chemistry ideas using skills that go beyond mere rote memorization and algorithmic problem solving,

(3) expand situational knowledge to predict and/or explain the behavior of chemical systems,

(4) demonstrate the critical thing and reasoning involved in solving problems including laboratory measurement

(5) translate across scales and representations (Holme, Luxford, & Brandriet, 2015, p.1480).

In this study, the conceptual understanding was determined by the conceptual understanding of general chemistry concepts and was measured by General Chemistry Concept Test (GCCT).

#### 1.5.10. Exam Achievement

Exam achievement means to the raw score in points obtained from each midterm and a final exam. Total exam achievement score was determined in this study by using thirty percent of the midterm exam I (MT1), thirty percent of midterm exam II (MT2), and forty percent of the final exam (FE) in the general chemistry course.

# CHAPTER 2

# LITERATURE REVIEW

*"The greatest difficulty of all is the application of a concept, finally grasped and formulated on the abstract level, to new concrete situations that must be viewed in these abstract terms..."*

*(Lev Vygotsky, 1986, p.151)*

*"I understand the concept; I just can't solve the problems."*

## 2.1. History of Peer-Led Team Learning

The Peer-Led Team Learning (PLTL) was originally presented as a "Workshop Chemistry" by David Gosser for his General Chemistry course at the City College of New York (CCNY) where it was supported for the greater improvement in chemistry by National Science Foundation (NSF) grants in the early 1990s. Then, it has been started to be implemented by "10 colleges of the City University of New York (CUNY) as well as St. Xavier University in Chicago, and the Universities of Pittsburgh, Pennsylvania, and Rochester" (Gafney & Varma-Nelson, 2008, p.10). This model has been disseminated to address faculty members' concerns about their student learning and high attrition rates in STEM courses in many colleges and universities in the United States (Goodwin, 2002). Due to the improvement in the student performance and taking positive results of the PLTL workshops in these institutions, the PLTL model was further developed and extended to other institutions successfully (Gafney & Varma-Nelson, 2008; Gosser, 2001). National Science Foundation (NSF) supported such implementations within two groups for disseminating this model nationwide to the many STEM areas;

- *Members of the first group:* The University of Montana, American University, Clark Atlanta, and the University of Kentucky.
- *Members of the second group:* The University of West Georgia, Miami of Ohio, Coastal Carolina University, Indiana University Purdue University at Indianapolis, Goucher College in Baltimore, and Prince George's Community College in Largo, Maryland, outside Washington, DC. (Gafney & Varma-Nelson, 2008, p.10).

### 2.2. Nature of Peer-Led Team Learning

PLTL is a structured form of team learning that provides an active learning environment for a team of undergraduates who meets each week for one or two hours under the guidance of a leader to solve a set of carefully developed problems in accordance with lecture topics (Gosser & Roth, 1998). Therefore, they are likely to discover how to discuss their ideas scientifically with each other and to improve their conceptual thinking and understanding in a social community (Sarquis et al., 2001; Varma-Nelson, Cracolice & Gosser, 2004). Students instructed with PLTL have opportunities not only to advance their intellectual and social development but also to take responsibility for their own learning for constructing their content knowledge (Crocolice & Deming, 2001; Varma-Nelson et al., 2004). According to Hockings, DeAngelis, and Frey (2008), PLTL aims to offer active and collaborative learning activities for undergraduates, demonstrate them how to work collaboratively with their peers, as well as advance their problem-solving skills, and provide necessary guidance to the team members.

There are certain fundamental characteristics of the PLTL model in chemistry education. One of the characteristics is related to the new structure of the course, which contains retaining the lecture. In this new structure, a weekly chemistry course generally includes 2–3 hours of lecture instructed by the course instructor, 3-4 hours of laboratory session facilitated by teaching assistants, and 1.5–2 hours of PLTL chemistry workshop guided by peer leaders (Varma-Nelson et al., 2004). The time intervals can change based on the type of implementation of the PLTL model. About how the PLTL workshop was embodied with the course or was coordinated with the course elements (e.g. recitations), Gosser (2011, p.5-6) reports three different types of implementation of the model as follows:

- *Type I:* Like in CCNY and St. Xavier University, one or two hours of four-hour lecture sessions is replaced with a peer-led workshop, which requires full attendance.
- *Type II:* Like in the University of Rochester and Pittsburgh, graduate student recitation is replaced with a peer-led workshop, which requires full attendance.
- *Type III:* Like in the University of Kentucky and NY City Tech, a peer-led workshop is added to the course as a new element. Students choosing to participate in peer-led workshops are expected to attend at least 40 % for that semester.

The results of the several studies implementing these types of PLTL demonstrated similar increases in student chemistry performance as measured by the students' number and percent obtaining A, B, C grades, or by exam scores (Gosser, 2011). According to the study conducted by Varma-Nelson and Coppola (2005), the PLTL workshop is more likely to be successful if a chemistry course does not have recitation or discussion sessions.

It is possible to say that the other basic feature of the PLTL model is working as a team on the materials. During teamwork, all members of the team listen to each other, form and discuss their arguments and the views expressed by others, and deliver necessary guidance and support to promote individual performance and the performance of an entire team. The term "team" is generally confused with the "group". But in fact, a team of students is not only any group that works together, and a group of students cannot be easily a team. Thus how could we differ team from working groups? Katzenbach and Smith (1993) proposes four essentials of becoming a team, namely "common commitment and purpose, mutual accountability, performance goals, and complementary skills" and present the definition or description of a team as "a small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable" (p.2). The characteristic differences between teams and groups are defined in the previous studies (Katzenbach & Smith, 1993, p.4; Varma-Nelson & Coppala, 2005, p.4) to form a useful framework for understanding how a group working transforms to teamwork. The features of teams and groups were represented in Table 2.1 below.

Table 2.1. *The common features of teams and groups*

| **The features of teams** | **The features of groups** |
|---|---|
| Shared leadership roles | Strong and clearly focused leader |
| Individual and mutual accountability | Individual accountability |
| specific team objectives that they deliver themselves | objectives are imposed, mandated, granted and/or the same as the broader organizational mission |
| Collective work products | Individual work products |
| open-ended discussion and active problem-solving meetings | efficient meetings |
| Assessment of performance directly with collective work products | Assessment of effectiveness indirectly with the influence on others |
| Discuss, decide, and do real work together | Discuss, decide, and delegate |
| have open and honest dialogue | have polite discussions |
| can't wait to be together | meet because they have to |

Another important characteristic of this model is the presence and specific role of peer leaders who supply facilitated help for team members, unlike traditional cooperative learning. PLTL workshop team is typically comprised of six to eight undergraduates plus a leader who previously completed the course with success and demonstrated positive leadership skills and strong communication skills. In addition, in order to be better facilitators for students, peer leaders must take proper training and support during the implementation of the PLTL program.

## 2.3. The Workshop Model of Peer-Led Team Learning

The workshop leaders, students, faculty members, and learning specialists form four elements of the workshop community as shown in Figure 2.1 (Gosser, 2001, p.5). The relationships among these elements also describe the nature of PLTL workshops.

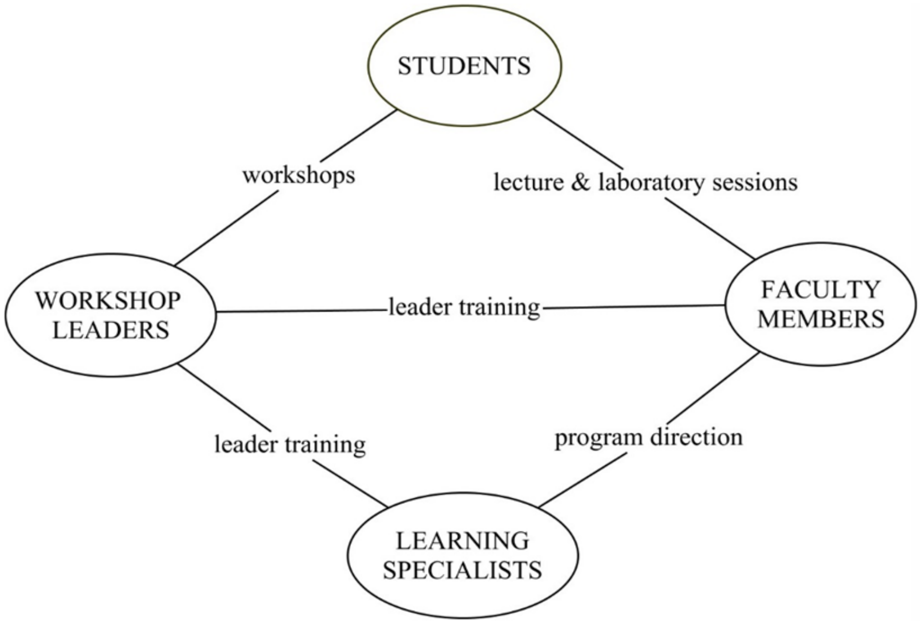


*Figure 2.1.* The workshop community

In the model as seen from the figure, the learning specialists who have specific training about the pedagogies and methods of the PLTL collaborate with the faculty members to build the leader training sessions and provide logistic support for student teaching and learning. Furthermore, successful undergraduate students undertake the role of workshop peer leaders and support both the interaction between students and faculty members and collaboration between faculty members and learning specialists. In a workshop session, each peer leader distributes the written materials containing structured problems to their team members, and gives support about the steps in the solution of problems, resources, thinking patterns and process while undergraduate students work together for finding a solution of the problem (Crocolice & Deming, 2001). Besides, peer leader facilitates a discussion among the students in each team by interacting with them, stimulating critical thinking, and promoting them to find a solution for challenging problems. At the end of the PLTL workshop, students summarize the concept and specify their solutions for the problems. The physical conditions of the lecture hall should be appropriate for the teamwork in which desks are arranged in circles or semi-circles (Crocolice & Deming, 2001).

The role of faculty members or course instructors in the PLTL program is to prepare workshop materials as well as choose and train the peer leaders for their PLTL workshops. Since the content of the workshop should be consistent with the lecture hour weekly schedule, peer leaders come together with course instructors to discuss the concepts and workshop materials each week. The aim of this workshop is also to evaluate the process of finding several possible solutions instead of giving correct answers so that the answer keys of the problems are withheld from students or peer leaders (Varma-Nelson & Coppola, 2005). Furthermore, it is often the case that undergraduates are not well-prepared for solving problems in PLTL workshops because workshop sessions generally do not include any graded work or earned credit for the course (Gafney, 2001a). Simply stated, they do not come to the workshops ready due to lack of rewards or concern about grades Accordingly, Varma-Nelson and Coppola (2005) suggest some methods to cope with this problem such as assigning preliminary readings, end of the chapter problems, self-tests, and pre-workshop quizzes.

## 2.4. Conceptual Background

### 2.4.1. Learning Theories and Educational Approach /Pedagogies

It is reasonable to conclude that team learning is a second-generation pedagogy that results from a combination of well-established theories and methods for the instructional design of the higher educational setting. The development of the PLTL instructional model is mainly based on the learning theory of Social Constructivism (Tien et al., 2002) as well as Vygotsky's Sociocultural Theory (Cracolice & Trautmann, 2001; Varma-Nelson and Coppola, 2005). Besides, cooperative learning is an important approach contributing to the strong side of PLTL (Tien et al., 2002). Those that interact and inform the PLTL model were discussed as follows.

Social Constructivist perspective emphasizes that the main source of acquisition of skills and knowledge for cognitive development and intellectual growth is the individual's social interactions with instructor or peers, in science and science education (Phillips, 2000). According to the view of social constructivists, the students in the classroom or lecture hall refer to a community or a society who meet to construct their knowledge through interaction, discussion, and criticism of the ideas in the social and collaborative setting. Gredler (2009) states that students are involved in social or collaborative activities that are likely to promote meaningful learning. As an implication of this perspective in PLTL model, Cracolice and Trautmann (2001, p.99-100) recommend the use of some features of a social constructivist classroom (e.g. Oldfather, West, White, & Wilmarth, 1999, p.74) to discuss the differences between PLTL workshops and traditional classroom:

- A primary goal of the classroom is collaborative construction meaning. The focus is on sense-making rather than on the construction of a single right answer. Errors are viewed as a natural part of learning and considered to be opportunities for growth. Teachers and students search for meaningful connections between what they know and what they are learning. Everyone shares ownership of knowledge. The teacher is not the sole authority for knowledge.
- Teachers pay close attention to students' perspectives, logic, and feelings.
- The teacher is teaching and learning. Students are teaching and learning. Everyone is asking questions and pursuing them.
- Teaching and learning are based on social interaction. The talk is both structured and unstructured. The flow of ideas and information is multidirectional.
- Everyone is treated as a whole person. Students' physical, emotional and psychological needs are considered along with their intellectual needs.

- The teacher and students believe that everyone can succeed. Assessment is based on each individual's progression and not exclusively on competitive norms.

Based on the cultural and cognitive theory of development by Lev Vygotsky as a social constructivist, due to the acquisition of cognitive skills and thinking patterns in the sociocultural aspect of the classroom, the community has a significant role in the learning process (1978). Three key concepts of Vygotsky's theories on cognitive development are crucial for the implementation of the PLTL model (See Figure 2.2).

One of Vygotsky's fundamental contribution is his concept related to the interaction with the More Knowledgeable Other (MKO). The term "MKO" refers to a person with a greater understanding about, or more skilled in a particular task, process, or concept than the learner. This capable individual could be one of the leaner' parents, mentors, tutors, teachers or peers. According to Vygotsky (1978), whoever serves as the MKO creates an active social atmosphere where students are likely to collaborate with a more competent person and to acquire new knowledge and skills from this social interaction process. He also believes that the cognitive development of learners is scaffolded through these social dialogues.

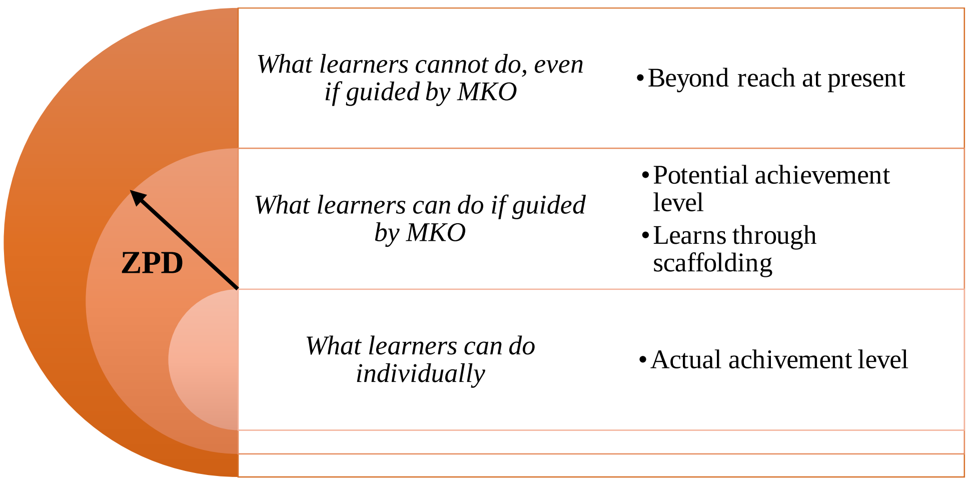


*Figure 2.2.* Vygotsky's ZPD and other key constructs.

In the PLTL model, the peer leader is an undergraduate with high academic capability than peers in their teams in terms of a particular course. Since they have recently completed the course with high grades, they are likely to provide necessary guidance to the students to perform a task, solve a problem and enhance their cognitive development (Cracolice & Trautmann, 2001). It is important to note that as Vygotsky's suggestions, peer leaders frequently use pair-problem solving strategies that aim to pair a less competent student with more knowledgeable peers to solve a problem in PLTL workshops.

Scaffolding is another construct as an educational application that reflects Vygotsky's assisted learning concept. Wood, Bruner, and Ross (1976) originally described "scaffolding" and then Bandura (1986) discussed this term in his social cognitive theory. Despite not being used by Vygotsky, the idea of scaffolding has been linked to the theories of Vygotsky, particularly to his incredible work, Zone of Proximal Development (Puntambekar & Hübscher, 2005). According to Schunk, the concept of "instructional scaffolding" refers to "the process of controlling task elements that are beyond the learner's capacity to focus on and master those features of the task that they can grasp quickly" (2012, p.245). The quality and quantity of scaffolding can change according to an individual's actual or current level of achievement. During the scaffolding process, the student takes the needed guidance and support from MKO to perform a task, but this support gradually decreased and removed until the student is able to complete it individually (Puntambekar & Hübscher, 2005). In the PLTL model, peer leaders provide scaffolding to the peers in their team to gain the ability and skills which are required to solve the team-based problems (Cracolice & Trautmann, 2001).

The other important concept in his theory is the notion of the Zone of Proximal Development (ZPD). It refers to "the distance between actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance, or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). In other words, it can be defined as the difference between what an individual can do individually without the support and what he or she can achieve with guidance and encouragement from a skilled and more knowledgeable one. The scaffolding concept also thoroughly related to the ZPD of Vygotsky. He proposed that learning activities and tasks should be constructed for students to enhance their actual level of development. When designing and selecting appropriate instructional materials and problems for PLTL chemistry workshop, ZPD takes into account so that as a result of interaction with peer leaders students can accomplish to solve easily the challenging team problems that they cannot solve on their own (Gafney &Varma-Nelson, 2007; Varma-Nelson & Coppola, 2005).

English Language or Multilingual Language Education contexts, researchers (e.g. Donato, 1994; van Lier, 1996; Walqui & van Lier, 2010) have expanded the Vygotsky's conceptualization of ZPD with the notion that learning is not only restricted to the social interactions between students and MKO but also it can be enabled with various interactions. Based on this expanded view of the ZPD that was proposed by van Lier (1996, 2004), learners have opportunities to learn a particular concept, complete a task or solve a problem at least four potential contexts of learning; the scaffolded "interactions with peers and teachers, interaction with equal peers, interaction with less capable peers and working alone" as indicated in Figure 2.3.

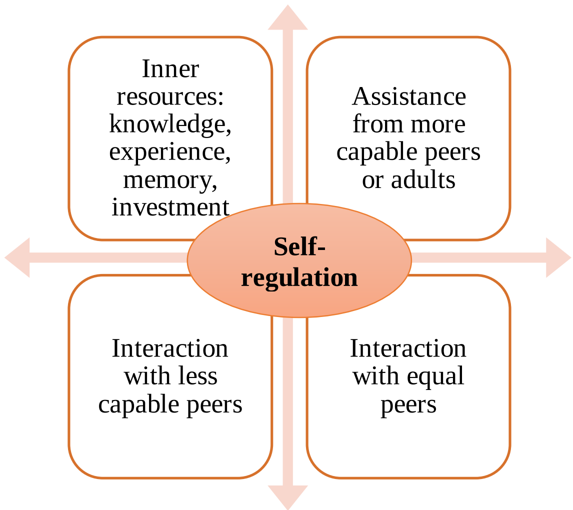


*Figure 2.3.* The expanded model of ZPD (van Lier, 2004, p. 158)

- *Assistance from more capable peers or adults* (learning through scaffolding): When learners receive support, advice, modeling or guidance from MKO, they are likely to improve their performances as suggested in original ZPD.
- *Interaction with equal peers* (learning through collaboration): When learners collaborate with other learners having relatively equal achievement levels, they are likely to form zones of proximal development for each other and construct their knowledge with social interactions and shared understanding.
- *Interaction with less capable peers* (learning through teaching): When a novice learner assists or teaches a less competent peer, both concurrently have opportunities to learn are expanding their knowledge and work in the zone of proximal development.
- *Working alone* (learning through internalization, inner resources): Learners have internalized teaching and learning strategies in a self-directed way by working within their zone of proximal development when they apply "learning strategies, inner speech, resources in their environment, and experimentation" (Walqui & van Lier, 2010, p. 31).

As using for ELE students, the expanded model of ZPD can be adapted to the science education context. It is also suitable to consider the implication of this expanded ZPD for the PLTL model. Since in the PLTL model, a team has a heterogeneous structure which means that there are six to eight students with different ability levels so that the peer leader and other team members are the mediators who provide essential scaffolding to guide one another to learn the concepts and solve the problems (Cracolice & Trautmann, 2001). Thus the learner is able to solve a team problem through the interactions with such other team members who could have slightly less, same or more knowledge than the learner. Meantime peer leader creates a supportive and reflective environment in which peers can become responsible for their own performance and understanding (Crocolice & Deming, 2001).

Tien et al. (2002) claim that the PLTL model shares a common ground with cooperative learning (CL). According to Johnson, Johnson, and Smith (1991, 1998), CL refers to an instructional pedagogy in which learners work cooperatively in small groups to accomplish a mutual learning goal or certain task (e.g. solving problem). It is significant to note that a group activity could be a CL if it contains the following five elements (Johnson & Johnson, 1999; Johnson, Johnson, & Smith, 1991):

- *Positive interdependence:* it means the perception that group members are dependent on each other to achieve the common goal of the team so that every person completes their part to accomplish the task. (E.g. they sink or swim together).
- *Individual accountability*: it refers to the belief that every group member is held accountable for their part of the task and her/his performance and learning. After the individual performance assessment provided to the group and the individual, they check whether they need more support in their learning.
- *Face-to-face promotive interaction:* it refers to the interactions in which group members positively influence each other by providing help and assistance, supporting, and encouraging to reach the goals of the group.
- *Social skills:* it means that in addition to the academic skills group members are encouraged and helped to develop and practice interpersonal and cooperative skills (e.g. leadership, decision-making, and communication skills) for reaching the outcome goals.
- *Group processing:* it refers to the reflections of a group about the efficiency of its members in contributing to the cooperative activity to reach its goals. Thus, they set shared goals, discuss and evaluate occasionally the actions of members as a team, and revise them to perform more successfully.

The PLTL model incorporates three elements of CL discussed above, namely positive interdependence, individual accountability, and face-to-face promotive interaction (Felder & Brent, 2007; Tien et al., 2002; Varma-Nelson and Coppola, 2005). They explained that during the PLTL workshops, students are engaged in some difficult team problems that they cannot solve individually so that they must benefit from other peers or peer leader to develop solution ideas that stimulate positive interdependence, and they must take guidance and feedback from each other as well as their peer leader that promotes face-to-face promotive interaction. Further, the peer leaders, who encourage individual accountability of team members, facilitate decision making, provide feedback about each members' performance and support them to explain their understanding to their peers in their team.

Unlike CL, it does not have formal procedures for teaching social skills (e.g. leadership, decision-making, and trust-building, communication, and conflict-management skills). On the other hand, according to Felder and Brent (2007), it is likely to occur throughout informal instruction in the case of the social interactions among peers facilitated by the peer leaders. The last element of CL does not appear in the PLTL model that aimed at the improvement of individual performance. Therefore, it does not have either any self-evaluation about team processing or any graded work (Tien et al., 2002). In traditional cooperative learning, students might not work as a team in some cases unless they had a leader. However, in the PLTL model, each team has a peer leader who enables the required support for them and challenges them to bear some responsibility for their own learning (Crocolice & Deming, 2001).

The PLTL model also has some similarities with other student-centered learning approaches such as problem-based learning (PBL), and process-oriented guided inquiry learning (POGIL). Therefore, Eberlein et al (2008) compared and contrasted the characteristic features of those based on the four categories; fundamental aspects, classroom characteristics, out-of-class and miscellaneous.

### 2.4.2. Components of Peer-Led Team Learning

PLTL is an instructional model that proposes the integration of a peer-led workshop to the undergraduate courses. It has been defined by a model containing six critical components that were supported by the initial PLTL implementers in the developmental process of the model (Gafney, 2001d). Researchers (Gafney, 2001d; Gafney & Varma-Nelson, 2008) explain these six critical components as follows:

- *Faculty involvement:* This component explains the significant role of the relationship of the faculty member who teaches the course with both the peer-led workshops and the peer leaders. More specifically, the role of the professor is to plan the workshop, prepare and revise workshop materials, select and train the peer leaders as well as meet regularly with them to establish good relations.
- *Integral to the course:* This component specifies that the PLTL workshop is an important part of the course. Those who have selected to participate should see it as a requirement of the course as a lecture, homework assignments, exams, and tests.
- *Leader selection and training:* This component emphasizes the function of the peer leaders on the success of the PLTL workshops. Peer leader is a key force in workshops so that the process of selection, training, and supervision of peer leaders in terms of pedagogical content knowledge and interpersonal skills should be properly organized and closely monitored.
- *Appropriate materials:* This component is related to the use of appropriate materials for the proper implementation of the model. The workshop materials need to be challenging, be suitable for group work, encourage active learning throughout using various approaches such as using models, designing from easier to more difficult questions as well as implementing graphical analysis, data interpretation, maps, and metacognitive analysis. Since most textbook problems and exercises are prepared for individual use, they should not be used for the workshops without revision.
- *Appropriate organizational arrangements:* This component is related to group size, location, time, noise level, etc. It is reported that for the workshop the ideal group consists of six to eight students and the best length is 90–120 minutes.
- *Administrative support:* After realizing the importance of the administrative support in performing successful workshops, this component was added to the list. Thus, workshops should be reinforced by the department and the institution with a financial and organizational commitment.

Consequently, these critical components allow researchers to implement the model successfully and distinguish it clearly from some related methods such as peer-assisted models (peer tutoring, cooperative learning), and study groups, etc. According to Gafney and Varma-Nelson (2008), it is reported that PLTL increases student satisfaction, motivation and academic performance in the case of implementing this model based on six critical components. Otherwise, you may meet some difficulties and problems. Further, it is commonly advised that these six components can be used as a rubric (Gafney & Varma-Nelson, 2008; Gosser, Kampmeier &Varma-Nelson, 2010). In short, all requirements of the components must be met for the successful implementation, proper dissemination, and evaluation process.

### 2.4.3. Peer Leaders

#### 2.4.3.1. Role of Peer Leaders

As mentioned before, the primary feature of the PLTL model that distinguishes it from cooperative learning or student-assisted learning is the role of the leader. Thus, what is his or her role in this new teaching method? Tien, Roth, and Kampmeier (2004) specified that PLTL workshop encourages the conceptual discussion for solving the problems among students and peer leader who guides this discussion instead of a course instructor who gives lecturing or shows the solution of the problem through the traditional instruction. In addition, the role of the peer leader is to actively engage students in problem-solving activities and their team members and, to support them to develop conceptual understanding, and to provide an environment for students to have an equal opportunity to participate and discuss scientific concepts and ideas as well as to motivate and offer support and guidance (Gafney &Varma-Nelson, 2008; Gosser & Roth, 1998; Roth, Cracolice, et al., 2001). In time, these leaders become mentors and role models for peers in their teams. Besides, they serve as a bridge between students and faculty members because they make weekly meetings with the instructor of the course, give feedback and suggestions to advance the learning and academic performance of students, establish a dynamic equilibrium between both teachers' and students' perspectives (Gafney & Varma-Nelson, 2008). Therefore, peer leaders are effective resources in implementing, documenting, and disseminating the PLTL model.

#### 2.4.3.2. Choosing and Training Peer Leaders

The selection of peer leaders is an important issue because peer leaders should meet some conditions and have characteristics for the implementation of the model. For example, they should have attended the same course previously and completed it successfully with a grade of B or better. In addition to a good conceptual understanding, they should have enthusiasm, self-confidence, as well as an ability to work with others, leadership, and communication skills (Berke, 2003). Before the intervention of the PLTL program or project, peer leaders should be selected from the undergraduate students who apply for the program voluntarily and should sign an acceptance letter that show the agreement with the requirements such as participation in the training session and weekly meetings with their teams in PLTL workshop; be awareness of the course material; participate in discussions and fill the evaluative surveys (Hockings, DeAngelis & Frey, 2008).

After the selection of peer leaders, the next issue is the preparation of peer leaders. In PLTL chemistry workshops, leaders are required to attend weekly training sessions led by a chemistry professor and/or learning specialists. The main goal of these training sessions or programs is to develop their chemistry content knowledge, to provide and discuss pedagogical ideas about how students learn, and to foster leadership skills and group functioning (Tien et al, 2002, 2004). The PLTL Leader Handbook (Roth, Goldstein, & Marcus, 2001) can be used as a guide in these training sessions. It provides useful information about how to train peer leaders for PLTL workshops in terms of the topic of learning theory, group dynamics, class, and gender, students with disabilities, student-leader relationships, etc. The first training session for the leaders generally aims to welcome them, give general information about PLTL, and their role in the PLTL chemistry workshop.

The review of the course material containing problems and activities for the upcoming workshop usually constitutes the majority of weekly training meetings. Since peer leaders are the MKO in the PLTL model, they must have sufficient subject matter knowledge. As related to this, Cracolice and Deming (2001) claim that if leaders are well-trained in content knowledge, they become experienced and more confident in themselves and the teaching of the workshop materials so that they are likely to get more involved in their peers.

The remaining time is used to provide background information about pedagogy and leadership issues. Peer leaders are required to have pedagogical knowledge and pedagogical content knowledge (PCK) which integrates pedagogical ideas with the subject matter. The content knowledge can be defined as "one's understanding of the subject matter" while pedagogical knowledge means "one's understanding of teaching and learning processes independent of the subject matter" (Bucat, 2004, p.217). PCK, on the other hand, refers to the "blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction." (Shulman, 1987, p. 8). In other words, it represents the knowledge for teaching and learning a particular concept. It also includes not only being informed about content-specific teaching strategies such as illustrations, examples, daily life applications, analogies, demonstrations, and experiments but also being aware of student alternative conceptions and difficulties related to the subject matter to revise those using appropriate teaching methods and strategies (Cracolice & Deming, 2001; Tien et al., 2004). Accordingly, during their training, peer leaders learn which specific questions to be asked, which teaching strategies to be used, which misconceptions and difficulties to be discussed, what types of questions to expect from students, and how to answer to them while discussing and solving the particular problems.

The last discussed topic in training sessions is connected with group work and leadership skills because peer leaders must also learn how to support effectively their peers through the problem-solving process. As a result, certain issues are required to be covered in the training sessions such as workshop setting, student problems, group dynamics and diversity, ethics, motivation, leadership as well as management and problem-solving skills, etc. (Hooker, 2006; Varma-Nelson et al, 2004).

### 2.4.4. Peer-Led Chemistry Workshop Materials

According to Vygotsky (1978), in case of being appropriately challenged and supported by the MKO, students are more likely to extend their capacity and reach a higher level of understanding. The main activity within the PLTL workshop is the discussion of collaborative learning materials under the guidance of a well-trained peer leader. Therefore, such workshop materials including a set of activities and problems must be prepared for creating a challenging environment in which students are engaged with materials and collaborate with each other. In this way, PLTL chemistry materials prepared for each workshop session offer the challenge while peer leaders provide the required help for students (Strozak & Wedegaertner, 2001). Besides, they should be carefully constructed by the course instructor not only to include some common misconceptions/ difficulties and to improve conceptual understanding of chemistry concepts (Varma-Nelson et al, 2004) but also to encourage interaction, collaboration, communication and active involvement with materials and peers in teams (Gosser & Roth, 1998). Taking into consideration of the feedback and suggestions from peer leaders is also beneficial for designing workshop materials. In accordance with the course goals, Gosser and Roth (1998, p.186) reported a range of approaches to design good PLTL chemistry workshop problems:

- Stepwise or structured problems, reflective problem solving,
- Construction of concept maps, simulations using concrete models,
- Interpretation of graphs, observation/deduction problems,
- Problems involving the use of molecular models,
- Workshops based on laboratory experience,
- Problems based on historical developments in chemical thought,
- Problems related to important contemporary issues,

- Creating strategies for synthesis, moving from data to structure and mechanism.

The more students engage with PLTL chemistry workshop problems covering such approaches, the more efficiently they will benefit from the PLTL chemistry workshops to solve collaborative problems. Besides, good materials include various approaches as models, graphical analysis, data interpretation, maps, and metacognitive analysis (Gosser, Kampmeier &Varma-Nelson, 2010). The textbook questions, teacher's guide, and worksheets can be used after they are revised for cooperative/collaborative work at an appropriately challenging level (Cracolice & Deming, 2001). To be transformed into PLTL chemistry workshop problems they should be organized into parts that include questions supporting higher-order thinking skills, logical thinking through reasoning, recognizing patterns, relationships (e.g. Flowcharts) and visual representations (e.g. Molecular-level) (Varma-Nelson et al, 2004). Additionally, PLTL materials can be selected and structured by using many resources such as general chemistry (Gosser, Strozak, & Cracolice, 2006; Strozak & Wedegaertner, 2001), organic and biochemistry (Varma-Nelson & Cracolice, 2001) and standardized instruments such as the American Chemical Society (ACS) test (Quitadamo, Brahler & Crouch, 2009).

The answer key for workshop problem has not been presented to the students and peer leaders because PLTL workshops aim to form a small-group setting where peers discuss about different problem-solving steps and paths instead of simply confirming the answers and solutions in the key (Gosser & Roth, 1998; Varma-Nelson et al, 2004).

### 2.5. Assessment and Evaluation of Peer-Led Team Learning

Despite the fact that educational assessment and evaluation have different meanings, it is seen that they are frequently used interchangeably due to having difficulty in distinguishing them from each other. Assessment refers to the process of obtaining a description and measuring performance within a particular characteristic by using tests, exams or grades, whereas evaluation refers to a more comprehensive term that emphasizes the process of gathering, examining and interpreting information to make a judgment and decision about one's performance and learning (Angelo & Cross, 1993; Bodner, MacIsaac & White, 1999; Gronlund & Lin, 1990; Weiss, 1998). Consequently, students' academic outcomes as an assessment are only the component of a total evaluation and so they are not enough in themselves to make decisions on students' learning. From this perspective, since PLTL concerns about various aspects of teaching and learning process, the evaluation of PLTL was multi-dimensional when considering the implementation, dissemination process and learning outcomes (Gafney & Varma-Nelson, 2008);

- Six critical components could be used to evaluate the implementation of the PLTL model.
- Survey and written questionnaires could be performed to gather information about ideas, attitudes, and experiences of students, peer leaders, and faculty members with PLTL workshops.
- Interviews could be conducted through students, peer leaders, faculty members, and administrators, etc. to gather information about the problems in the intervention process and dissemination, advantages, and limitations of PLTL workshops and other issues.
- The discussion could be employed with students and peer leaders to provide information about the PLTL model.
- To gather data regarding student outcomes, faculty members generally could use grades and test data such as midterm and final exams which constitute the final grade of the students in the course. These final grades could be compared between students in the PLTL and non-PLTL groups to determine student achievement and PLTL effectiveness in enhancing student performance. Additionally, student performance can be examined with a longitudinal study in case of no modification in materials throughout the years.
- Students' course attendance could be collected to be used as a predictor of the students' performance in the course.

- Standardized tests and exams such as the American Chemical Society (ACS) could be used as a pre and post-test.
- Site visits, participant observations, and focus groups could be conducted to collect information about the issues related to implementation, dissemination, and sustainability.
- Leader and student reflections and a course portfolio could be used as in the study of Coppola, Daniels, and Pontrello (2001).

### 2.6. Research Studies on Peer-Led Team Learning

A growing body of research regarding STEM courses in undergraduate education has provided an argument to support that the PLTL model has had a positive impact on;

- *(1) students' outcomes* such as achievement, success rate, retention, attrition, attitude, self-concept, satisfaction, motivation, engagement, perception, discourse process, group dynamics or mechanism, critical thinking skills and higher-level thinking skills (e.g. Chan, & Bauer, 2015; Drane, Micari & Light, 2014; Eberlein et al., 2008; Hockings, De Angelis & Frey, 2008; Hooker, 2006; Lewis, 2011; Mitchell, Ippolito, & Lewis, 2012; Muller, Shacham & Herscovitz, 2018; Prezler, 2009; Tien et al., 2002); and
- *(2) peer leaders' outcomes* such as verbal behavior, peer leader style, confidence, achievement and content knowledge, decision-making skills, leadership skills, critical thinking skills, facilitation skills, beliefs about teaching and learning, teaching skills and love of teaching (e.g. Amaral & Vala, 2009; Gafney & Varma-Nelson, 2007; Glover, Hammond, Smith, & Guerra, 2018; Hug, Thiry, & Tedford, 2011; Kulatunga & Lewis, 2013; Snyder & Wiles, 2015; Stewart, Amar & Bruce, 2007; Streitwieser & Light, 2010; Tenney & Houck, 2004).

The literature associated with PLTL can be categorized into six areas in terms of the variants of the typical or standard PLTL model. The first five classifications were presented by Wilson and Varma-Nelson (2016) and the last one was added by the researcher. Those PLTL variants are explained briefly as follows;

- *(1) Peer-Led Guided Inquiry (PLGI):* it refers to the combination of the PLTL model and process-oriented guided inquiry learning (POGIL). Toulmin's argumentation pattern (TAP) could also be embedded into PLGI. (e.g. Kulatunga, Moog, & Lewis, 2013, 2014; Lewis & Lewis, 2005, 2008).
- *(2) Online PLTL:* it was implemented through two ways in which PLTL was transformed into an online setting, namely cyber Peer-Led Team Learning (cPLTL) and Moodle-based PLTL. In cPLTL, a web conferencing program is used to provide the simultaneous interaction with students and their peer leaders (e.g. Mauser et al., 2011; Smith, Wilson, Banks, Zhu, Varma-Nelson, 2014) while in the application of Moodle-based PLTL study, student groups discussed asynchronously controversial healthcare issues with changing role of leader each week as well as lack of collaborative problem-solving process and training sessions of peer leaders (e.g. Pittenger, & LimBybliw, 2013).
- *(3) PLTL in Laboratories*: it included the combination of PLTL within an undergraduate laboratory course such as general chemistry laboratory, where peer leaders take the role of laboratory mentors of eight students (e.g. McCreary, Golde, & Koeske, 2006).
- *(4) Utilization of In-Class Peer Leaders*: the term "in-class peer leaders" refers to the students being selected as peer leaders from the present participants of the course. They are trained as typical peer leaders (e.g. Schray, Russo, Egolf, Lademan, Gelormo, 2009)
- *(5) Increased Student-To-Peer-Leader Ratios:* In this kind of study, the duration of PLTL workshop was decreased, whereas the number of students in each team was increased when compared to the typical PLTL studies (e.g. Lyon & Lagowski, 2008; Prezler, 2009)
- *(6) Flipped PLTL:* It refers to a combination of a flipped approach and PLTL. It was implemented in General Chemistry and Organic Chemistry in large

classes whose sizes greater than 100 students. In this flipped-PLTL, students learn the course content via short videos presented through a course management system while the course hours are used for PLTL workshops (e.g. Liu, Raker & Lewis, 2018; Mutanyatta-Comar & Mooring, 2019; Robert, Lewis, Oueini, & Mapugay, 2016)

To conclude, these PLTL studies commonly confirmed that the model has been beneficial for increasing student performance and peer leader outcomes within different course settings, such as in a laboratory course or lecture-based courses.

### 2.6.1. Research Studies on Typical Peer-Led Team Learning in General Chemistry

Strong evidence demonstrates that PLTL advances students' academic performances in college STEM courses (e.g. Drane, Micari & Light, 2014) including chemistry, biology, physics, mathematics, anatomy and physiology, computer science, and engineering course. In the area of chemistry, it has been studied in particularly general chemistry (Hockings et al., 2008; Lewis, 2011; Mitchell et al., 2012; Shields et al., 2012;) and organic chemistry (Kampmeier & Varma-Nelson, 2009; Lyle & Robinson, 2003; Tien et al., 2002) courses to increase students’ achievement, motivation, as well as engagement and to reduce student attrition rates in chemistry.

In this research setting, the present intervention study was carried out in a general chemistry course with a traditional PLTL model reported by Gafney and Varma-Nelson (2008). Accordingly, previous standard PLTL studies in general chemistry were examined and briefly summarized in Table 2.2. As perceived in the table, PLTL studies have been performed across semesters in just only first-semester general chemistry course, GC1 (Chan & Bauer, 2015; Frey, Fink, Cahill, McDaniel, & Solomon, 2018; Hockings et al., 2008; Lewis, 2011; Lyon and Lagowski, 2008; Shields et al., 2012; Stewart et al., 2007;) or both in first and second-semester general chemistry courses, GC1 and GC2 (Alger and Bahi, 2004; Baez-Galib et al., 2005; Carlson, Turvold-Celotta, Curran, Marcus, & Loe, 2016; Mitchell et al., 2012;

Stephenson, Miller & Sadler-McKnight, 2019). The results of these empirical researches have indicated the improvement in various student outcomes such as students' course and exam achievement, course pass rate, retention, self-confidence, critical thinking skills, engagement, self-concept, and attitude towards both the subject and the course. Comprehensive information about these research studies is discussed in the following sections.

At Coastal Carolina University Goodwin (2002) conducted a research study in General Chemistry I to determine the effect of computer-based study materials on student performance. In this study, e-Workshop problems were developed as electronic materials in addition to the print-based materials in the "PLTL General Chemistry" workbook (Gosser, Strozak, & Cracolice, 2001) and implemented in PLTL workshops. It was reported that the supplemental electronic problems increased self-assessment of their ability in essential mathematical skills, basic computational skills, and visualization of molecular processes and structures as well as improved confidence in these skills and overall student performance in general chemistry.

A study conducted by Alger and Bahi (2004) aimed to compare the scores of mid-term tests and the ACS final exams in general chemistry between the PLTL group attending the course during two semesters in the 2001-2003 and the non-workshop group attending the course during two semesters in 2001-2002. The results of t-tests (at the 95th percent confidence level) revealed that from the academic year of 2001-2002 to 2002-2003, students improved their scores on mid-term exams as well as ACS final exams through the fall semester, but they did not show any progress on the American Chemical Society (ACS) final exam scores through the spring semester.

Báez-Galib et al. (2005) designed and implemented Chem-2-Chem Program (C2C) in the General Chemistry Course I and II for the students in general sciences program or chemistry, biology, mathematics, physics, and education programs during the seven semesters from 1997.

Table 2.2. *PLTL Studies implemented in General Chemistry Courses*

| **Study** | **Institution** | **Sample** | **GC** | **Semester** | **Comparison groups** | **Workshop duration** | **Student outcomes** |
|---|---|---|---|---|---|---|---|
| Alger & Bahi (2004) | Southern Utah University | Fewer than 50 of GC1 and fewer than 40 of GC2 for PLTL | GC1 and GC2 | FS and SS of 2001-2002 and 2002-2003. | RC with computer-aided instruction during 2002-2003 | 2 h per week | Higher achievement in midterm exams<br>Similar achievement in ACS final exams during the fall semester<br>Higher achievement in ACS final exams during the spring semester |
| Báez-Galib et al. (2005) | University of Puerto Rico | 1849 students from chemistry, biology, mathematics, physics, and education programs | GC1 and GC2 | FS and SS from 1997 to 2000. | non-participants of Chem-2-Chem Program (C2C) | 3 h per week | Higher percentages of final grades of A, B, and C (successful outcomes)<br>Lower percentage of final grades of F and W (unsuccessful outcomes)<br>Lower withdrawal rate of students<br>Positive perception of program by C2C participants |
| Stewart et al. (2007) | University of Maine | 60 students FS of 2000 after FS of 2002 with 500-600 students | GC1 | FS from 1997 to 2003. | non-PLTL group | 2 h per week | Improvement in grades and retention rates.<br>Improvement in success rates (%ABC) with time<br>Higher correlation between PLTL attendance and grades |
| Hockings et al. (2008) | Washington University | 1125 students from arts and sciences, engineering, business, art, or architecture faculty | GC1 | FS of 2003- 2004 | non-PLTL group | 2 h per week | Improvement in grades and retention rates.<br>Positive attitudes toward PLTL and toward the chemistry<br>Being more afraid of working in groups by females<br>The use of more visuals to better understand the concept by females |

Table 2.2. (Continued)

| Study | Institution | Sample | GC | Semester | Comparison groups | Workshop duration | Student outcomes |
|---|---|---|---|---|---|---|---|
| Lyon & Lagowski (2008) | University of Texas at Austin | A total of 457 students (348 students for pre-test analysis) from science majors | GC1 | SS of 2000 | non-PLTL group | NA | Higher achievement in four lecture-oriented, hour-long examinations and course grades. |
| Lewis (2011) | A large, mainly undergraduate institution located in the southeastern US. | 29 general chemistry classes | GC1 | NA | non-PLTL group | 50 min per week | Higher retention rates<br>Similar performance on the ACS final exam<br>Similar gains in passing the course in terms of gender<br>Largest gain in pass rates by minority PLTL students |
| Mitchell et al. (2012) | A large, mainly undergraduate institution located in the southeastern US. | 55 classes of GC1 and GC2 Excluding 4 classes offered during summer semesters | GC1 and GC2 | From FS of 2009 to SS of 2011 | Group1 PLTL(GC1)-PLTL(GC2)<br>Group2 PLTL(GC1)-TI (GC2)<br>Group3 TI(GC1)-PLTL (GC2)<br>Group4 TI(GC1)-TI (GC2) | 50 min per week | Higher pass GC1 rates for PLTL classes than TI.<br>Lower pass GC2 rate for PLTL classes in GC1 than the traditional GC1 classes<br>Similar in the decision to the Enroll GC2 (attrition) rate<br>Similar pass GC2 rate for PLTL and TI in GC1 Similar achievement in GC2 ACS exam. |

Table 2.2. (Continued)

| Study | Institution | Sample | GC | Semester | Comparison groups | Workshop duration | Student outcomes |
|---|---|---|---|---|---|---|---|
| Shields et al. (2012) | NA | 426 underprepared students from arts and sciences and engineering faculty | GC1 | FS of 2007, 2008, and 2009 | Group1 (ER and PLTL)<br>Group2 (ER, PLTL and peer mentoring)<br>Group3 (RR and PLTL)<br>Group4 (RR only) | 90 min ER<br>2 h PLTL workshops<br>2 h peer mentoring | Highest performance of group 2<br>Lowest performance of group 4<br>Higher course performance of group 1 than group 3 but not statistically significant.<br>Improvement in chemistry performance, confidence in their abilities, positive attitude through ER and peer-mentoring |
| *Drane et al. (2014) | Northwestern University | Students enrolled in Chem 101 sequence from five STEM disciplines | Chem 101 sequence | Over a 10-year period between FS 2001 and SS 2011 | non- participants of the Gateway Science Workshop (GSW) program | 2 h per week | Higher course grades in chemistry regardless of their gender or ethnicity.<br>Higher retention rate in chemistry, favoring minority students. |
| Chan & Bauer (2015) | University of New Hampshire | A majority of students majoring in engineering, sciences, health and human services, and liberal arts | GC1 | FRD for two FS of 2008 and 2009<br>QED in FS of 2004 to 2007, and 2011, 2012, 2013. | FRD: non-PLTL (other options)<br>▪ self-organized study groups<br>▪ instructor-led review sessions<br>▪ drop-in tutorials<br>▪ instructor office hours<br>QED: TI | FRD: Nearly every week, 80 min in 2008 and 50 min in 2009<br>QED: 50 min in 2009 and 2011 while 80 min in other years | FRD:<br>Similar in achievement, attitude, or self-concept<br>Higher positive attitude, self-concept, and achievement of freshman students<br>Higher positive attitude and self-concept of male students.<br>QED:<br>Improvement in exam achievement. |

Table 2.2. (Continued)

| Study | Institution | Sample | GC | Semester | Comparison groups | Workshop duration | Student outcomes |
|---|---|---|---|---|---|---|---|
| *Carlson et al. (2016) | A private, medium-sized, liberal-arts university in the Midwest of the US | A total of 59 matched pairs for GC1 and 108 matched pairs for GC2. | GC1 and GC2 | FS and SS | non- STEM Learning Community (LC) chemistry program | 2 h LC per week | Higher performance on nearly all exams including both final exams of GC1 and GC2.<br>Higher improvement on the ACS GC final exam.<br>Higher performance in terms of grade (A, B and C) subgroups, more positive impact on more at-risk students of GC1. |
| Frey et al. (2018) | NA | 1254 first-year students who self-identified as white or an underrepresented minority | GC1 | FS of 2012 through 2016 | Group1 (PLTL)<br>Group2 (non-PLTL)<br>Group3 (Growth-Mindset Intervention with PLTL)<br>Group4 (Growth-Mindset Intervention without PLTL) | 2 h per week | Higher improvement in exam averages for PLTL group regardless of the conditions (with or without Growth Intervention, group1 and 3), but the effect was larger among students no participating in Growth Intervention (group1)<br>Similar improvement in exam averages for all identity groups (sex and race subgroups) of PLTL.<br>Higher performance of PLTL students with less college preparation |

Table 2.2 (Continued)

| Study | Institution | Sample | GC | Semester | Comparison groups | Workshop duration | Student outcomes |
|---|---|---|---|---|---|---|---|
| Stephenson et al. (2019) | A regional three-year university in the Caribbean | 159 students from STEM majors including Life Sciences, Chemistry, Biochemistry, Mathematics, and Physics | Intro. Chem (GC1 and GC2) | FS and SS | non-PLTL groups<br>▪ SWWT group<br>▪ TI | 2 h PLTL workshops 4 h SWH-based lab session and 2 h critical-thinking-focused workshops | Higher improvement in inference, evaluation, and explanation subscales, and overall critical thinking skills by the PLTL and the SWWT groups, no significant difference between them.<br>Similar improvement in the analysis subscale |

Note 1. GC: General Chemistry Course, GC1: First-Semester General Chemistry, GC2: Second-Semester General Chemistry, FS: Fall Semester, S: Spring Semester, PLTL: Peer-Led Team-Learning, TI: Traditional Instruction, FRD: Fully-Randomized Design, QED: Quasi-Experimental Design, ER: Extended Length Recitations, RR: Regular Recitation, NA: Not Addressed, SWWT: Science Writing and Workshop Template

Note 2. * Only the general chemistry-related parts of the STEM study have been reported.

The results compared the average percentages of final grades in GC1 and GC2 courses for successful course outcomes (A, B, C final grades) and unsuccessful course outcomes (F, W final grades) of the PLTL group and non-PLTL group participants. The results indicated that there were highly statistically significant differences among groups with a 99.9 % confidence level for both successful and unsuccessful course outcomes ($\chi2 = 35.91$; $df = 1$; $p < 0.0001$), supporting the significant effect of C2C program on all final grades.

Another study carried out by Hockings, DeAngelis, and Frey (2008) at Washington University in St. Louis examined the influence of the PLTL model on students' academic performance and attitudes and self-confidence. The participants included 1125 students enrolled in General Chemistry I during the 2003 and 2004 fall semesters from Arts and Sciences, Engineering, Business, Art, or Architecture programs. They found that PLTL students significantly outperformed the non-PLTL students on final GC1 course grades by around one-third of a grade point ($\beta = 0.30$, which means an average of B versus B–). Consistent with the study of Báez-Galib et al. (2005), the results confirmed that PLTL students have higher percentages of final grades of A, B, and C. Besides, students with more academically well prepared, with higher SAT mathematics score, and from non-minority groups performed significantly higher. The study also reported the positive effect of PLTL on the improvement in retention rate. According to the attitudinal survey results, higher achievers were more likely to perceive PLTL more positively than low achievers, but in general, students showed positive attitudes toward PLTL and chemistry subject. Notably, gender differences were seen in the survey; for example, male students felt more comfortable working in groups than female students who prefer using visuals for understanding a concept when compared to the males.

In fall 2006, Frey, Brown, and Sawyer (2009) made a qualitative research in a general chemistry course at Washington University to learn about the group mechanisms and types of discourse processes between the leaders and students in PLTL groups that lead to the improved performance in terms of the three PLTL activities; content review, problem-solving, and concept discussion. The findings of the study indicated that leaders mostly utilized a mixture of instructional and facilitative discourse, varying the extent of the talk with respect to the peer leader. Further, student discourse could change regarding PLTL activities and groups but mainly facilitation and problem-solving. Additionally, there were differences in the percentage of time denoted to peer-leader discourse, student discourse, individual tasks, and off-task behaviors during three PLTL activities.

According to the research about an evaluation of the PLTL model in GC1 (Lewis, 2011), students' performance on the ACS exam, pass rate, and retention rate were studied in a large undergraduate institution placed in the southeastern United States. The sample consisted of students who represent a diverse set of groups, 56.6 % female, 9.5 % Black, 61.9 % White, 3.4 % Hispanic, 5.3 % Asian, and 20.0 % mixed-race students. Unlike the PLTL literature (Gafney & Varma-Nelson, 2008; Gosser et al., 2001) in which each team includes six to eight students and its own peer leader, in this study firstly a peer leader was assigned to a team of 12-16 students and then peer leader distributed those into small groups of four students to work on problems once a week for 14 total peer-led session. He documented that PLTL students demonstrated a statistically significant 15% progress on pass rates of student groups than TI ($t = 3.69$, $p < 0.05$, Cohen's $d = 1.56$, large effect size). Additionally, the percentage of students in PLTL groups taking the ACS exam was 12 % higher than that with the TI ($t=3.41$, $p < 0.05$, Cohen's $d =1.49$, large effect size). The results also pointed out a higher retention rate of PLTL students. These gains are in line with previous studies conducted by Stewart et al. (2007) and Hockings et al. (2008). Moreover, TI and PLTL classes indicated similar improvement in ACS final exams as reported by Alger & Bahi (2004) study in the fall semester. Considering the students' groups, similar improvements in the percentage of students passing GC1 course were seen between males (12.8 %) and females (12.3 %), whereas the largest improvement (17.7 %) in pass rates was seen among PLTL students in underrepresented minority groups (Blacks, Hispanics, and American Indians). Those matches the results of the study performed by Drane et al. (2014), with the strong potential for improving students' course grades regardless of their gender or ethnicity and for increasing retention rate in chemistry, favoring students from underrepresented minority groups.

Mitchell, Ippolito, and Lewis (2012) implemented PLTL model in successive two semesters of General Chemistry courses and examined not only the impact of PLTL model implemented in GC1 on student performance in GC2, students' decision to enroll in GC2 but also the impact of PLTL model in GC2 on the GC2 chemistry performance. The participants consist of GC1 students from the SS of 2009 through the FS of 2010, with 12 PLTL classes out of 35 GC1 classes, and GC2 students from FS of 2009 through SS of 2011, with 8 PLTL classes of 24 GC2 classes. Based on the results of the analysis conducted at the class-level ($\alpha = .05$), there was little or no impact of PLTL model on students' decision to continue GC2 sequence or in subsequent chemistry courses despite a significant gain in student performance and pass rate in GC1 through PLTL. The higher pass rate in GC2 also found for the traditional GC1 classes and PLTL in GC2 classes so that it supports the implementation of PLTL in both GC1 and GC2 to acquire a higher student performance. Lastly, PLTL classes in GC2 shows a positive impact on student withdrawal rates and percent taking GC2 ACS exam and percent passing the GC2 class. The evidence collected in the study emphasizes the need for curriculum-wide implementation of the PLTL model since the effect would be minimized in other cases.

The impact of a transition program on underprepared students' performance in general chemistry was explored by using data from the FS of 2007, 2008, and 2009 (Shields et al., 2012). The participants were 426 students (40% of the 1070 total students) having predicted end-of-course (EOC) scores of 67 or below. Their study compared the effectiveness of four learning groups on students' course performance, namely group1 (Extended recitation and PLTL participation), group2 (Extended recitation, PLTL participation, and peer mentoring), group3 (Regular recitation and PLTL participation) and group4 (Regular recitation only). Of these groups, group2 students showed significantly the highest course performance, while group4 students scored significantly lower among them. In addition, group1 students outperformed those in group3; however, the result was not statistically significant ($p > 0.001$). Moreover, according to the students' perception of the transition program, extended-length recitations and peer-mentoring groups developed their general chemistry performance.

At the University of New Hampshire, Chan and Bauer (2015) made a research to investigate exam achievement in general chemistry I and affective characteristics (self-concept and attitude towards chemistry) of students who majors in engineering, sciences, health, and human services, and liberal arts, contrasting PLTL participation with alternative study groups in a fully-randomized experimental design (FRD) for FS of 2008 and 2009 and with TI groups in quasi-experimental design (QED) for FS of 2004 through 2013. They reported that there are no significant differences in exam achievement among learning groups in FRD, while PLTL groups in QED had higher exam achievement scores compared to non-PLTL students in the following years of 2006, 2007A, 2007B, 2011A, and 2012. (A-B referring different course sections). The comparison of attitude and self-concept was made only in QED. The results of the overall scale of attitudes showed no significant differences between the two groups. As within the groups during the semester, students' attitudes towards chemistry altered in a negative way ($p<0.001$). When the attitude subscales were examined, a statistically significant decrease was found in intellectual accessibility subscale, interest and utility subscale, and emotional satisfaction toward the chemistry subscale. Nonetheless, during the semester, students demonstrated a significant increase in anxiety and fear of chemistry. This pattern of attitude is in contrast with the study of Hockings et al. (2008) who found a positive attitude toward chemistry. The students' self-concept about chemistry as another affective construct of the study was not significantly different between learning groups (PLTL or non-PLTL) with a merely significant decline in academic enjoyment of self-concept subscale. Furthermore, in terms of differences in student characteristics, first-year students and males had higher self-concept and positive attitudes toward chemistry. More specifically, females presented higher fear in FS of 2008 while males presented higher intellectual accessibility towards chemistry in FS of 2008 and higher emotional satisfaction in FS of 2009.

In the mixed methods research study implemented in a private university in the Midwest of the United States, Carlson et al. (2016) examined the impact of Learning Community (LC) program (PLTL program) on achievement of students in introductory biology, chemistry, calculus and applied statistics courses. About the general chemistry, paired-samples statistical tests showed that LC chemistry students performed higher than their matched pairs on nearly all exams including both final exams of GC1 and GC2 ($\alpha = .05$), with predominantly the higher performance on the ACS General Chemistry final exam ($t(107) = 4.916$, $p < .001$). This improvement of the program on ACS scores contradicted the results seen in other studies that have indicated similar achievement in ACS final exams (Alger & Bahi, 2004; Mitchell et al., 2012). The study also revealed that participants of LC Program in GC1 and GC2 get higher scores than those in non-LC groups in terms of grade groups (A, B, C, and D/F) who are categorized based on their Toledo (an American Chemical Society chemistry placement exam) scores. The significant differences among the A, B, and C subgroups were found in the GC2 final exam.

The other study regarding PLTL intervention performed in a regional three-year university in the Caribbean with first-year chemistry students from different sets of STEM majors including Life Sciences, Chemistry, Biochemistry, Mathematics, and Physics (Stephenson et al., 2009). Their study aimed to explore the effect of the implementation of PLTL and the Science Writing and Workshop Template (SWWT) approaches on critical thinking (CT) skills of students. California Critical Thinking Skills Test (CCTST) was used to measure critical thinking skills. Regarding the comparison of the results of post-test with pretest score, the SWWT group had a greater post-test score of CT ($M = 15.21$, $SD = 4.30$), with a gain of 3.19 points that was 4 times higher than TI group had ($t(53) = 5.98$, $p < 0.001$, higher effect size).

Besides, the PLTL group had a greater post-test score of CT (M = 14.28, SD = 4.12), with a gain of 2.26. This was three times higher than the TI group had ($t (53) = 5.03$, $p < 0.001$, medium effect size). Additionally, ANOVA results revealed that PLTL and SWWT groups students obtained similar overall CT gains ($p = 0.318$) despite significant differences in gains of their CT between SWWT and TI groups and between PLTL and TI groups. When the CT subscales were examined within-group analysis, it was found that there were significant improvements in the inference and evaluation scale as well as explanation scale in students of SWWT and PLTL groups, but no significant gain in the analysis subscale. The findings of the between-group analysis of the subscales also indicated that there were significant differences in any of the CT subscales neither between students in PLTL and TI groups nor between students in PLTL and SWWT groups. On the other hand, significant differences were observed on the explanation subscales as well as inference and evaluation subscales between students in SWWT and TI groups.

### 2.7. Anxiety

In addition to the investigation of cognitive variables in science education, measuring affective variables is a crucial issue because various studies have supported that affective variables could influence the conceptual understanding and performance of students in science (Chandran, Treagust, & Tobin, 1987). As an affective construct, anxiety refers to the "subjective feeling of tension, apprehension, nervousness and worry associated with an arousal of the autonomic nervous system" (Spielberger, 1983, p. 15). It includes feelings of discomfort, unease, worry, nervousness, and threatening in some situations (Spielberger, 1972). According to the American Psychological Association (APA), anxiety is also defined as "an emotion characterized by feelings of tension, worried thoughts and physical changes like increased blood pressure". Further, Kalisch et al. (2005) state that anxiety is a general human feeling that influences the physiological stimulation and cognitive functions of individuals. The symptoms of anxiety could be either psychological or physical. For example, such adverse emotions and physical responses might be difficulty in breathing, sweating of hands, accelerating in heartbeat, panic, nervous, fear, stress, shame, as well as lack of confidence, impotency, and inability to focus on (Seligman, Walker, & Rossenham, 2001).

Throughout their school years, students can experience various causes of anxiety in science courses including lack of role models, past bad experiences in science classes, gender and racial stereotyping, exposure to science anxious teachers and the stereotyping of scientists in the popular media (Mallow, 1986; Mallow et al., 2010). Besides, it might be triggered by family, school, or environmental factors (Mallow, 2006). The performances of individuals in their daily life or the classroom setting could be affected through these feelings of anxiety. A body of research provides a piece of evidence that some degree of anxiety may be helpful for an individual to perform effectively while a high level of anxiety may hinder student's performance in the science learning process by locking the utilization, attention resources, or developing more cognitive interference from the worries and fears (Mallow & Greenburg, 1982). Thus, it is widely inferred that a moderate level of anxiety is essential for a student's success.

Related to its negative effect on student's learning and academic performance, previous studies have found that students with high levels of anxiety have a decreased span of working memory, lack of concentration, and poor reasoning skills (Aronen, Vuontella, Steenari, Salmi, & Carlson, 2005), show a negative attitude towards learning processes such as low level of interest, low performance in assignments and exams (Vitasari, Wahab, Othman, Herawan, & Sinnadurai, 2010) and less motivation in classroom (Hancock, 2001). More clearly, Spielberger (1975) examines the effects of a high level of anxiety on performance and finds its interruption role in remembering the essential information, particularly related to the more difficult problems within the evaluative conditions.

Several studies have demonstrated that high anxious students have poorer academic performance (Czerniak & Chiarelott, 1984; McCraty, 2007) and low academic achievement can cause a high level of anxiety among students (Luigi et al., 2007). Accordingly, there is a possible relationship between a high level of anxiety and low academic performance among students and so maintaining the anxiety cycle. Hembree (1998) notes that the high level of anxiety of low-achievers is commonly more attributable to their poorer academic performance than that of high-achievers. Based on the study conducted by Vitasari et al. (2010), this relationship between the high level anxiety and low academic performance is found among engineering students with significant correlation. Similarly, Spielberger reports that college students with high anxiety have lower grades and higher dropout rates (1971).

On the contrary to above literature that indicates the effect of anxiety on academic success as a predictor, there are also research findings revealing no relationship between anxiety and academic achievement (Jakubowski & Dembo, 2002; McCann & Meen, 1984). McCann and Meen also uncover that for low-achievers, there was a negative correlation between anxiety and achievement while for high-achievers, anxiety and achievement are positively correlated.

Although numerous studies have investigated the effect of attitude and motivation constructs (Bennett, 2001; Glynn, Aultman, & Owens, 2005; Koballa & Glynn 2007; Rani, 2000; Reiss, 2004; Salta, K., & Tzougraki, 2004; Simpson, Koballa, Oliver & Crawley, 1994; Simpson & Oliver, 1990), a few research examined the effect of anxiety on student achievement in science education, particularly on chemistry subject as a separate construct (Woldeamanuel, Atagana & Engida, 2013). Besides, it was not discussed in the PLTL projects in the literature as a separate variable.

### 2.7.1. State and Trait Anxiety

According to Spielberger's theory of anxiety, anxiety concept is more understandable when it was classified as trait anxiety and state anxiety. He (1983) defined the "concept of state anxiety" related to the "temporary emotional condition" that refers to "one's interpretation of a particularly stressful situation at a particular time or emotions at a particular moment in time". On the other hand, he defined the "concept of trait anxiety" related to the "permanent personality characteristics" that refers to "relatively stabilizing individual differences in anxiety tendency". In other words, trait anxiety means a general feeling of anxiety experienced by an individual whereas state anxiety is a situation-specific form of anxiety at a certain moment. Spielberger (1972, 1983) states that individuals, who experience more intense anxiety than other people have, commonly have high levels of trait anxiety, and in some stressful situations a high level of state anxiety too. For example, during an exam, a student with an elevated level of trait anxiety is more prone to find testing situation frightening or dangerous than those with low trait anxiety. Therefore, students who score high on trait anxiety are more likely to experience an elevation in state anxiety (Zeidner, 1998). Besides, regarding the degree of perceived danger, state anxiety might vary in a particular situation such as preparation for the exam (e.g., amount of time studying), difficulty level or the type of test questions (e.g., multiple-choice), and personality differences among individuals (Spielberger, 1972; Spielberger & Vagg, 1995; Zeidner, 1998).

Several studies regarding anxiety indicate that although state anxiety influences positively students' academic performance, trait anxiety generally changes their academic performance in a negative direction due to its effect on people's memory and cognitive functioning (MacIntyre & Gardner, 1991).

#### 2.7.2. Social Anxiety

Despite the significant role of social interaction among individuals in their physical and psychological development, some people do not prefer being in social interaction with others and show shyness, fear, and anxiety in social situations. Those performing this behavior are accepted as socially anxious individuals (Ayeni, Akinsola, Ayenibiowo, & Ayeni, 2012). Social anxiety can be defined as a multidimensional construct that includes cognitive and affective features such as feelings of inadequacy, nervousness, fear, and embarrassment (Leary, 1983; 1991) and behavioral features such as avoidance, awkwardness, and inhibition (La Greca & Lopez, 1998) in social settings. Social anxiety also refers to the persistent fear of negative evaluation or social distress within social situations in which the person is subjected to new conditions or stressful interactions with other individuals (Leary, 1991). Notably, high socially anxious people are generally afraid of being negatively evaluated by other people, and feel communication uneasiness (Beidel, Morris & Turner, 2004; Leary, 1991) so that they are more likely to avoid new social interactions. According to the cognitive model of social anxiety in the study by Clark and Wells (1995), an individual's certain belief systems and related assumptions are triggered after interacting with other people within a community and s/he can perceive himself or herself as a failure if the right or proper answer to the question is not given. The earlier experiences generally form such beliefs about personal inadequacy and cause anxiety in social situations (Topham & Russell, 2012).

Most students might face with social anxiety in their school careers. Students with high social anxiety are more likely to avoid participating in group work, completing a group task, or might show fear about asking for help from their peers. In higher education, undergraduate students might also be situated in common learning circumstances that cause high social anxiety such as lectures in halls, presentations, group projects, laboratory work, work experience, and employment interviews. More specifically, they are usually supposed to speak speaking out in public or in front of large groups (40-200 individuals) in a lecture or laboratory and to argue their ideas about their subject area with specialists, professors, and more knowledgeable people in seminars (Topham & Russell, 2012). Most university students also reported that they experience frequent social anxiety associated with making a presentation (Russell & Topham, 2012). The analysis of the results obtained in a study conducted by Russell and Shaw reveals that high levels of social anxiety exist in university students with a relatively small number but a significant proportion (approximately 10% of students). Further, a significant difference in scores for total fear and fear of social interaction are found for undergraduates from the faculties of Technology and Arts (2009).

High socially anxious students deal with many challenges and perturbing circumstances in their both everyday lives and school lives. It is shown in the literature that these people generally perceive themselves as being less friendly, less clever and antisocial among their peers (Christensen, Stein, & Means-Christensen, 2003), have poor social skills (Bögels, Rijsemus, & De Jong, 2002), get well in with fewer peers in school (Beidel, Rao, Scharfstein, Wong, Alfano, 2010; Russell &Topham, 2012), involve less in social learning activities, and prefer careers demanding not as much of social interactions with others (Beidel et al., 2010), have poor social performance, poor communication skills, and less interpersonal perceptions (Angélico, Crippa & Loureiro, 2013) and have low academic ability and performance (Eng, Coles, Heimberg & Safren, 2005; Russell & Shaw, 2009) than those with less social anxiety.

Additional studies provide evidence about the adverse influence of a high level of social anxiety on exam failure and failure to complete school and graduate (Stein & Kean, 2000; Wittchen, Stein, & Kessler, 1999). On the other hand, the results of another study (Strahan, 2003) uncover that social anxiety is not a statistically significant predictor for academic achievement and college perseverance. However, Angélico, Crippa, and Loureiro (2013) claim that social anxiety is likely to indirectly influence the academic performance and retention of the students because there is a negative and moderately significant relationship between social anxiety and academic adjustment that had a significant impact on indicators of academic achievements.

All the above studies have highlighted the importance and necessity of the educational pedagogy and programs that support students with social anxiety. It is obvious that teachers and professors are required to use new teaching strategies that aim to increase students’ self-confidence and ease anxiety in social learning activities, predominantly including public speaking and interaction with strangers.

# CHAPTER 3

# METHODOLOGY

*"In the long history of humankind (and animal kind, too) those who learned to collaborate and improvise most effectively have prevailed."*

*(Charles Darwin)*

In this chapter, the design of the study, population and sample of the study, variables, and instruments used to collect data, procedure, treatments, data analyses, treatment fidelity, and verification, power analysis, unit of analysis, and assumptions of the study were explained briefly.

## 3.1. Design of the Study

To examine the impact of PLTL over TCI on improving students' exam achievement, and conceptual understanding, as well as reducing the state anxiety and social anxiety, the experimental research methodology was selected to be employed in this study because this method enables researchers to manipulate the independent variable (teaching methods of PLTL and TCI) as a cause and observe its effects on the dependent variable (students' exam achievement, conceptual understanding, state anxiety, and social anxiety). In other words, it is the best method to establish and analyze the cause-effect relationships among variables (Shadish, Cook & Campbell, 2002). In particular, a quasi-experimental pretest-posttest control group design (i.e. the static-group pretest-posttest design) as a type of experimental design was utilized. Random assignment of the participants is not applicable in this design as the subjects are not randomly assigned to the experimental group or control group through a random procedure. Rather, already formed groups (i.e. classrooms, sections) are used to be randomly assigned to these groups (Fraenkel & Wallen, 2012). In addition to being appropriate for intact groups, this design minimizes the threats to internal and external validity (Campbell & Stanley, 1963; Cook, & Campbell, 1979).

The subjects of the experimental group (EG) and the control group (CG) were selected from two sections of one semester General Chemistry (GC) course taught by the same instructor. At the outset of the fall semester of 2016-2017 education year, students were assigned to GC course sections. Thus, in order to determine which sections are EG and CG, first, a number was drawn from a box in which the GC section numbers were written on a piece of paper, and then it was assigned as CG of the study. Another number drawn from the box was identified as EG. As a result of using a random procedure, while section one constitutes CG, section two forms the EG. Table 3.1 briefly described the experimental design of the study.

Table 3.1. *Experimental design of the study*

| **Groups** | **Pre-tests** | **Treatments** | **Exam** | **Treatments** | **Exam** | **Treatments** | **Post-tests** | **Exam** |
|---|---|---|---|---|---|---|---|---|
| (EG) | GCCT<br>STAI<br>SAQ | PLTL | MT1 | PLTL | MT2 | PLTL | GCCT<br>STAI<br>SAQ<br>SS<br>LS | FE |
| (CG) | GCCT<br>STAI<br>SAQ | TCI | MT1 | TI | MT2 | TCI | GCCT<br>STAI<br>SAQ | FE |

Note. EG: Experimental Group, CG: Control Group, GCCT: General Chemistry Concept Test, STAI: State-Trait Anxiety Inventory, SAQ: Social Anxiety Questionnaire for Adults, PLTL: Peer-Led Team Learning, TCI: Traditional College Instruction, Survey, MT1: Midterm Exam 1, MT2: Midterm Exam 2, FE: Final Exam SS: Student Survey, LS: Leader Survey

As seen from Table 3.1, the participants of EG were involved in PLTL workshops while the participants of CG received TCI and did not get involved in these workshops.

General Chemistry Concept Test (GCCT) was applied to both groups before the intervention to decide whether there was a significant mean difference among groups with regard to students' previous conceptual understanding of general chemistry concepts. Moreover, the State-Trait Anxiety Inventory (STAI), and Social Anxiety Questionnaire for Adults (SAQ) were administered to experimental and control groups to compare the students' general anxiety, and social anxiety level respectively. After the implementation of PLTL and TCI, General Chemistry Concept Test (GCCT), State-Trait Anxiety Inventory (STAI), and Social Anxiety Questionnaire for Adults (SAQ) were administered to both groups again to investigate the effectiveness of the PLTL model over TCI. Participants' exam achievements were assessed with midterms applied twice during the term and final exam at the end of the term. To evaluate the PLTL model in detail, the student survey and leader survey were used in the PLTL group at the end of the semester.

### 3.2. Population and Sample

The target population of the study contains all undergraduate freshman engineering students taking General Chemistry course in the private or foundation university at which the medium of instruction in engineering programs is English in the province of Ankara. There are five private or foundation university (Atılım, Bilkent, Çankaya, TED, Türk Hava Kurumu) in Ankara that meets these criteria. Of those, the medium is English for all courses and departments in four universities, while the medium of instruction can change depending on the departments in one university (Türk Hava Kurumu). However, the engineering programs and General Chemistry course for engineering students are English for this university. There were totally 1689 students who were admitted to the engineering programs in those universities in the fall semester of 2015-2016 education year. However, for Bilkent University student profile is somehow different from the students in other universities in the population. For example, with respect to the college of engineering entry scores (CEES, LYS-MF4), Bilkent University engineering students' scores change in the range of 370-555 while those in other universities change in the range of 230-430. Therefore, Bilkent

University was excluded from the target population and so the number of students in the target population dropped in 1274. Instead of 2016 data, Student Selection and Placement Center (OSYM) 2015 placement results were used since they were required to attend a one-year preparatory school before taking general chemistry course. Due to having difficulty in reaching all target population in these universities, the accessible population of the study was determined. The accessible population was all undergraduate freshman engineering students taking General Chemistry course at Atılım University in Ankara. Atılım University was selected by using a convenience sampling method from the target population. The sample of this study was also determined from the accessible population (Atılım University) by using purposive sampling in the fall semester of the 2016-2017 education year. In that semester, a total of 500 engineering students (generally almost 350 students for that university) enrolled in the general chemistry course. For the implementation of the study, two intact sections of General Chemistry instructed by the same professor were designated from its three sections as an experimental and control group. The curriculum, class content, and all examinations were identical for all sections of the course. The lecturer was an experienced female professor who participated voluntarily in this study.

General Chemistry at Atılım University for engineers (CEAC 105) is a one-semester course including the chemistry concepts of first and second-semester General Chemistry. This course has been taught through weekly three 50-minute lecture sections with biweekly three 50-minute laboratory sessions. While the lecture style of EG was a combination of two-thirds teacher-centered lectures with one-third PLTL workshops that of CG was three 50-minute teacher-centered lectures and problem-solving. Figure 3.1 indicates the process of how the participants in CG (TCI), and EG (PLTL) were determined to be included in the sample. At first, the course enrollments in the fall semester of 2016-2017 education year were 181 for EG and 174 for CG. However, nearly two-thirds of the population have not been included in the sample.

To avoid bias among participants (P) of the study and nonparticipants (NP), some demographic data regarding students' age, gender, major, and academic abilities based on university entrance scores (LYS) were obtained from university records and compared among the students in P and NP groups. For example, the average age of the students for both groups was 19 and the ratio of gender for P and NP were similar (P, 78% male, and 22% female; NP, 79% male, and 21% female). P and NP groups include students from six different majors:

- electrical and electronics engineering (27% of P and 14% of NP)
- manufacturing engineering (3% of P and 14% of NP)
- mechatronics engineering (17% of P and 22% of NP)
- civil engineering (33% of P and 22% of NP)
- automotive engineering (5% of P and 11% of NP)
- software engineering (15% of P and 17% of NP)

In terms of major ratios, some percentages were not so close for P and NP as seen above. However, it could be inferred that there were students with different academic abilities in both groups since LYS scores of students generally changed between 220 and 400 for each major. Additionally, there was found no statistically significant different between P (M=295.37, SDP= 37.37) and NP (M= 287.93, SDNP = 33.14) of the study ($t(353) = 1.77$, $p = 0.084$). It was, therefore, possible to say that P and NP students showed similarity in such demographic features.

As seen from Figure 3.1, engineering students attending these two sections for this particular course took both pretests in the first meeting at the outset of the semester and posttest at the end of the semester. To be taken as a sample of CG, engineering students enrolled in section 1 were required to fill in all instruments given as pretests and posttests or only for the post-tests. To be taken as a sample of EG, engineering students enrolled in section 2 were required to fill in all instruments given as pretests and posttests or only for the post-tests. The additional requirement for EG was that they were able to participate at least 50% of the PLTL workshops, that is, at least three sessions. If students did not fulfill these requirements, they were not included in the sample.

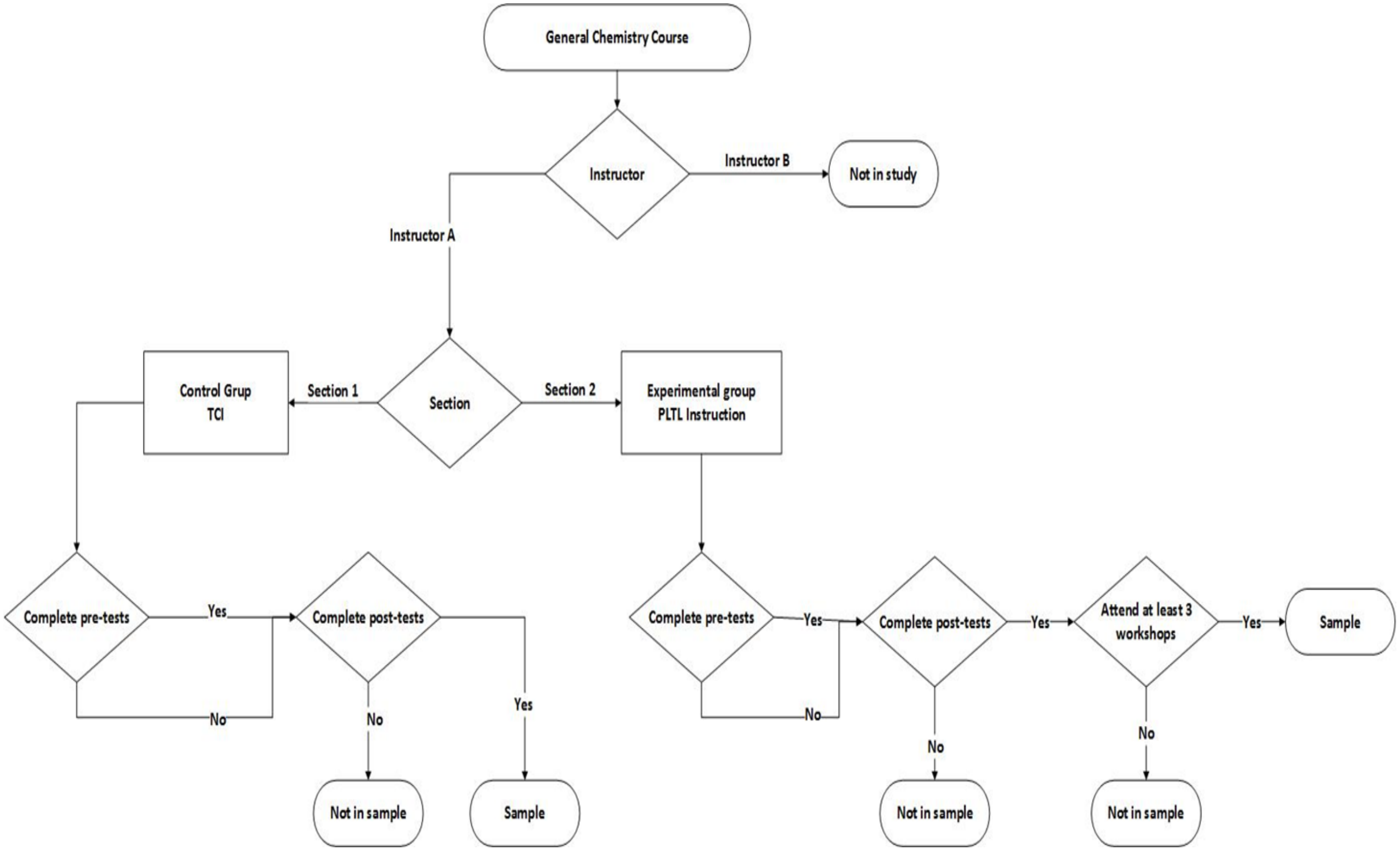


*Figure 3.1.* The selection process of the students in the sample of the study

Details about the sample of this study were summarized in Table 3.2. The subjects of this study consisted of 128 undergraduate engineering students. In terms of groups and gender, the participants consisted of 60 undergraduate students (47 males and 13 females) for CG and 68 undergraduate students (53 males and 15 females) for EG with a total number of 28 females and 100 males. The students' age varied from 18 to 27, particularly 19. The CG and the EG had students in different majors. The CG students' majors were electrical and electronics engineering, manufacturing engineering, mechatronics engineering, and mechanical engineering, whereas EG students' majors were civil engineering, automotive engineering, and software engineering. In order to engage in the study, voluntary participation and acceptance form were given to students to be signed (see Appendix A).

Table 3.2. *Distributions of the number of students in the sample across groups, gender, and departments*

| | **CG** | | | **EG** | | | **Total** |
|---|---|---|---|---|---|---|---|
| | EE | MFGE | MECE | CE | AE | SE | |
| Male | 26 | 4 | 17 | 30 | 7 | 16 | 100 |
| Female | 8 | 0 | 5 | 12 | 0 | 3 | 28 |
| Total | 34 | 4 | 22 | 42 | 7 | 19 | 128 |

Note. EE: Electrical and Electronics Engineering, MFGE: Manufacturing Engineering, MECE: Mechatronics Engineering, CE: Civil Engineering, AE: Automotive Engineering, SE: Software Engineering.

To make the experimental group and control group equal, CEES scores were compared to match the students in EG and CG. The distributions of the score were found in the range of the 220 and 400 for both groups. Although both groups had students from different majors, it was seen that CEES scores were not different in both groups, not favoring one group. In order to make each PLTL group as similar as possible, workshop time and demographics (sex and major) were tried to be balanced. Consequently, the PLTL groups in this study indicated the following common features:

- The team size was in the range of 4–6 engineering students with median size of 5 students per group.
- Two-thirds of teams included one female, with the rest having two females.
- Teams were dominated by the undergraduates majoring in civil engineering with most of the remainder was from software engineering.

As peer leaders, there were 14 undergraduate students in their sophomore year in the study. These leaders were selected by using a purposive sampling method. For the proper implementation of the PLTL model, they are required to have two main characteristics. First, those who have earlier attended the General Chemistry (CEAC 105) should have performed successfully (B grade or better). Second, they should have some skills in leadership, interpersonal relationships, communication, guidance as well as collaborative and cooperative works. Therefore, the course professor primarily assisted to identify the students who have these characteristics. Then, they were contacted by telephone and asked if they wanted to attend such a project. Finally, volunteer participants were determined and signed both voluntary participation and acceptance form (see Appendix B). Distribution of the number of leaders in the study across gender and departments was given in Table 3.3.

Table 3.3. *Distributions of the number of peer leaders in the sample across groups, gender, and departments*

| | **Peer Leaders** | | | | **Total** |
|---|---|---|---|---|---|
| | CEAC | ENE | ME | CE | |
| Male | 1 | - | 2 | 1 | 4 |
| Female | 7 | 2 | 1 | - | 10 |
| Total | 8 | 2 | 3 | 1 | 14 |

Note. CEAC: Chemistry Engineering and Applied Chemistry, ENE: Energy System Engineering, ME: Mechanical Engineering; CE: Civil Engineering.

## 3.3. Independent and Dependent Variables of the Study

There were three independent variables (IVs) and four dependent variables (DVs) in this study. Their lists and characteristics were presented in Table 3.4 below.

According to this table, the teaching method, CEES scores of students, and trait anxiety of students were IVs of the study. The teaching method variable was categorical and measured at a nominal scale with two levels which were PLTL and TCI. The CEES scores of students were continuous and measured on an interval scale. However, in some analyses, it changed into the categorical one in terms of academic abilities and had three levels namely, low, middle, and high achievers. Lastly, the trait anxiety (STAI-T) variable taken as an indicator of students' trait anxiety level was measured on an interval scale.

Table 3.4. *List of variables*

| Variables | Type | Nature | Scale |
|---|---|---|---|
| Teaching Method | IV | Categorical | Nominal |
| Academic Abilities (CEEC) | IV | Continuous | Interval |
| Academic Abilities (CEEC) | IV | Categorical | Ordinal |
| Trait Anxiety (STAI-T) | IV | Continuous | Interval |
| General Chemistry Exam Achievement (GCEA) | DV | Continuous | Interval |
| Conceptual Understanding (Post-GCCT) | DV | Continuous | Interval |
| State Anxiety (Post-STAI-S) | DV | Continuous | Interval |
| Social Anxiety (Post- SAQ) | DV | Continuous | Interval |

All DVs in the study were continuous and measured on an interval scale. DVs for students' cognitive experiences were students' general chemistry exam achievement (GCEA) representing students' success in two midterm exams and final exam and post-test scores on general chemistry concept test (Post-GCCT) representing students' conceptual understanding. Also, DVs for students' anxiety experiences were post-test scores on state anxiety inventory (Post- STAI-S) representing students' state anxiety level, and post-test scores on social anxiety questionnaire for an adult (SAQ) representing students' social anxiety level.

### 3.4. Instruments

In this study, three main parts; evaluation of student cognitive experience and evaluation of student affective (anxiety) experience and evaluation of the program were targeted to examine in detail as shown in Figure 3.2.

Accordingly, in order to evaluate student cognitive performance in General Chemistry, students' conceptual understanding was assessed with General Chemistry Concept Test (GCCT) while exam achievement in general chemistry was assessed with two midterm exams and a final exam. Quizzes also were used to identify the students' individual gain after solving team problems in EG. Besides, the College of Engineering Entry Scores were used to identify the level of students' academic ability. On the other side, the State-Trait Anxiety Inventory (STAI), and Social Anxiety Questionnaire for an Adult (SAQ) were used as an affective instrument to measure anxiety levels of students in many different social conditions. Furthermore, to evaluate the implementation of the PLTL program, student and leader surveys and critical components rubric as components of the model were used as instruments. The general characteristics of these instruments were explained in detail below.

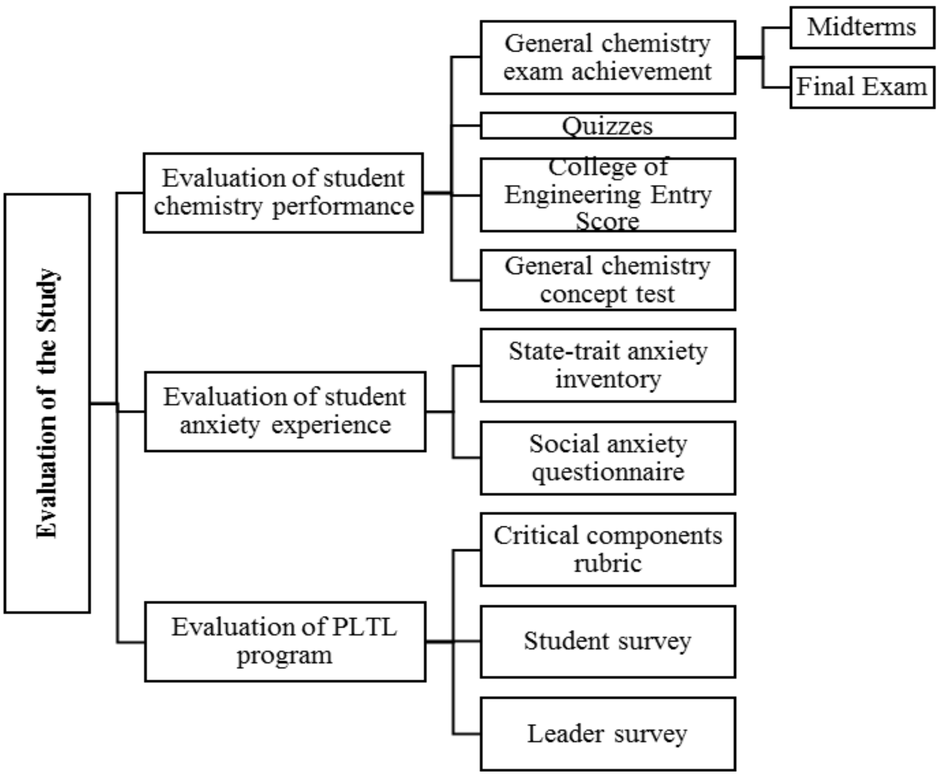


*Figure 3.2.* Instruments used in the evaluation of the study

### 3.4.1. General Chemistry Exam Achievement (GCEA)

General chemistry exam achievement (GCEA) was the raw score in points calculated by using the students' scores in two midterms and a final exam. In the current study, GCEA scores represented the achievements of students in General Chemistry. The content of these exams was determined based on the chapters of the course textbook written by Brown et al. (2015). Table 3.5 showed the chapters discussed during the term respectively and the time needed for each chapter to be understood. Two midterm exams were given at a one-month interval in the spring semester. Midterm exam I (MT1) tested the chemistry content of four units such as the electronic structure of atoms, periodic properties of the elements, basic concepts of chemical bonding, molecular geometry and bonding theories while midterm exam II (MT2) contained the topic of gases, liquids and intermolecular forces, solid and modern materials, thermochemistry, thermodynamics, and chemical kinetics. About three weeks after the second midterm exam, the final exam (FE) was performed which covered all units in midterm exams plus chemical kinetics chapter. The questions in the exams were written by the chemistry group for the students in all sections (1-2-3) of CEAC 105 and prepared in the format of multiple choice. Each exam consisted of twenty items that did not offer an advantage to any course sections. All exams were scored out of 100 so the maximum score that a student can obtain from these exams was 100 and the minimum score was 0.

Table 3.5. *Topics covered in the course and its estimated lecture hours*

| Chapter Numbers | Topics | Estimated Lecture Hours |
|---|---|---|
| 6 | Electronic Structure of Atoms | 7 |
| 7 | Periodic Properties of the Elements | |
| 8 | Basic concepts of Chemical Bonding | 5 |
| 9 | Molecular Geometry and Bonding Theories | 4 |
| 10 | Gases | 3 |
| 11 | Intermolecular Forces, Liquids | 5 |
| 12 | Solids and Modern Materials | 2 |
| 5 | Thermochemistry | 6 |
| 19 | Thermodynamics | |
| 14 | Chemical Kinetics | 5 |

When computing the GCEA score for each student, the raw scores from the MT1, MT2, and FE were used and their contribution rates were 30 %, 30%, and 40% of the total grade respectively. Like in the study conducted by Chan and Bauer (2015), total exam achievement score was used instead of using course letter grade in most of PLTL studies. Since the letter grade generally includes the credit of other works such as attendance and laboratory work. Additionally, students would differ from each other year to year in the cutoff values for their grade; in other words, there has been no absolute way to control systematically how they were decided. Furthermore, they reported that a letter grade is an ordinal variable, which reduces the statistical power of the study. Consequently, GCEA was taken as a dependent variable in this study.

### 3.4.2. Quizzes (QZ)

Quizzes were prepared by the researcher and checked by the chemistry experts and course instructor to assess the individual progress in the workshops after solving the problems as a team. Therefore, quizzes were conducted throughout the semester in each workshop session and consisted of one or two questions for each unit. They might be in multiple-choice or open item question format. After each item was scored, necessary feedback was given to the students in PLTL group. For multiple-choice and short answer questions, the correct answer was scored as 1 and an incorrect one was scored 0. For open-ended items, the researcher used a rubric as in the study implemented by Pyburn, Pazicni, Benassi, and Tappin (2014, p.2048). It presented as follows:

- Students earned full credit if a response was scientifically accurate and was linked to the question asked.
- Half-credit was assigned if the response was scientifically accurate, but was not linked to the question.
- No credit was given if the response was not scientifically accurate or linked to the question.

According to Pyburn et al. (2014), repeated testing of students prior to course examinations positively affects student academic performance, particularly students with low abilities in General Chemistry. In other words, the involvement of students in the process of working through a quiz might enhance their learning and course achievement.

### 3.4.3. College of Engineering Entry Score (CEES-MF4 scores)

At Atilim University as a Turkish University, admission to undergraduate engineering programs is fulfilled according to the students' high school grade point averages (GPA) and their scores on the university entry examinations directed by the Student Selection and Placement Center (OSYM). It makes the university entrance examination every year, with changing approaches in the system. Between 2012-2018 years, students participated in two-stage university entry exams as Transition to Higher Education Examination (YGS, Yuksek Ögretime Geciş Sınavı) and Undergraduate Placement Examination (LYS-Lisans Yerleştirme Sınavı):

- *Stage 1 (YGS):* It is the first exam that is generally applied in April or March. It is also a multiple-choice exam including a common curriculum of 9th and 10th grade for all courses such as science, mathematics, Turkish and social sciences. Students have six different scores (YGS-1-2-3-4-5-6) of YGS. In this stage, a student must get at least 140 points out of 500 points to pass into stage 2.
- *Stage 2 (LYS):* This stage consists of five different exams based on different subject areas, namely Mathematics, Science, Social Sciences, Turkish Language and Literature, and Foreign Language (either English, German or French). Those are commonly conducted in June or July and contain mostly the curriculum of 11th and 12th grade. Students could obtain a minimum score of 100 points out of 500 points. After taking these exams, twelve different scores are calculated for each student as follow:
    - MF-1-2-3-4 (Mathematics-Science),
    - TM-1-2-3 (Turkish Language and Literature-Mathematics)
    - TS-1-2 (Turkish Language and Literature-Mathematics-Social Sciences)

- LANG-1-2-3 (Foreign Languages).

In order to be placed in a program at the college of engineering, their MF-4 (Mathematics-Science) scores are calculated from the scores of YGS, LYS-1 (Mathematics) and LYS-2 (Physics, Chemistry, and Biology) tests by OSYM. In this study, Atılım University student affairs unit provided the information regarding MF4 scores of the participants who enrolled in CEAC 105. The participants' MF-4 scores change between 209 and 390.65 with an average of 295.10 and a standard deviation of 39.75. In the current study, MF-4 scores refer to the CEES that would show the academic abilities of engineering students. Related to the main problem 1 and the first four sub-problems (SP1.1-SP1.2-SP1.3, SP1.4), it was used as a covariate on a continuous scale. On the other hand, for the main problem 2 and the last six sub-problems, (SP2.1-SP2.2-SP2.3-SP2.4-SP2.5-SP2.6) it was used as a categorical independent variable. Thus, MF-4 scores were transformed into the categorical scale to acquire students with different academic abilities as low, medium, and high achievers. Table 3.6 demonstrated the related frequency values based on the categorization of students' academic abilities.

Table 3.6. *Cumulative relative frequency table in terms of students with different academic abilities*

| **Academic Abilities** | **LL-HL (Scores range)** | **N** | **Relative Frequency (%)** | **Cumulative Frequency (N)** | **Cumulative Relative Frequency (%)** |
|---|---|---|---|---|---|
| Low-achievers | <270.00 | 46 | 36 | 46 | 36 |
| Moderate-achievers | 270.00-319.99 | 50 | 39 | 96 | 75 |
| High-achievers | 320.00> | 32 | 25 | 128 | 100 |
| Total | | 128 | 100 | | |

Note: LL: Low limit, HL: High limit, N: Number of students.

### 3.4.4. General Chemistry Concept Test (GCCT)

The general chemistry concept test (GCCT) was developed and administered to both PLTL and TCI groups by the researcher to assess students' conceptual understanding in general chemistry. The definition of conceptual understanding can be changed concerning the subjects. Holme, Luxford, and Brandriet (2015) defined the conceptual understanding in general chemistry as follows:

> There are core chemistry ideas that include theories, practices, patterns, and relationships. A student who demonstrates conceptual understanding can:
> - Apply core chemistry ideas to chemical situations that are novel to the students,
> - Reason about core chemistry ideas using skills that go beyond mere rote memorization and algorithmic problem solving,
> - Expand situational knowledge to predict and/or explain the behavior of chemical systems,
> - Demonstrate the critical thing and reasoning involved in solving problems including laboratory measurement,
> - Translate across scales and representations. (p.1480).

As reported in numerous studies (Driver, Asoko, Leach, Mortimer, & Scott, 1994; Duit & Treagust, 2003; Duit, Treagust, & Widodo, 2008; Pabuccu & Geban, 2006), most students who have had alternative conceptions or misconceptions, still held these conceptions after the science instructions in class because of not being provided suitable conditions for students to improve a conceptual understanding of scientific concepts. For this reason, students' common alternate conceptions and difficulties related to the chemistry concepts were taken into account when constructing the test.

For the development of GCCT, primarily, a content list was prepared to cover the chapters found in the CEAC105 General Chemistry. The following chapters are commonly covered in this General Chemistry Course:

- Matter and measurement,
- Chemical reactions and reaction stoichiometry,
- Atoms, molecules, and ions,
- Reactions in aqueous solution,
- Thermochemistry,
- Electronic structure of atoms,
- Periodic properties of the elements,
- Basic concepts of chemical bonding,
- Molecular geometry and bonding theories,

- Gases,
- Liquids and intermolecular forces,
- Solids and modern materials,
- Thermodynamics,
- Chemical kinetics
- Electrochemistry

Then, questions in the chemistry textbooks and books (Barke, Hazari, Yitbarek, 2009) dissertations (Balcı, 2006; Bozkoyun, 2004; Ceylan, 2004; Çelebi, 2004; Çetin, 2009; Kaya, 2011; Pabucci, 2004; Uzuntiryaki, 2003; Yalçınkaya, 2010) journal articles (Al-Balushi, Ambusaidi, Al-Shuaili, & Taylor, 2012; Ayyıldız & Tarhan, 2012; Mulford &Robinson, 2002; Pabucci & Geban, 2006), and the American Chemical Society (ACS) Chemistry Olympiad Exams prepared by the American Chemical Society (ACS) (2016), and Advanced Placement (AP) Chemistry exams produced by the College Board (2016) were examined in terms of conceptual questions, chemistry misconceptions and difficulties reported in the literature. And then they were used to construct the test items. After that, multiple-choice test items were formed and the number of questions for each unit has been arranged with regard to the estimated time in which each unit discussed in the lecture as specified in Table 3.5 because it is reported that there should be a correlation between the weight of the content domain and the number of items measuring those contents' objectives (Klein & Kosecoff, 1975 as cited in Crocker & Algina, 2008). This first version of the inventory consisted of 40 multiple choice questions covering these topics. Then, at the beginning of the term, the course curriculum at this university was revised and the first four chapters and the last chapter were removed. These chapters were matter and measurement, chemical reactions and reaction stoichiometry, atoms, molecules, and ions and reactions in aqueous solution as well as electrochemistry.

Opinions of a group of experts who were a professor and an assistant professor majoring in chemistry education were taken to provide evidence for the face and content validity of the test. They evaluated this test in terms of the appropriateness of items to the students' level and content of the course in order to measure their conceptual knowledge about the concepts of general chemistry. Moreover, they checked the items of concept test for any incomprehensibility and errors in the answer key.

30 multiple-choice items were retained in the test after making the required revisions. Of those, 5 items were taken from high-stakes tests; one item from an ACS Olympiad exam (ACS, 2014, 2016) and four items from AP Chemistry exam (College Board, 2014, 2016) and used with their copyright notice in the text. Furthermore, paired items were used by means of questioning a chemical or physical effect (first pair) and the reason for this effect (second pair) so as to specify students' alternative conceptions about chemistry concepts before treatment and observe the changes in these alternative conceptions after treatment. According to Tsai and Chou (2002), such diagnostic tests can identify students' alternative conceptions and the sources of related explanations. In the paired items, the first pair had alternatives between two and four while the second pair had four or five alternatives. For other items, non-paired ones had five alternatives, but only one item had four alternatives. Before the treatment, this version was piloted with 67 undergraduates majoring in chemistry education as well as chemical engineering and applied chemistry to check for clarity and length. The students were required 40 to 45 minutes to complete the examination. The correct responses and incorrect responses of students were coded as 1 and 0 respectively, both for non-paired items and paired ones (Mulford & Robinson, 2002); thus, a student could obtain from GCCT as a maximum score of 30 and a minimum of 0.

SPSS 24.0 program was used for the item analysis of GCCT to check some values such as reliability, item difficulty, and item discrimination. It was found that the Cronbach alpha reliability of the GCCT was 0.799 for the pilot study, indicating high internal consistency due to being among the acceptable values of reliability coefficient of 0.70 or more (Pallant, 2011). It is important to note that using a large set of test items (25 or more) could raise its reliability as a larger number of items is more likely to reflect the actual features of the test and embody entire content intended to be measured than the smaller item size do (Kaplan & Saccuzzo, 2009). In accordance with the domain sampling model, GCCT included 30 items from 10 different content domains. The results of the pilot study were presented in Table 3.7 that shows the descriptive information and scale statistics (difficulty and discrimination indices) of GCCT. The item difficulty value of each item demonstrates the proportion of students who answer that item correctly. Since items were dichotomously scored, the mean item score corresponded to the difficulty indices of the items which ranged from 0.40 to 0.63 with an average of 0.51. It can, therefore, be concluded that the difficulty level of GCCT was medium. Crocker and Algina (2008) advocate that the test should contain homogeneously medium difficulty items rather than having a collection of the low, medium, and high difficulty items because such items provide not only higher value of standard deviations and item variances but also more reliable item discrimination indices, particularly students with different academic abilities.

Item discrimination measures an item about how effectively it discriminates between high-achievers and low achievers on the test. In item analysis, point biserial correlation coefficients were used for the item discrimination and their values ranged from 0,140 to 0,582 with an average of 0,305. Crocker and Algina (2008) specified the minimum level of point biserial correlation as two standard errors above 0.00 to retain the items in a test.

They proposed the following formula to determine the convenient approximation for the standard error for the Pearson product-moment correlation;

$$\hat{\sigma}_{\rho} = \frac{1}{\sqrt{N-1}}$$

N: the sample size

When the sample size of 67 was written into the equation, the standard error was found to be 0.123 and, the minimum critical value was calculated as 0.00 + 2(0.123) = 0.246. Consequently, items with point biserial values of .246 or greater would be retained.

Table 3.7. *Description of items in GCCT*

| The content domain of the questions | Question Number | Difficulty indices | Discrimination indices |
|---|---|---|---|
| Thermochemistry | Q1 | 0,46 | 0,356 |
| | Q2 | 0,63 | 0,415 |
| | Q3 | 0,52 | 0,286 |
| Electronic Structure of Atoms | Q4 | 0,48 | 0,203 |
| | Q5 | 0,63 | 0,225 |
| Periodic Properties of the Elements | Q6 | 0,45 | 0,269 |
| Basic Concepts of Chemical Bonding | Q7 | 0,51 | 0,315 |
| | Q8 | 0,52 | 0,236 |
| | Q9 | 0,40 | 0,275 |
| | Q10 | 0,58 | 0,330 |
| | Q11 | 0,54 | 0,268 |
| Molecular Geometry and Bonding Theories | Q12 | 0,49 | 0,206 |
| | Q13 | 0,46 | 0,356 |
| | Q14 | 0,61 | 0,332 |
| | Q15 | 0,60 | 0,336 |
| Gases | Q16 | 0,43 | 0,329 |
| | Q17 | 0,61 | 0,349 |
| | Q18 | 0,43 | 0,334 |
| Liquids and Intermolecular Forces | Q19 | 0,58 | 0,251 |
| | Q20 | 0,42 | 0,344 |
| | Q21 | 0,48 | 0,582 |
| | Q22 | 0,45 | 0,331 |
| Solids and modern materials | Q23 | 0,49 | 0,217 |
| Chemical Kinetics | Q24 | 0,43 | 0,334 |
| | Q25 | 0,55 | 0,318 |
| | Q26 | 0,45 | 0,336 |
| | Q27 | 0,61 | 0,286 |
| Chemical Thermodynamics | Q28 | 0,46 | 0,322 |
| | Q29 | 0,66 | 0,140 |
| | Q30 | 0,48 | 0,269 |

Question 29 has a lower discrimination index which was 0.14 than suggested ranges; however, it was revised instead of excluding from the test since it is required to measure the conceptual understanding of students in entropy concept and to sustain the sufficient number of items in that content domain. The other four questions which have low discrimination indices between 0.2 and 0.246 were examined and revised in terms of the wording of the item thus the number of item in text conserved.

After performing all revisions on the GCCT, the final version (see Appendix C) was administered to PLTL and TCI groups as a pre-test and post-test in the current study. The pre-test scores were used to compare whether students in the two groups were different from each other when their knowledge of concept tests considered before the implementation. The administration of the test needs approximately 45-55 minutes.

### 3.4.5. State-Trait Anxiety Inventory (STAI)

State-Trait Anxiety Inventory (STAI) is a self-reported inventory originally developed by Spielberger, Gorsuch, and Lushene (1970) to measure high school and college students' two separate anxiety concepts: state anxiety and trait anxiety. Then, this original version (STAI-Form X) was revised to STAI-Form Y by Spielberger (1983) by replacing twelve of the original 40 items because of their problematic nature with less skilled students and their measurement of depression. This last version has a total of 40 items and 2 subscales: state anxiety scale (Items 1 – 20) and trait anxiety scale (items 21 – 40) with a 4-point Likert-type. Both scales are unidimensional measures.

In this study, STAI-Form Y was selected to measure students' state anxiety and social anxiety in General Chemistry (see Appendix D). To measure situational or state anxiety, its state anxiety subscale (STAI-S) was used. Students rate the degree of many self-statements based on their feelings at a particular time which refers to the time that they took the STAI (feelings "at this moment" or "right now") on a 4-point Likert scale ("Not at all"=1, "Somewhat"=2, "Moderately so"=3, "Very much so"=4). To measure trait anxiety, trait anxiety subscale (STAI-T) also was used. Students rate the degree of many self-statements based on their feelings in a general manner (“generally”) on a 4-point Likert scale (“Almost never” =1, “Sometimes” =2, “Often” =3, “Almost always” =4). Higher scores in both scales represent high levels of anxiety. From each anxiety subscale, a student can get a minimum of 20 out of 80 after reversing scores for positively-worded items in STAI-S (item 1-2-5-8-10-11-15-16-19-20) and STAI-T (item 21-23-27-30-33-34-36-39).

In the related literature reliability and validity evidence have been provided through the studies with high school and college engineering students. Spielberger (1972) reported test-retest reliability values as internal consistency reliability coefficients in the range of 0.65 to 0.86 for STAI-T and internal consistency reliability coefficients in the range of 0.16 to 0.62 for STAI-S. He also concluded that the low stability in the reliability of the STAI-S is probably attributable to the fact that some situational factors may influence students’ state anxiety during testing. Related to the validity of STAI-T, Spielberger (1983) correlated it with other measures of anxiety and found the correlation coefficient of 0.52 for the Multiple Affect Adjective Check List, 0.75 for IPAT Anxiety Scale, and 0.80 for the Taylor Manifest Anxiety Scale. Similarly, Vitasari, Wahab, Herawan, Othman, and Sinnadurai (2011) used STAI for engineering students in Malaysia and found adequate pieces of evidence about the reliability of STAI (Cronbach alpha of 0.850), reliability of STAI- S (Cronbach alpha of 0.797) and reliability of STAI- T (Cronbach alpha of 0.781).

In the current study, the STAI-S was applied to both groups as a pre-test to measure situational anxiety at the beginning of the semester and as a post-test to explore the changes in students’ anxiety after the implementation of the interventions. On the other hand, STAI-T was used as a covariate in the study to control students’ general anxiety level at the beginning of the semester. It was not selected as a dependent variable due to having difficulty in changing trait anxiety as a permanent personality characteristic. Additionally, the Cronbach alpha reliabilities were determined as 0.948 for STAI, 0.915 for STAI-S, and 0.909 for STAI-T in this study. According to Pallant (2011), all Cronbach alpha values pointed out the high reliability of the scale ($\alpha > .70$).

### 3.4.6. Social Anxiety Questionnaire for Adult (SAQ)

The social anxiety questionnaire for an adult (SAQ-A) is a self-report instrument developed by Caballo, Salazar, Irurtia, Arias, and Hofmann to measure social anxiety (2010). There have been several item versions of this scale (i.e., 512-item, 118-item, or 82-item format). In this study, its 30-item format (SAQ-A30) revised by Caballo, Salazar, Arias, et al. (2010) was applied to engineering students so as to measure their uneasiness in certain social situations. In this final version SAQ, undergraduate students rated their anxiety in these social situations based on a 5-point Likert scale (1 = not at all or very slight, 2 =slight, 3 =moderate, 4 =high, and 5=very high or extremely high). Besides, there are five factors/dimensions in the SAQ-A30, containing six items each; "(1) Speaking in public/talking with people in authority, (2) Interactions with the opposite sex, (3) Assertive expression of annoyance, disgust, or displeasure, (4) Criticism and embarrassment, and (5) Interactions with strangers". The high score on SAQ means a high level of social anxiety. For each factor, a student can get a minimum of 6 out of 30, and for the whole SAQ a student can get a minimum of 30 out of 150.

Based on the study of Caballo, Salazar, Arias, et al. (2010), it was .91 of Cronbach's alpha for the whole SAQ and .93 of the split-halves reliability coefficient (Guttman). In addition, this scale has a high correlation with the Liebowitz Social Anxiety Scale (The LSAS, Liebowitz, 1987). This study also noted that Cronbach's alpha and the split-half reliability coefficient for the whole SAQ were 0.923, and 0.898, respectively.

At the beginning of the fall semester, SAQ (see Appendix D) was performed as a pretest to assess undergraduate engineering students' social anxiety and at the end of the spring semester, it was performed again to observe the changes in their social anxiety level.

### 3.4.7. Critical Components Rubric (CCR)

Six essential components of the PLTL model, explicitly faculty involvement, integral to the course, leader selection and training, appropriate materials, appropriate organizational arrangements, and administrative support were reported by first implementers of the project as a tool for implementation and evaluation of PLTL model. Gafney and Varma-Nelson also clarified that these components have provided (1) a roadmap for implementers, (2) descriptions to those who were interested, and (3) evaluation about implementation after its adaptation and dissemination (2008).

In this direction, in order to measure the effectiveness of PLTL implementation, the Critical Components rubric was constructed by the researcher based upon these six components (see Appendix E). The criteria used in the rubric were taken from the questions in the research-based book "Peer-led team learning: evaluation, dissemination, and institutionalization of a college-level initiative" written by Gafney and Varma-Nelson (2008). The components of faculty involvement, workshop materials, and organizational arrangements had 5 criteria while integral to the course and administrative support components had 4 criteria, and workshop leader components had 6 criteria. Then consequently, a total of 29 criteria were identified in the Critical Components Rubric (CCR).

Researcher rates each criterion in a 3-point scale (0= none, 1=partially, 2=fully). "None" means that no attempt was made to complete the requirements, "partially" means that some of the requirements were completed well and "fully" means that all the requirements were completed well. Furthermore, there was a comment part of each criterion to write the explanations, suggestions, feedback, etc.

The researcher examined the results for each component and check whether all the requirements of the critical components were completed to be a good implementation of the PLTL study. The problems and failure in some aspects of the CCR might negatively influence students' performance and bring about a lack of enthusiasm for students and faculty members; thus, it was significant to examine and analyze these components.

### 3.4.8. Student Survey and Leader Survey (SS and LS)

PLTL Student Survey (SS) and Leader Survey (LS) prepared by Gafney (2001b) were used in this study to evaluate the PLTL model. He designed these surveys based on the items from surveys, interviews, and focus groups study. With the help of these surveys, students' and leaders' experiences could be also examined statistically.

SS was used to collect valuable information about how PLTL students perceived and experienced peer-led chemistry workshops and whether their perceptions and experiences matched with the aims of the study (see Appendix F). About the beliefs and satisfaction of students with PLTL, there were three parts and 36 items in SS. In the first part, students rate items 1-21 about whether workshops were helpful for them to improve their grades based on a 5-point Likert scale (1 = strongly disagree, 2 =disagree, 3 =neutral, 4 =agree, and 5=strongly agree). One additional item in this part, item 22, was related to the average number of hours they spend studying per week and they rated this item in five categories: (1) 0–2 hours, (2) 2–4 hours, (3) 4–6 hours, (4) 6–8 hours, (5) 8–10 hours. In the second part, students rate items from 22 to 29 about workshop materials based on a 5-point Likert scale (1=not at all, 2=somewhat, 3=rather well 4=very well and 5=excellent). In the last part, students rate items 30-36, according to the amount of workshop time devoted to each activity presented based on a 5-point Likert scale (1= almost no time, 2= a small amount of time, 3= a moderate amount of time, 4= a large amount of time and 5= most of the time).

LS provides the researchers not only to obtain some information about that leader would have but also to compare the experiences of students with the team leaders (see Appendix G). Like in the SS, there were three parts too. The first part asks the leaders about the organizational arrangements in the workshop and leaders respond to 9 open-ended questions related to them. In the second part, leaders not only rate items from

10 to 16 according to the amount of workshop time devoted to activity presented based on a 5-point Likert scale (1 = almost no time, 2 = a small amount of time, 3 = a moderate amount of time, 4 = a large amount of time and 5= most of the time) but leaders also respond to open-ended questions from 17 to 19 related to group dynamics. In the last part, students rate items from 20 to 26 about workshops materials based on a 5-point Likert scale (1 = not at all, 2 =somewhat, 3 =rather well 4 =very well and 5=excellent) and answer opened ended questions between 17 and 34 related to the workshop materials and leader training sessions.

Consequently, these two written surveys of students and leaders produce valuable information about student and leader satisfaction with the program and how well the program was progressing. For example, the critical components such as appropriate materials and adequate organizational arrangements could be analyzed to learn whether they were functioning and the workshop dynamics were appropriate. Therefore, they would provide evidence that students study together in productive ways under the guidance of the peer leader (Gafney & Varma-Nelson, 2008).

### 3.5. Procedure

In the procedure of this study, many steps are followed to plan, conduct, and evaluate the peer-led team learning in general chemistry context as follows:

- The research problem was determined according to the researcher's interest in the effectiveness of peer-led team learning in an undergraduate general chemistry course
- Many key terms were used to make a literature review such as; "peer-led team learning (PLTL)", "peer leader", "chemistry workshops", "anxiety", "social anxiety", "state-trait anxiety", and "undergraduate general chemistry". Literature review was performed in each step of the study.
- Next, the literature review was conducted by using these keywords in a variety of combinations through some educational databases such as Web of Science, Educational Resources Information Center [ERIC], EBSCOhost, Education

Research Complete, ProQuest Dissertations & Theses, Science Direct, Google Scholar, METU Library Theses and Dissertations.

- After the review of the related literature, the conceptual framework of the study was formed.
- PLTL Workshop materials were developed by the researcher compatible as being consistent with course content based on the reviews of a professor and an assistant professor majoring in chemistry education and a professor majoring in chemical engineering and applied chemistry.
- To be implemented in the current study, GCCT, QZ, and CCR instruments were developed by the researcher. After expert opinions were taken, a pilot study of the GCCT was performed before the treatment. Then, necessary revisions were accomplished and the final version of GCCT was formed. In addition, permission was taken for preexisting instruments in the study (STAI, SAQ, SS, and LS).
- The leader training syllabus and reading materials were prepared.
- Permissions from the Applied Ethics Research Center at METU and Atılım University were obtained to conduct this study with undergraduate engineering students at Atılım University.
- Atilim University Chemical Engineering and Applied Chemistry department and course instructors were informed about the study and their role in involvement in the research. A course instructor who has two intact classes were selected and notified about the PLTL and its components, workshop hours and materials, leader training, PLTL implementation, and data collection.
- The PLTL leader selection process was conducted and candidates were determined. After that, peers who met all requirements were selected as peer leaders for the present study. They took information about the study and their roles.
- Pre-tests (GCCT, STAI, RTT, and SAQ) were administered to both PLTL and TI groups at the beginning of the 2016-2017 fall semester.

- Students' teams were determined based upon their demographic information and one peer leader was assigned to each team randomly.
- The implementation period lasted for fourteen weeks (1 class hours for two weeks) in the 2016-2017 fall semester. Sections of this course were randomly assigned to experimental and control groups. The researcher observed workshops as a non-participant observer and rated critical components rubric. Before each workshop, peer leaders were trained in terms of weekly content knowledge, pedagogical knowledge, and leadership and communication skills. In addition, the students' study hall was arranged to conduct chemistry workshops by preparing the seats for collaborative work, hanging the group lists and posters, and giving necessary materials such as attendance sheets, pens, papers, the periodic table, etc. to each team provided by the researcher. Quizzes were applied by the researcher throughout the term in each workshop with the help of the leaders. Two midterm exams were conducted by Atilim University Chemical Engineering and Applied Chemistry department in November and December in the 2016-2017 fall semester.
- Post-tests (GCCT, STAI, RTT, and SAQ) were administered to 68 engineering students from both groups. Also, a student survey and leader survey were conducted with 26 students from PLTL groups and 12 peer leaders.
- The final exam was implemented by Atilim University Chemical Engineering and Applied Chemistry department in January in the 2016-2017 fall semester.
- Data attained from the instruments (pre and post-tests, midterms, and a final exam) were entered into SPSS to conduct the corresponding analysis. Furthermore, data attained from quizzes, student and leader surveys were entered into MS Excel to determine the percentages of students' scores. The qualitative data from the critical components rubric, and leader surveys were transcribed.
- To check the hypotheses of this study, descriptive and inferential analyses were carried out. The transcribed data were coded and categorized under levels.

- The dissertation was written and completed.

### 3.6. Implementation of the Treatments in GC

At the end of the previous semester (approximately three months before the implementation) a meeting about the implementation of the PLTL model was held at Atilim University with the course professor who participate in the study, head of the department, and vice-rector of Atılım University. At this meeting, key concepts were discussed about the scope of the subject, the important findings of the field, the evaluation of the present situation at this university, the reason why we need to model, the details of the training given to the leaders and how to operate the course during the semester. After taking all supports from the university management and ethical permission from the applied ethics research center at METU (see Appendix H), this study was conducted during fourteen weeks in General Chemistry course of sections 1 and 2 which were assigned as CG and EG respectively to perform this quasi-experimental study. The CG was taught by using TCI with weekly three 50-minutes lecture periods. On the other hand, EG was instructed by using the PLTL model which combines two 50- minutes teacher-centered lecture periods with 70-minutes PLTL workshop sessions. In accordance with the course curriculum, PLTL workshop materials were prepared by the researcher with the support of one professor and one assistant professor majoring in chemistry education and one professor majoring in chemical engineering and applied chemistry. After the selection of the peer leaders, they have participated in the training sessions throughout the fall semester to assist their peers to solve challenging workshop problems. PLTL students attended 6 chemistry workshops every two weeks during the study. Similar to CG students, they also joined three 50-minutes lecture sessions of the course in the other weeks in which PLTL workshops were not held. Apart from the first workshop, PLTL students took 10-minutes quizzes in each workshop. The PLTL workshop materials were uploaded to the learning management system (LMS) of the course (MOODLE) to be reached by the CG. Thus, the implementation of PLTL is intended to be less novel for CG. The course professor generally participates in PLTL workshops since they are likely to increase students' and leaders' anxiety and so influence the group dynamics. The researcher attended as nonparticipant observers to PLTL workshops while she attended as supervisors and learning specialists to the leader training sessions in the study.

### 3.6.1. Experimental Group Treatment: PLTL Model

For the carrying out of PLTL instruction in GC properly, it was grounded in Gafney's theoretical framework with six essential principles (2001a, 2001b, 2001c). Figure 3.3 showed these critical components explained briefly in the following parts of the study.

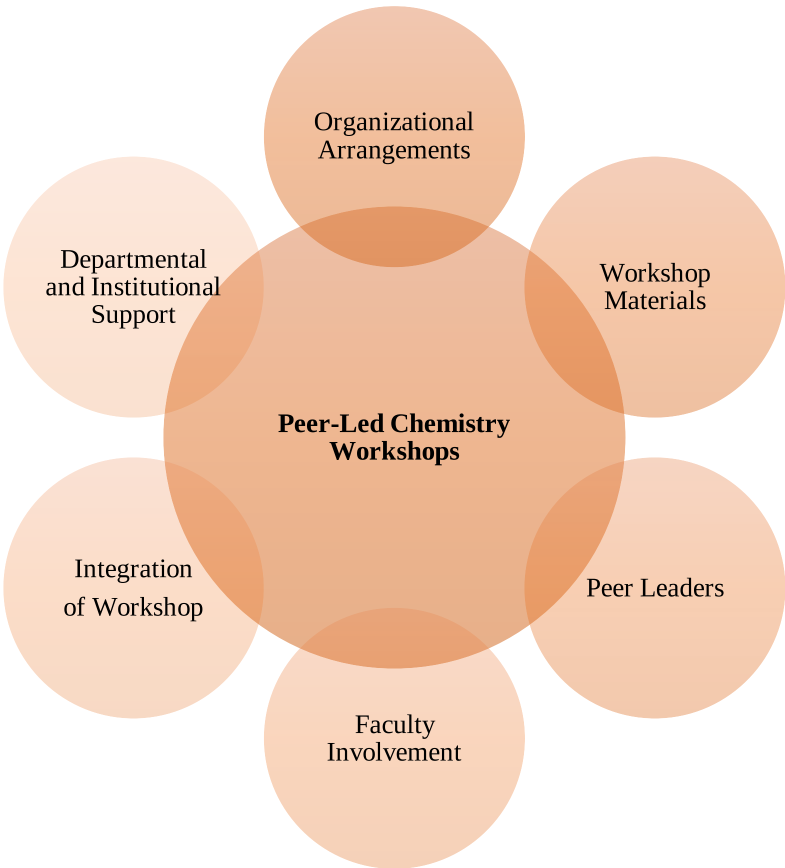


*Figure 3.3.* Critical component framework

### 3.6.1.1. Organizational Arrangement

Before the implementation of PLTL in EG, the organizational arrangement considering the time, group size, location, and teaching resources are required to be planned and conducted to create a more effective discussion setting for teams. The first thing to do was placing PLTL workshops into one of the course lecture sessions. Hence, one 50-minutes teacher-centered lecture was changed into 70 minutes of PLTL chemistry workshops (20 minutes added). This twenty-minute addition was necessary to organize the classroom setting and distribute the course materials to the groups and students. According to the three integration models of PLTL proposed by Gosser (2011), this study correlated with the Type I which some part of the lecture was replaced by a workshop required part of the course.

The course schedule for PLTL group students was presented in Table 3.8 which covered the lecture, laboratory work, chemistry workshop, and leader training sessions. Students could select laboratory 1 or 2 according to the other course schedule. Furthermore, PLTL workshops were held at the end of every one or two units of study, naturally every two weeks, as shown in Table 3.9 which also indicates the topic discussed in each workshop.

Table 3.8. *The schedule for the PLTL group*

| | Monday | Tuesday | Wednesday | Thursday | Friday |
|---|---|---|---|---|---|
| 9.30-10.20 | | | | | |
| 10.30-11.20 | | Leader training session | | | |
| 11.30-12.20 | | | Lab1 | | Workshop |
| 12.30-13.20 | | | | | |
| 13.30-14.20 | Lecture | | | Lab2 | |
| 14.30-15.20 | | | | | |
| 15.30-16.20 | | | | | |

For the EG, the course enrollment in the 2016-2017 fall semester was 181. However, nearly one-third did not attend the chemistry workshop at all. At the outset of the semester, groups were formed as eight students based on the number of students who attended the first meeting of the course. In this case, 14 leaders existed but then two leaders withdrew from the study. As a consequence of this situation, group size and number were adjusted to nine students and 12 groups respectively. During the term, the students who attended the workshop had been changed consistently, so group size too. In addition to a peer leader, there were normally four to six students in a team, concentrating on five students.

At the beginning of the semester, it was tried the teams to have had equal opportunities, possibilities, and features. Therefore, the team was formed based on students' academic abilities, major and gender. Taking into consideration the college of engineering entrance scores (CEES), the students were categorized into their academic abilities as low, middle and high achievers. It was therefore tried to be students from these three categories in each team. Despite the small number of female students among engineering students, it was ensured that each group had a female student. Furthermore, a heterogeneous structure was constructed by including students from all departments in EG to each team. The teams remained intact through the year and if a student came after the first meeting, s/he was incorporated into a group that had a low number of students and skills that s/he had.

As a PLTL workshop location, a student study hall in their engineering building was selected. The sample pictures of this study hall where chemistry workshops were held were given in Figure 3.4. This hall has a large area including four small rooms which had one big desk and 10-15 chairs each. Additionally, there was one big room having 30 desks to study collaboratively. The necessary equipment like chairs was supplied before implementation and the hall was closed to the use of other students during workshop hours. Moreover, teaching resources such as A3 size papers, colorful board markers, periodic table, and chemistry problems booklets were provided to the students and teams.

*Figure 3.4* Chemistry workshop location

#### 3.6.1.2. Workshop Materials

The preparation of workshop materials is one of the major challenges in PLTL interventions. For this reason, primarily the general chemistry (CEAC 105) was examined based on the course description, the course syllabus, objectives, textbooks, etc. This course at Atılım University was a compulsory five ECTS credits course conducted with three lecture sessions every week and three laboratory sessions every two weeks. It was required by all engineering students except for both chemical engineering and applied chemistry department and metallurgy and material engineering.

To construct the PLTL workshop materials, the course content of the course, and the time needed for them represented in Table 3.5 were taken as a basis. Ten selected topics in the course textbook (Brown et al., 2015) were explored to specify their learning objectives. The important points in the preparation of the problems were emphasized in PLTL model and proposed in the "PLTL Guidebook" by Strozak and Wedegaertner (2001), as (1) enforcing the students at the appropriate level in a challenging way, (2) being suitable for the content of the course and (3) encouraging active and collaborative learning at the same time.

Accordingly, the PLTL chemistry booklet was constituted in which there are ten units. Each unit consists of two sections; (Section A) content outline and corresponding learning outcomes and (Section B) workshop problems. A sample of workshop materials for a chemistry topic (chemical kinetics-rate of reaction) was presented in Appendix I.

The theoretical framework used in the construction of the PLTL workshop problems was Vygotsky’s important concept of “ZPD” (1987). In this direction, PLTL workshop problems in each unit were classified into three parts as follows:

- *Part I: Individual Review Problems:* Students are required to complete them before the workshops.

- *Part II: Team Learning Problems:* Students are required to solve them with their peers in the workshops.
- *Part III. Individual Assessment Problems:* Students are required to solve them individually after the workshops.

In Part I, several multiple-choice questions that cover all learning objectives were provided in the booklet for reviewing the corresponding weeks' topic. Students could solve individual review problems independently because they do not include higher-level critical thinking problems. Students were said to solve these questions before they came to the workshop, and then the questions that they are not able to solve (unsolved or problematic questions) were discussed in the workshop. According to Stewart et al. (2007), those who take the material before the workshop are likely to be prepared for PLTL workshops and show enthusiasm to solve problems.

After discussing individual review problems, teams have started to solve team learning problems in the second part. Peers solved generally three or four problems collaboratively in the guidance of peer leaders. Such problems were designed as a stepwise or structured form to contain different perspectives such as conceptual and critical thinking, reflective problem solving, interpretation of graphs and data, as well as inductive reasoning (moving from data to structure and mechanism). In order to be able to solve these problems, students should collaborate with their peers and leaders, otherwise, they could not solve them individually, because the aim at preparing these problems is to enhance students' potentials. Accordingly, team learning problems were designed considering the initial conceptualization of the ZPD (Vygotsky, 1978) and its expanded view (van Lier, 1996, 2004).

In the last part, individual problems were applied to the students as a quiz to assess individual chemistry performances. Those consisting of 1 or 2 problems that are parallel with the structure of team learning problems. After learning how to solve team problems, it is expected that students can answer alone. The difference that arises between the level of problem-solving independently without help and the level at which the individual can solve the problem after entering the social interaction with the help of the peer leader constituted their zone of proximal development. As a result, it can be concluded that social interaction among students could promote their potential development in GC. Feedback also was provided to the students by leaders after the assessment of individual problems.

When constructing the chemistry booklets, many sources were examined. For example, chemistry local exam and national exam part I and part II prepared by the American Chemical Society (ACS, 2016) containing multiple-choice and open-ended questions were scanned from 2007 to 2016 and Advanced Placement (AP) chemistry exam prepared by the College Board (2016) containing multiple-choice and open-ended questions were searching from 2008 to 2015 related to the course content. Furthermore, some questions were taken from a web page about ACS final exam topics and questions built by Russel (2017) who was a chemistry professor at Mt. Hood Community College in the US. In addition to them, the course textbook questions (Brown et al., 2015) were checked to be implemented in the workshop. Besides, the researcher developed some problems that matched the course curriculum at this university. All questions were designed to be used in either review, team learning, or assessment part of the materials. Necessary modifications were also accomplished on these materials.

#### 3.6.1.3. Peer Leaders

The PLTL model is separated from the most teaching and learning methods/strategies with the use of peer leaders. Thus, both the selection of peer leaders and the preparation of these leaders into the workshops are very crucial processes. In the process of selecting qualified leaders, a list including students who took the GC course previously and passed it with success (at least CB) was formed with the help of the course professor. Then, phone calls were achieved with those students by providing some information about the study. If they said they would want to participate in this project, they were supposed to meet the researcher and the course professor. After that, interviews were conducted to identify competent students who are likely to be a good team leader. By considering their communication skills and status in GC, 14 peer leaders were finally elected. They passed GC with a high grade (generally varied between AA and BB). Only two students with CB were included in the study because they were good at leading students by using their interpersonal communication skills, enthusiasm towards PLTL, influencing their peers to learn. Two weeks later, two peer leaders dropped the study. Consequently, this research was conducted with 12 peer leaders from the Department of Chemistry Engineering and Applied Chemistry (CEAC), Energy System Engineering (ENE), Mechanical Engineering (ME), and Civil Engineering (CE). Those majoring in CEAC take the general chemistry course in two semesters in details so their content knowledge is better than the other departments. Leaders were assigned randomly to their teams based on the alphabetical name order and they signed a voluntary participation form (see Appendix B) and leader contract (see Appendix J) regarding the following requirements: (1) taking part in peer-leader training session and PLTL chemistry workshop; (2) having knowledge about course material; and (3) participating in evaluative surveys and interviews. The leaders also completed a form about their demographic information to be used in the analysis (see Appendix K).

All PLTL leaders should be capable of solving all the workshop problems and leading their peers to achieve their potentials. After selecting the leaders, the next challenge for reaching this goal was to train them. In this direction, leaders were expected to participate in each leader training sessions, which lasted at least 1.5-hours. These sessions were held after the lecture hours and before the chemistry workshops. The time of these training sessions was constituted regarding the course schedule of leaders. In their training, peer leaders would receive training on three issues; leadership skills, pedagogical support, and chemistry content knowledge which were recommended by Roth, Goldstein et al. (2001) in their book entitled “PLTL A Handbook for Team Leaders”. When they met in training sessions, leaders usually learn how to effectively communicate with others, how to become effective leaders in their teams, how to use pedagogical information to teach a particular chemistry concept and discuss the workshop problems. The program of the training sessions that included the topics covered each meeting was shown in Appendix L.

Being able to be a successful leader and communicator is so important in implementing PLTL effectively. They are expected to lead their teams by taking the role of positive catalysts (in chemistry it increases the rate of a reaction by using another way having low activation energy) who motive them with a positive attitude, energize the team members with enthusiasm, attract their attention and interest on the subject and productively manage the group dynamics. They also learned about how they use body language and time effectively, how they handle the interruptions and interventions in an appropriate way, and how they enhance listening skills and questioning techniques.

Under the pedagogical support, leaders of the study were engaged in training in terms of some important educational issues such as learning theories and styles, teaching methods and strategies/tools (paired problem solving, round-robin flowcharts, analogy, concept map, etc.), students' learning differences, motivation, and equal opportunities for everyone, etc. Leaders were expected to select and apply the appropriate PLTL teaching strategy in each subject matter based on the student profile in their team. During their training sessions, it was discussed what is important in the workshop problems, which teaching strategies they could use for the particular subject matter, which misconceptions and difficulties related to the subject matter/content they could discuss in the workshop, how they use such strategies to change students' alternative conceptions and handle with their difficulties, and which questions could be more suitable for eliciting students' prior knowledge, involving students in the discussions and solving the particular problems; thus, they had information about pedagogical content knowledge. For example, when discussing why the slowest step determines the rate law, the peer leaders could use a flag race as an analogy. Consequently, training would guide peer leaders in the process of using appropriate teaching methods and strategies in solving problems of a particular concept (content-specific strategies), giving their peers a time to think, letting them understand the problem, giving clues, establishing a balance between low- and high-achievers and creating equal opportunity for all.

The main activity in the training session was discussing the subject matter knowledge of the workshop materials problems. Thus, they devoted three-quarters of time (nearly seventy-five percent) to understand and explain the subject matter knowledge of problems and solve collaboratively the problems of the corresponding week. Before the chemistry workshops, peer leaders studied with PLTL chemistry problems in groups under the guidance of the researcher to discuss effectively the subject matter (chemical principles, theories, laws, etc.) and leading problem-solving processes in workshops. Furthermore, they were informed about how much time they should have spent with review problems and team problems. As underlined in the PLTL literature (Varma-Nelson & Coppola, 2005), peer leaders or students did not take the answer keys to the workshop problems. It was very significant that the leaders must have understood their role in the study and must have behaved guides or facilitators for the students who needed assistance and feedback rather than teachers or teaching assistants who teach the concepts.

#### 3.6.1.4. Faculty Involvement

The course professor has volunteered to get involved in the PLTL study. Throughout the study, she assisted the process of choosing and training peer leaders and developing workshop problems. More specifically, she gave the updated course syllabus to prepare the workshop problems, she checked all workshop problems and provided necessary feedback to make revisions on the problems to cover corresponding week content and its learning objectives. She also aided to identify the successful undergraduates who are capable of being a peer leader. In addition to the selection of the peer leaders, she presented some guidance in the training sessions regarding becoming a role model for the interpersonal dynamics within a team and supporting content knowledge in understanding, discussing, and solving problems.

#### 3.6.1.5. Integration of Workshops to the Course

Like lecture hours and laboratory sessions, it was essential to be perceived PLTL workshops as a course component. In this regard, it was integrated with the course by taking one hour of the course instead of adding one hour to the course. At the beginning of the term, the professor encourages the students in EG to participate in the PLTL workshops and reminded the attendance requirement. During the semester peer leaders kept records about the attendance of students in their team. The synchronization between the workshops and lectures was reinforced. Finally, it was thought that making quizzes could provide some advantages such as obtaining data about the assessment of individual improvement in GC and supporting high retention of students in workshops.

#### 3.6.1.6. Departmental and Institutional Support

Before and during the implementation of the study, Atılım University administration and chemistry engineering and applied chemistry department provided their supports. Next, it was started to think about what could be done to ensure that the candidate leaders participated in this study. At Atılım University, successful students with a minimum CGPA of 2.50 could apply to participate in the "Sharing the Success" program and could study in an academic or administrative division through sharing their success. Within such units, those generally undertake several tasks such as working on various projects with academic staff in academic units or studying in administrative units and library and providing mentoring to their peers. If the students have studied at least 40 hours in a semester and completed the program with success, they would have a certificate of participation in Sharing the Success Program. In the current study, Atılım University Sharing the Success Programme Certificate was given to 12 peer leaders attending the workshops and training sessions and completing them successfully. Also, the cost of copying and printing the materials was supported by the university.

### 3.6.1.7. Peer-Led Chemistry Workshops

For peer-led chemistry workshops, 12 teams (named as Team 1 to Team 12) with an average of 5 students of the CEAC 105 course were formed and guided by a team leader who had done well in the course previously and had good communication skills. In the first lesson, some tests and questionnaires were applied as a pretest. They were informed that they should have attended in 70 minutes of chemistry workshops every two weeks as a part of the course. Before coming to the workshops, materials were distributed to the students to examine them and solve the review problems in Part I. According to the experiences of Stewart et al. (2007), students taking the materials previously are more prepared and more enthusiastic to learn and to PLTL.

Students met with their team leader for their workshop sessions at the student study hall. As indicated in Table 3.8, after discussing the particular concept in the lecture hours (Monday) and preparing peer leaders in training sessions (Tuesday) students worked on some structured problems with their peers with the guidance of their leaders in chemistry workshops (Friday). Throughout the study, six peer-led chemistry workshops were performed and their programs were identified in Table 3.9 with the data collection time.

Students and leaders were expected to wear an identification card at the workshops including some information about their name, team number and title as a leader or student. In a typical chemistry workshop, peer leaders initially took attendance of students in their teams. Then they started discussing students' answers to the individual review questions. They separated 10 or 15 minutes to determine where students were challenged in these questions, discuss these challenges and summarize the particular subject matter knowledge. After that, they continued with team learning problems. By using different teaching methods and strategies discussed in the leader training sessions leaders led them to solve the problems by allowing students to read, analyze the problems and discuss their opinions with each other, asking some questions and providing some feedback and clues regarding problem-solving. Lastly, peer leaders summarized by checking all students' understanding of the problems.

Table 3.9. *Workshop program and data collection schedule*

| Week | Workshop | Topics | Data Collected |
|---|---|---|---|
| 1. | No workshop | Information about the study<br>Pre-test | Pre-GCCT<br>Pre-STAI<br>Pre-RTT<br>Pre-SAQ |
| 2. | Workshop 1 | Electronic Structure of Atoms<br>Periodic Properties of the Elements | |
| 3. | | Lecture | |
| 4. | Workshop 2 | Basic Concepts of Chemical Bonding | QZ1 |
| 5. | | Lecture | |
| 6. | Workshop 3 | Molecular Geometry and Bonding Theories<br>Gases | QZ2 |
| 7. | | Lecture | MT1 |
| 8. | Workshop 4 | Liquids and Intermolecular Forces<br>Solid and Modern Materials | QZ3 |
| 9. | | Lecture | |
| 10. | Workshop 5 | Thermochemistry<br>Thermodynamics | QZ4 |
| 11. | | Lecture | MT2 |
| 12. | Workshop 6 | Chemical Kinetics | QZ5 |
| 13. | No workshop | Post-test | Post-GCCT<br>Post-STAI<br>Post-RTT<br>Post-SAQ<br>SS<br>LS |
| 14. | No workshop | Final exam | FE |

For example, in the last workshop session students studied the problems related to the chemical kinetics concept. Regarding one chemical kinetics problem (Appendix I, Team problem 1) experimental data were given about reactant concentrations and initial rates for a specified reaction at a constant temperature. By using these rate data, students were asked to find the reaction rate (R) at the instant when a different concentration of reactants was provided ([NO] = 0.35 M and [$H_2$] =0.20 M). Some leaders used a "round-robin" strategy to solve this multi-step problem by assigning each student to one step of the problem and taking verifications of the correctness of each step from all group members:

- The first student determined the order of one reactant ($NO^X$) and explained the answer to the group and then all students agreed whether it was correct or not.
- Then the second student determined the order of another reactant ($H_2^Y$) and other group members check it.
- Third one wrote rate law (Rate = k $[NO]^2[H_2]$) and a group agreed on the result.
- Fourth student did the next step, finding the rate constant for the reaction (k = rate/ $[NO]^2[H_2]=0.136/(0.42)^2(0.12)=6.424\ M^{-2}s^{-1}$).
- The last one found the instant rate of the reaction (Rate=k $[NO]^2[H_2] = 6.424x\ (0.35)^2x(0.20) =0.157$ M/s) by using giving data. The results were discussed by peers and agreed on the findings. The leaders guided them by finding each step and finally made a summary.

On the contrary, some leaders applied a "pair problem-solving" strategy in this problem. They divided groups into pairs and assigned them roles of solver and listener. In other words, the role of one of the pair was to solve the problem and the other one was to listen and check the solution. Since leaders were aware of the students' level of chemistry understanding, high knowledgeable students served as a problem solver and low knowledgeable students served as a listener in each pair. If the listener did not understand the solution of the problem, s/he asked solver for more clarification and if the solver had forgotten either next step, rule or equation listener reminded him or her.

About this problem (Appendix I, Team problem 1), other leaders preferred using flowchart as a tool to make the abstract procedure more visual. For example, one leader asked the students that "how can you solve this problem?", "what are the steps?" With the help of the students, she constructed a flowchart with team members as a startup activity (see Figure 3.5).

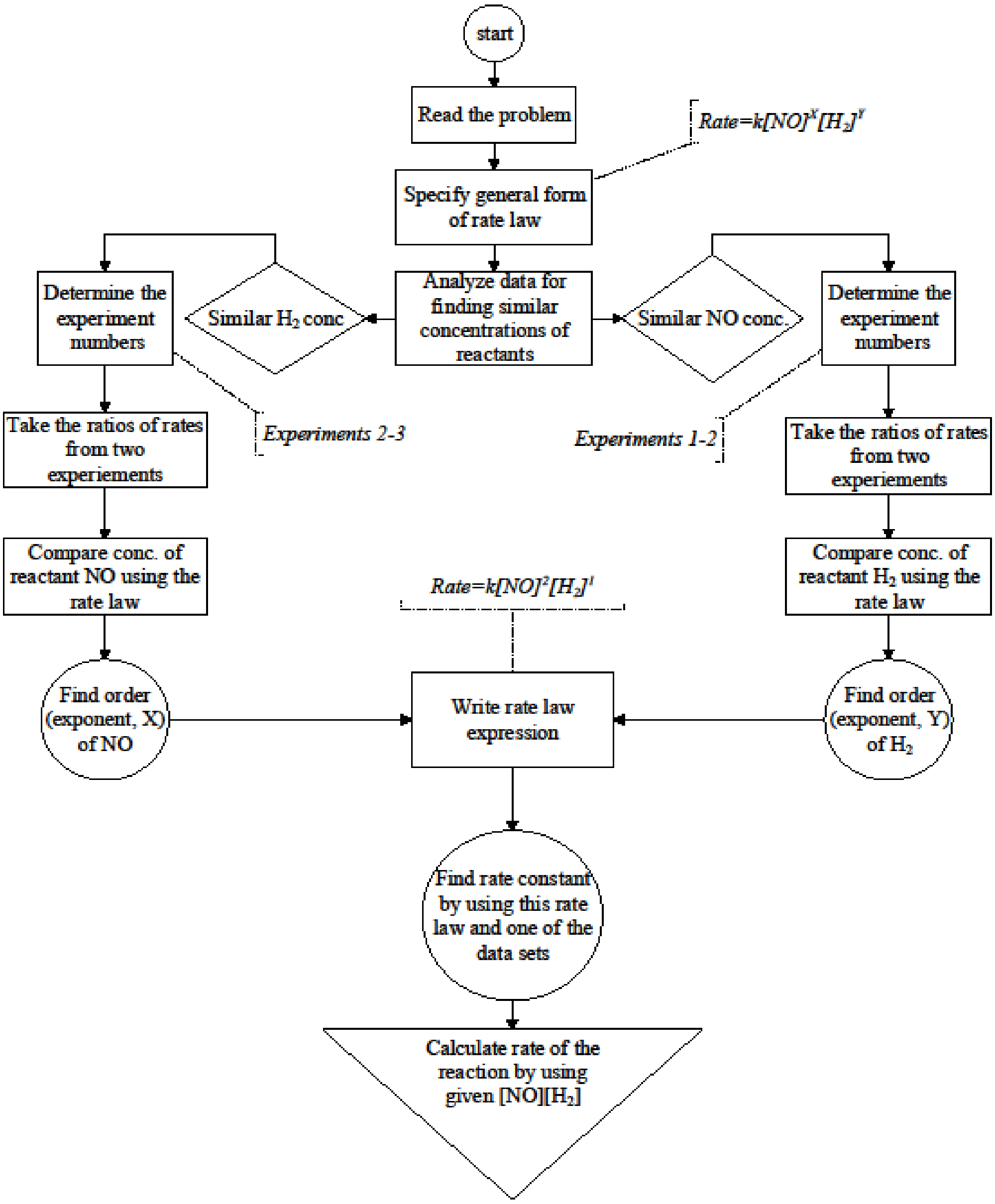


*Figure 3.5.* A flowchart sample constructed by a peer leader

Then students solved the problems by discussing their steps and results with facilitated support of the peer leader in this discussion. By using all these strategies team leaders encouraged peers to present and support their ideas, interact and communicate scientifically with one another, and think beyond simply getting the “right answer.”

After team learning problems, a quiz (QZ) was given to students by each leader to answer in 10 minutes. For example, related to the chemical kinetics concept a problem was given concerning the reaction of chlorine dioxide with fluorine and asked about the rate law, rate constant and explanations of how increasing the concentration of fluorine affects the rate of reaction. Expect for the first workshop, students had a quiz so there were five quizzes that cover the eight concepts. Leaders collected them and delivered them to the researcher.

During the present study, lecture, leader training sessions, and chemistry workshops were concurrently conducted. At the end of the workshop 3 and workshop 5, students entered the midterm examination I and 2 respectively

Besides, at the end of the term, some tests and questionnaires were applied again as a posttest. Students who completed all workshops also filled SS while leaders filled LS to evaluate the implementation of PLTL. Lastly, all participants of the study took a final exam in general chemistry.

### 3.6.2. Control Group Treatment: TCI

At the CEAC 105 course, the first section students (CG) were treated with traditional college instruction (TCI) in this study. TCI group students attend three 50-minutes lecture sessions every week and three-hour laboratory sessions biweekly. Unlike the PLTL students, TCI group students did not participate in chemistry workshops. The course schedule for TCI group students was presented in Table 3.10 which covered the lecture and laboratory work. Students could select laboratory 1 or 2 according to the other course schedule.

Table 3.10. *The schedule for TCI group*

| | Monday | Thursday | Friday |
|---|---|---|---|
| 9.30-10.20 | | | Lab2 |
| 10.30-11.20 | | Lecture | |
| 11.30-12.20 | | Lab1 | |
| 12.30-13.20 | | | |
| 13.30-14.20 | | | |
| 14.30-15.20 | | | |
| 15.30-16.20 | Lecture | | |
| 16.30-17.20 | | | |

Since the same professor taught the chemistry concepts to the EG and CG, the instruction in both lecture session was the same. It was mainly teacher-centered instruction in which she presented the chemistry concepts in the course book and solved and explained several questions. TCI group had longer lecture hours than the PLTL group. It was, therefore, possible that the professor might solve more problems by herself. In this case, students generally took notes about the solution of the problem. The methods used in the TCI group appeared to be mostly lecturing, occasionally discussions between the professor and a few students and questioning performed by the professor. Generally, students do not ask questions or do not think deeply about the concept. Mostly, they do not follow what was going on in the lecture because they give their attention to other things. For that reason, the conceptual understanding was not adequately reinforced. As in the data collection schedule of the PLTL group, pretests, posttests, midterm exams, and final exam were applied to TCI group students. However, they neither responded to any surveys nor took the quizzes.

### 3.7. Data Analysis

To evaluate the effect of the implementation in the study, quantitative data were obtained by several instruments; general chemistry concept test (GCCT), state-trait anxiety inventory (STAI), and social anxiety questionnaire for an adult (SAQ), midterm exams (MT1 and MT2), final exam (FE) and quizzes (QZ). Students' background information about gender, age, CEES, mother and father educational level, and family income were also collected. To evaluate the PLTL model, student survey (SS), leader survey (LS), and critical components rubric (CCR) were used. The data obtained from the observations of two researchers were evaluated by using the critical components rubric (CCR). The additional data obtained from SS with 26 PLTL students and from LS with 12 peer leaders were categorized under some themes. The percentages of their responses in terms of three categories (agree, neutral, and disagree) were provided for each question and corresponding themes. Furthermore, some sample responses from peer leaders were added.

All quantitative data were entered into the MS Excel program and then were transferred and run with the IBM Statistical Package for the Social Sciences (SPSS) Statistics 24.0 program for Windows. Missing data were checked for the posttests and pretests. It is reasonable to conclude that handling with missing data in dependent variables is challenging. Therefore, if there were undergraduates who did not complete their post-tests, they would not be taken in the main analysis. Consequently, 128 students had completed the post-tests and exams. However, there were 5 missing cases for Pre-GCCT (123 students had completed Pre-GCCT) and 11 missing cases for Pre-STAI-S, Pre-SAQ, and CEES (117 students had completed Pre-STAI-S, Pre-SAQ and CEES). According to Tabachnick and Fidell (2013), missing values that is randomly distributed through a data set would not cause severe concerns or problems in the analysis. For the missing values in the pretests, a dummy variable adjustment was conducted to learn whether there is a pattern. Since the pattern was not found in the analysis, missing data in pre-test scores and GEES were replaced with the mean scores of the group. Further details about the percentages of missing values and analysis were presented in the subsequent sections of the result.

The reliability analysis of STAI and SAQ and item analysis of GCCT were also performed with the IBM SPSS Statistics 24.0 program. Descriptive and inferential statistics for pretests and posttests were provided under the statistical analyses of the study. The descriptive statistics of each variable were provided for PLTL and TCI groups such as “mean, standard deviation, skewness, kurtosis, minimum, and maximum values”. Correlational analysis was also performed to decide the covariates of the study. CEES, STAI-T, Pre-GCCT, and Pre-STAI-S were determined as covariates in the current study. In terms of the inferential statistics, multivariate analysis of covariance (MANCOVA) was carried out with three DVs, which were Post-GCCT, Post-STAI-S, and Post-SAQ; one IV, which was treatments (PLTL and TCI); and four covariates. This analysis was suitable to generalize the results of the sample to the population. Follow-up ANCOVAs were also performed to examine the impact of PLTL and TCI on each DV. Before conducting MANCOVA, all variables were checked for its assumptions, which were normality, independence of observations, outliers, multicollinearity, homogeneity of regression, and homogeneity of variances. Furthermore, to address the second main problem in the study, two-way analysis of variance (ANOVA) was used with two independent variables, which were treatments (PLTL and TCI); and academic abilities (low, moderate, and high achievers) and one dependent variable, which was GCEA. The assumptions of ANOVA also met too.

### 3.8. Power Analysis

Before running an experimental procedure, as part of the quality check, power analysis is generally implemented. It refers to the probability of constructing a significant effect for a particular study. Power analysis is also used to determine an appropriate sample size which is required to support statistical judgments that are accurate and reliable (Simon & Goes, 2013).

The sample size should not be too small or too large. If a sample size is too small, this can cause a lack of precision and influence the reliability of the study; whereas, if it is too large, that may cause a waste of time and resources for minimal gain (Williams, 1989). For that reason, the optimal number of the students in the sample should be calculated to get a pre-established power value for this study. Cohen, Cohen, West, and Aiken (2003, p.177), proposed the following formula for Model 1 to calculate this necessary sample size.

$$n = \frac{L}{f^2} + k_A + k_B + 1$$

*n: sample size*

*L: the function of determinants of the population hypothesis and error matrices*

*$f^2$: effect size*

*$k_A$: number of covariates*

*$k_B$: the number of independent variables*

To make this calculation, some values were previously specified. Prior to implementation, the alpha value (α), which refers to the “probability of rejecting a true null hypothesis” (Type 1 error), was set to .05 and the beta value (β) which refers to the “probability of failing to reject a false null hypothesis” (Type 2 error), was set to 0.2. Accordingly, the power of the study (1- β), which refers to “the probability of rejecting a false null hypothesis”, was set to 0.80.

Since the effect size for this study was recognized to be medium, $f^2$ value was determined as .15. (Cohen et al., 2003, p.179). The value of $k_A$ was 4 (CEES, STAI-T, Pre-GCCT, and Pre-STAI-S) and the $k_B$ value is 1 (interventions/teaching methods). Then, the “L” value for this study was read as 7.85 from the L table by using the values of α=.05, power=.80, $k_B$=1 (Cohen et al., 2003, p.651). Then, all these values are inserted into the equation. It was found that the necessary sample size sample should be 58.33. Since 128 students participated in this study, medium or large effect might be found with power higher than .80.

### 3.9. Unit of Analysis

The unit of analysis is a critical point in experimental research. In order to provide a valid probability statement about types of error, the statistical unit of analysis and the experimental unit must be stated properly. Peckham, Glass, and Hopkins (1969, p.341) defined the units of statistical analysis as “data considered to be the outcomes of independent repetitions of the experiment" or "the numbers counted when we count up degrees of freedom" "within" or "for replications". In addition, they defined an experimental unit as "the smallest divisions of the collection of the experimental subjects which have been randomly assigned to the different conditions in the experiment and which have responded independently from each other". According to Hopkins (1982), class means should be used as the unit of analysis to satisfy the statistical assumption of independence of error when the treatments are administered to the separate group. In the case of using individual scores, this assumption could be violated. In other words, the statistical unit and the experimental unit should be the same to satisfy the independence of observation.

In this study, the statistical unit of analysis is each individual (individual score) while the experimental unit is intact classes (class mean) because it was impossible to perform the PLTL or TCI for each individual separately for the experimental studies. For this study, many interactions were observed among students as a nature of the PLTL study so the independence of observation assumption was violated during the treatment. Nevertheless, when data were collected from students, they were not allowed to cooperate so during the data collection process, the independence of observation was met.

## 3.10. Treatment Fidelity and Verifications

### 3.10.1. Treatment Fidelity

In an experimental study, treatment fidelity has a significant role in the interpretation and generalization of research findings. It refers to the extent of the reliability of the implementation of an intervention (or independent variable) in the experimental study (Hinckley & Douglas, 2013). It should be checked to ensure that the expected difference in the dependent variable is caused by the treatments rather than other variables. Two things are important to satisfy the fidelity of treatment. Firstly, the treatment conditions should be defined properly. Another is that the conditions of two treatments (EG and CG) differ from each other to occur the intended manipulation of the independent variable. In this regard, treatment fidelity of the study was ensured and enhanced through several actions. The interventions used for these two groups were initially defined explicitly with the help of the PLTL literature and then the theoretical framework for the PLTL model was presented. The handbook about the implementation of the PLTL study (Gosser et al., 2001) was also taken as a guideline and six critical components (Gafney, 2001a) were followed as a basis for the intervention. For example, the departmental and institutional support was taken from the university as a critical component. Then the necessary organizational arrangements such as time, duration, location and group size were made. The workshop materials were developed by the researcher based on the PLTL model and suggestions in the "PLTL Guidebook" by Strozak and Wedegaertner (2001) and the theoretical framework of the concept of "zone of proximal development" proposed by Vygotsky (1987). The necessary revisions were made by three experts in chemistry and chemistry education. Moreover, the role of the course professor, researcher, and peer leaders were identified and information was provided to professor and peer leaders about the implementation of the study. What the professor should be done and what should not be done during PLTL and TCI implementations were discussed clearly to differentiate a comparison group from the treatment group. Besides, the selection of peer leader and their training session program were specified before implementation according to the recommendations related to the leader selection and training (Roth, Cracolice, et al. 2001; Roth, Goldstein & Marcus, 2001). The supervisor and co-supervisor of this study guided all these processes.

### 3.10.2. Treatment Verifications

Treatment verification refers to whether the treatment was conducted as intended during the study. In present study, critical components rubric (CCR), student survey (SS), and leader survey (LS) were implemented to evaluate the implementation of the PLTL model. To ensure treatment verification, these instruments also provided information about whether the implementation was conducted as it had supposed to be. The researcher monitored all general chemistry workshops in the EG and rated the critical components rubric. At the end of the implementation, 12 peer leaders and 26 students who had attended all workshops filled a survey. The general properties of all these instruments were discussed in the instrument part and results were presented in the result section. It is generally seen that all the components of the peer-led chemistry workshops were administered properly. In addition to the EG group, the researcher observed some of the lecture hours of the comparison group. According to the field notes taken by the researcher, the professor usually started the lecture by writing the main parts of the concept on the board and then continued explaining them and solving some problems herself. Throughout the problem-solving, she asked a few questions to the students but did not give enough time to think about them. Due to these reasons, students either only listened or took notes about the concept and problems. About the solution of algorithmic problems, few students asked one or two questions. During the study, it can be inferred that TCI was implemented by the professor as planned.

### 3.11. Ethical Issues

Before conducting this research, necessary permission about ethical issues was taken from the ethical committee of human research at METU by providing some information about the study and instruments used in the study (see Appendix H). This showed that the current study did not lead to any possible harm to the participants of the study so neither leaders nor students were placed at any risk with this research project. At the beginning of the study, the consent forms (see Appendix A and B) were given to the participants (students and leaders) for ensuring their participation in the study willingly and their rights to withdraw from the study. Two leaders, for example, quit the study after three weeks. Moreover, they were guaranteed that any data collected from the participants keep under the confidentiality; therefore, their names never be used in any publications. In addition, the researcher stressed the purpose of the study, the importance of expressing themselves correctly, and the requirements of proper results during the data collection process so as to get more reliable data. The researcher participated in PLTL workshops as a non-participant observer and thus PLTL participants were informed about the rationale for the researcher's participation in the workshop. No deception was done in the implementation, data collection, or data analysis as part of the research.

## 3.12. Assumptions and Limitations of the study

### 3.12.1. Assumptions

The following statements below are accepted as assumptions for this study;

- PLTL group students did not interact with TCI group students.
- The professor was not biased about the treatments.
- The participants responded independently, honestly, and seriously to all instruments in the study.
- All instruments were applied to both groups under the standard and equal conditions.
- The independence of observations was satisfied.

### 3.12.2. Limitations

The following statements below are accepted as limitations for this study;

- The results of the study are limited to the General Chemistry course.
- The participants of the study are restricted to 128 undergraduate engineering students at Atılım University.
- Random sampling was not conducted in the study.
- The independence of observation assumption may have been violated.
- The implementation period was limited to only one semester.
- The treatment time was not sufficient for the PLTL groups in some weeks.
- The generalizability is restricted to the private universities which have an English medium in Ankara city/province.
- Multiple-choice tests were used to evaluate students' achievement and conceptual understanding of general chemistry.

# CHAPTER 4

# RESULTS

*"Coming together is a beginning. Keeping together is progress. Working together is a success."*

*(Henry Ford)*

The results of the study were categorized under seven sections; missing data analysis, statistical analysis of CEES and STAI-T and pre-test scores, statistical analysis of post-test scores, statistical analysis of student exam achievements, assessment of quizzes, PLTL model evaluation and the summary of the results.

## 4.1. Missing Data Analysis

In statistical analysis, the missing data which was originated from the absence of the subject of the interest during data collection procedure is a very common problem so it is required to check the missing cases before conducting statistical analysis (Acuna & Rodriguez, 2004). Table 4.1 summarizes the missing values for each variable of this study. Therefore, 128 students acquired at least one of the instruments.

When Table 4.1 was examined, it was easily seen that 128 students had taken the posttests and course exams; on the other hand, 123 students had taken Pre-GCCT, but 5 students were missing for Pre-GCCT and 117 students had reported completely Pre-STAI-S, Pre-SAQ and CEES, but 11 students were missing for Pre-STAI-S, Pre-SAQ, and CEES. To result in less serious problems, missing values should be randomly scattered through a data set (Tabachnick & Fidell, 2013). For the Pre-GCCT, it could be assumed that the missing value was randomly distributed through the data due to the percentage of missing participants, which was under 5% (Tabachnick & Fidell, 2013).

Table 4.1. *Missing values based on variables in the study*

| Variable | Present (N) | Missing (N) | Missing (%) |
|---|---|---|---|
| Pre-GCCT | 123 | 5 | 3.9 |
| Pre-STAI-S | 117 | 11 | 9.4 |
| Pre- SAQ | 117 | 11 | 9.4 |
| CEES | 117 | 11 | 9.4 |
| STAI-T | 128 | 0 | 0 |
| Post-GCCT | 128 | 0 | 0 |
| Post-STAI-S | 128 | 0 | 0 |
| Post-SAQ | 128 | 0 | 0 |
| MT1 | 128 | 0 | 0 |
| MT2 | 128 | 0 | 0 |
| FE | 128 | 0 | 0 |
| GCEC | 128 | 0 | 0 |

Note. N: Number of the participants

However, for Pre-STAI-S, Pre-SAQ, and CEES, the percentage of missing data was 9.4 % so a dummy variable adjustment was carried out to control whether there was a pattern in missing values of those scores (Allison, 2001). The missing values were coded as 1 and the others as 0. The results have indicated that there was not statistically significant difference between missing and present participants. Thus, it could be assumed that there was no pattern in missing data so missing pre-test scores and CEES were replaced with the mean scores of the group. Consequently, all participants taking the pre-tests and post-tests were retained in the data set; thus, the total number of the students in the sample to conduct inferential statistics was 128.

### 4.2. Statistical Analysis of CEES, STAI-T and Pre-tests Scores

Before the implementation of the treatments in EG and CG, in order to determine the pre-existing differences between EG and CG, the responses of participants to the General Chemistry Concept Test (GCCT), the State-Trait Anxiety Inventory-State Anxiety Scale (STAI-S), State-Trait Anxiety Inventory- Trait Anxiety Scale (STAI-T), Social Anxiety Questionnaire for Adult (SAQ), and College of Engineering Entry Scores (CEES) were analyzed at .05 significance level with the IBM SPSS 24.0 program. The results of the descriptive statistics and correlational analysis were reported as well.

### 4.2.1. Descriptive statistics of CEES, STAI-T and Pre-tests Scores

The descriptive statistic results for the CEES, STAI-T, Pre-GCCT, Pre-STAI-S, and Pre-SAQ were given for the TCI and PLTL groups in Table 4.2. According to Table 4.2, there were minor differences between the means of both groups on those tests.

The mean scores of CEES for the TCI group and PLTL group were 296.70 and 293.25 respectively. CEES indicates students' prior academic achievement in the university entrance exam. It means that a high score refers to having a high level of prior knowledge. It could be said that TCI group students had a high level of prior knowledge than PLTL group students as the mean score of the TCI was higher than that of PLTL.

Table 4.2. *Descriptive statistics for CEES, STAI-T and pre-test scores across groups*

| **Variables** | **Groups** | **N** | **Mean** | **SD** | **Min.** | **Max.** | **Skewness** | **Kurtosis** |
|---|---|---|---|---|---|---|---|---|
| CEES | TCI | 60 | 296.70 | 39.9 | 209.0 | 388.7 | .195 | .006 |
| | PLTL | 68 | 293.25 | 39.3 | 238.1 | 390.7 | .743 | -.217 |
| STAI-T | TCI | 60 | 44.40 | 11.1 | 24 | 74 | .341 | .288 |
| | PLTL | 68 | 42.68 | 11.8 | 20 | 72 | .218 | -.293 |
| Pre-GCCT | TCI | 60 | 5.27 | 3.4 | 0 | 14 | .263 | -.509 |
| | PLTL | 68 | 4.93 | 3.2 | 0 | 11 | .067 | -.991 |
| Pre-STAI-S | TCI | 60 | 48.04 | 6.1 | 25 | 59 | -1.688 | 4.335 |
| | PLTL | 68 | 49.55 | 7.4 | 28 | 68 | -.248 | 1.194 |
| Pre- SAQ | TCI | 60 | 92.60 | 13.8 | 63 | 135 | .438 | 1.350 |
| | PLTL | 68 | 97.40 | 14.1 | 64 | 134 | .205 | .496 |

Note: PLTL: Peer-Led Team Learning, TCI: Traditional College Instruction.

When the descriptive results of STAI-T were investigated, the mean score of the TCI group was 44.40 and the mean score of the PLTL group was 42.68. It shows the trait anxiety of the students and the high level of scores in the test shows having a higher level of anxiety. This means that TCI group students were more anxious than PLTL students in general.

According to the Pre-GCCT results, the mean scores of both groups were very close to each other prior to the treatment. The mean score of Pre-GCCT was 5.27 for the

TCI group and 4.93 for the PLTL group. These numbers revealed that both groups had a low conceptual understanding before training on general chemistry concepts.

Similar to Pre-GCCT scores, there was a slight difference in means of Pre-STAI-S between groups. The mean score of Pre- SAQ was 92.60 for the TCI group and 97.40 for the PLTL group. This difference means that PLTL group students possessed more situational anxiety than the TI groups students had before the implementation. Based on these values, it was possible to say that PLTL group students were more anxious in social situations compared to the TCI group students at the beginning of the term.

### 4.2.2. Determination of Covariates

It was not possible to infer that the mean difference in TCI and PLTL groups was derived from the intervention effect if there were pre-existing differences among the students of TCI and PLTL groups. Accordingly, potential covariates of the study which has shown significant correlations with DVs should be determined prior to the analysis (Tabachnick & Fidell, 2013). In the current study, there were five possible covariates such as CEES, STAI-T, Pre-GCCT, Pre-STAI-S, and Pre-SAQ scores. Since a majority of the participants consisted of freshman engineering students without a GPA, their CEES were used in this study to control the pre-existing difference in their academic abilities.

In order to determine the actual covariates of the study from these five possible covariates, a correlational analysis was executed. Before conducting a correlational analysis, its level of measurement, related pairs, normality, linearity, and homoscedasticity assumptions were checked whether they could be satisfied; thereby, all assumptions were met. The results of the correlational analysis were presented in Table 4.3.

As indicated in Table 4.3, the two possible covariates, Pre-GCCT, and Pre-STAI-S were found to be significantly correlated with one DV (Post-GCCT). Additionally, there were statistically significant correlations between CEES, and two DVs of Post-GCCT and Post-STAI-S as well as between STAI-T and all DVs of Post-GCCT, Post-

STAI-S, and Post-SAQ. Pre-SAQ scores had a medium level of correlation with Pre-STAI-S but not significantly correlated with any of the dependent variables. Despite their low level of correlations with DVs (Post-GCCT, Post-STAI-S, and Post-SAQ), CEES, STAI-T, Pre-GCCT, and Pre-STAI-S were taken as covariates for further analysis in this study.

Table 4.3. *Correlations among variables*

| **Variables** | **CEES** | **STAI-T** | **Pre-GCCT** | **Pre-STAI-S** | **Pre-SAQ** | **Post-GCCT** | **Post-STAI-S** | **Post-SAQ** |
|---|---|---|---|---|---|---|---|---|
| CEES | 1 | -.135 | .077 | -0.81 | -.025 | .195* | -203* | -135 |
| STAI-T | -.135 | 1 | -.134 | .146 | -.055 | -.178* | .768** | .181* |
| Pre-GCCT | .077 | -.134 | 1 | -.083 | -.003 | .193* | -.100 | .046 |
| Pre-STAI-S | -.081 | .146 | -.083 | 1 | .338** | -.210* | .053 | .140 |
| Pre-SAQ | -.025 | -.055 | -.003 | .338** | 1 | -.029 | -.160 | ,059 |

Note: *Correlation is significant at the 0.05 level (2-tailed) **. Correlation is significant at the 0.01 level (2-tailed)

### 4.3. Statistical Analysis of Post-tests Scores

The first step was to determine which inferential statistics must be conducted. As mentioned earlier, in the study there were one categorical independent variable (treatments: PLTL and TCI) and three continuous dependent variables (Post-GCCT, Post-STAI-S, and Post-SAQ scores of the students). In addition to these, four continuous covariates (CEES, STAI-T, Pre-GCCT, and Pre-STAI-S) were determined. Accordingly, the appropriate inferential statistics test is MANCOVA that analyzes "two or more dependent variables while controlling one or more covariates across one or more independent variables" (Gravetter & Wallnau, 2007). As a result, MANCOVA was determined to be implemented in this study. Firstly, descriptive statistics of Post-GCCT, Post-STAI-S, and Post-SAQ scores were performed. Then, the assumptions of MANCOVA were checked to detect any violations. The IBM SPSS 24.0 was utilized to carry out MANCOVA at .05 significance level.

### 4.3.1. Descriptive Statistics of Post-GCCT, Post-STAI-S, and Post-SAQ Scores

The descriptive statistics of post-test scores were given for TCI and PLTL in Table 4.4. There were 60 students in the TCI group and 68 students in the PLTL group as a total of 128. The mean post-GCCT scores of the PLTL group (M = 9.53, SD = 3.15) were slightly higher than the score of the TCI group (M = 9.23, SD = 3.38). Moreover, the mean score of post-STAI-S was lower for the PLTL group (M = 42.54, SD = 12.69) than the TCI group (M = 45.03, SD = 11.57). However, PLTL group students obtained higher mean score in post-SAQ (M = 87.03, SD = 19.29) representing higher social anxiety compared to those of the TCI group students (M = 82.30, SD = 21.11).

Table 4.4. *Descriptive statistics for post-tests scores across groups*

| Tests | Groups | N | Mean | SD | Min. | Max. | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|---|
| Post-GCCT | TCI | 60 | 9.23 | 3.38 | 2 | 16 | -.112 | -.502 |
| | PLTL | 68 | 9.53 | 3.15 | 4 | 16 | .324 | -.818 |
| Post-STAI-S | TCI | 60 | 45.03 | 11.57 | 20 | 70 | -.035 | -.338 |
| | PLTL | 68 | 42.54 | 12.69 | 20 | 77 | .145 | -.117 |
| Post- SAQ | TCI | 60 | 82.30 | 21.11 | 30 | 123 | -.445 | -.036 |
| | PLTL | 68 | 87.03 | 19.29 | 30 | 150 | -.119 | 1.382 |

Note: PLTL: Peer-Led Team Learning, TI: Traditional College Instruction.

### 4.3.2. Assumptions of MANCOVA

Before conducting a MANCOVA analysis, its assumptions were required to be met. In the following parts, the assumptions of the MANCOVA analysis were discussed.

#### 4.3.2.1. Sample Size

According to Pallant (2011), the sample size assumption refers to “the equality of the minimum number of the cases in each cell to the number of DVs”. In this study, it was clear that the number of cases in each cell was more than the number of DVs, which was 3. Consequently, this assumption was met.

#### 4.3.2.2. Normality

The univariate normality assumption was checked from "the skewness and kurtosis values" in Table 4.4. Since these values were in the acceptable range of -2 and +2 for a normal distribution (Pallant, 2011), it could be assumed that this distribution was normal and the normality assumption was satisfied. Additionally, the histograms of each variable were also plotted and checked to test the normality assumption (see Figure 4.1). When the histograms in Figure 4.1 were examined for TCI and PLTL groups, all DVs might be accepted as normally distributed. It was concluded that the assumption was met.

#### 4.3.2.3. Outliers

In order to satisfy the outliers' assumption, it was needed to check for the possibility of univariate and multivariate outliers (Pallant, 2011). For the univariate outliers, Q-Q plots and box plots were examined for each DV separately as shown in Figure 4.2. It was therefore concluded that there were no extreme outliers in the study. In addition, for the multivariate outliers, first, the Mahalanobis distance value was calculated with the IBM SPSS Statistics 24.0 program and then it was compared with the critical value which was decided by using a chi-square table. This critical value for three DVs was 16.27 (Pallant, 2011, p.288).

In this study, the calculated Mahalanobis distance value was 13.98. Since Mahalanobis distance value was less than the critical value, it was assumed that there were no significant outliers in the study. As a result, the assumption of univariate and multivariate outliers was satisfied.

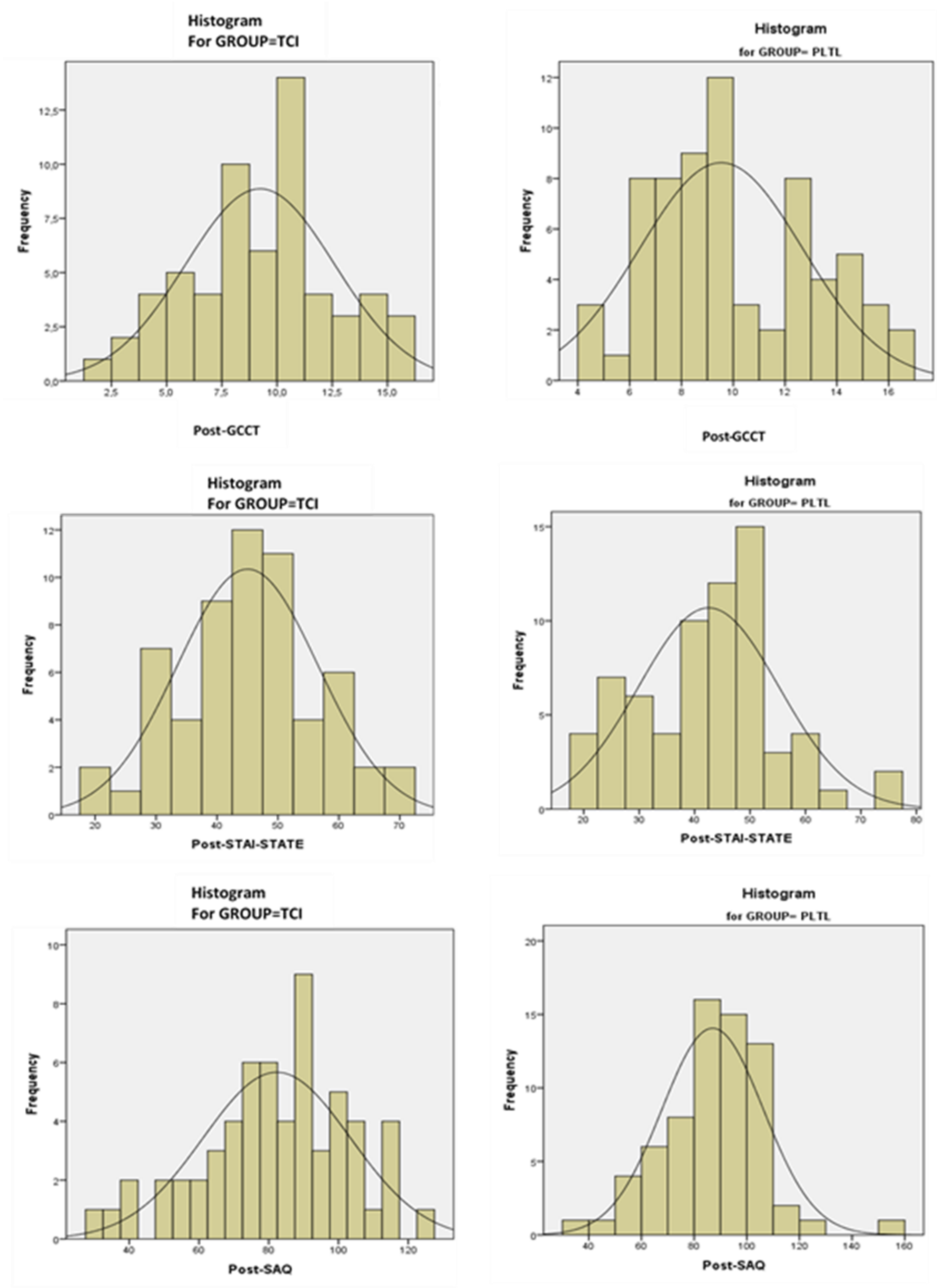


*Figure 4.1.* Histograms of the post-tests in terms of each group

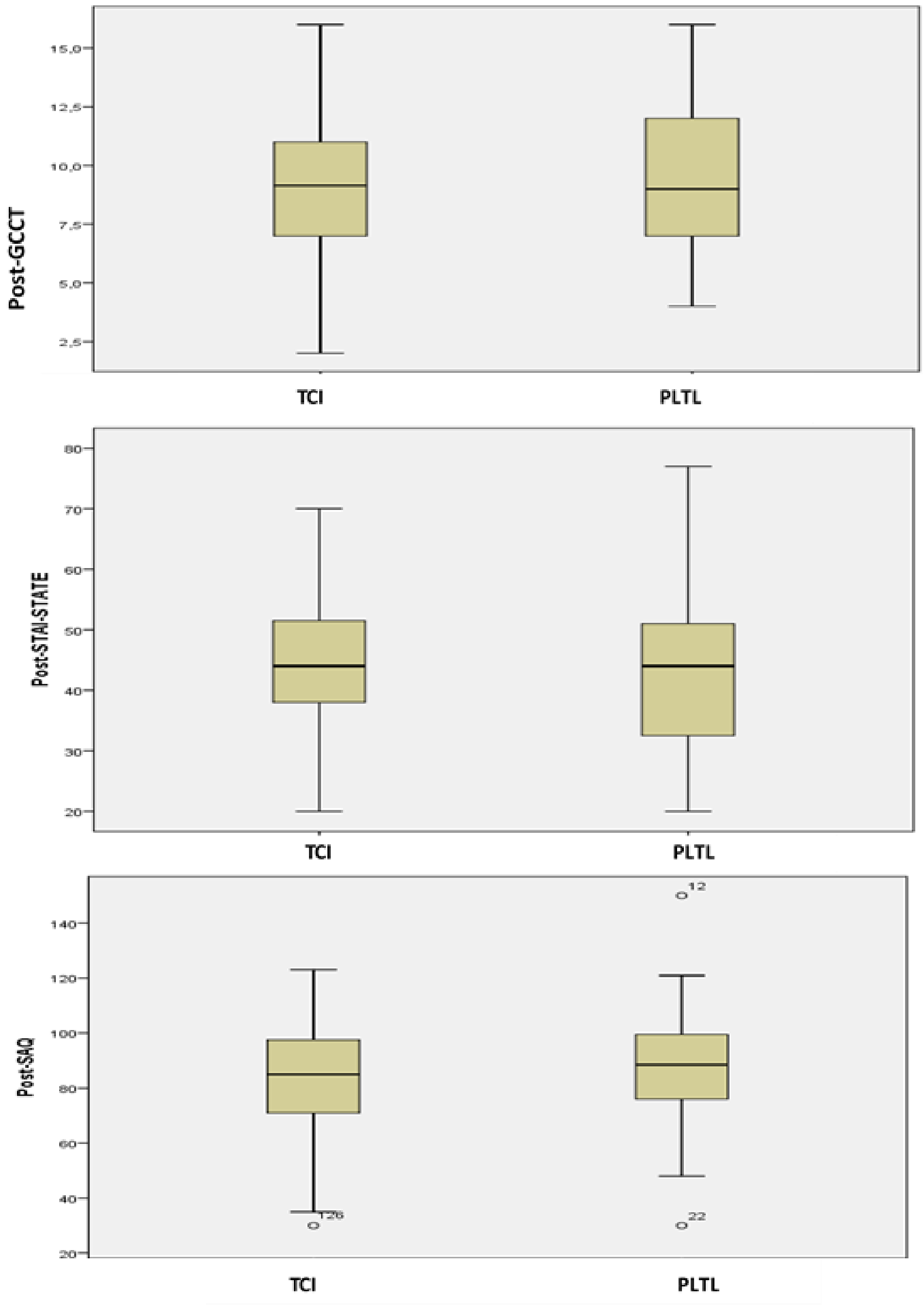


*Figure 4.2.* Box plots for each dependent variable in terms of groups

#### 4.3.2.4. Linearity

Tabachnick and Fidell (2013) explained the linearity assumption as the presence of a straight-line relationship. And it was checked by creating a matrix of scatterplots between each pair of DVs, covariates, and all DV–covariate pairs in each cell for each group. They stated that the deviations from linearity could reduce the power of the statistical tests. Figure 4.3 showed the linear relationship among all pairs of DVs, covariates and all DV– covariate pairs in each cell for each group. It was concluded that the assumption of linearity was met.

#### 4.3.2.5. Multicollinearity and Singularity

The multicollinearity refers to the presence of a high correlation among DVs and singularity means the combination of other variables. Multicollinearity and singularity could be checked via correlation analysis. Table 4.5 shows the correlation values among the DVs. Based on the values in the table, it was highly possible to infer that multicollinearity and singularity assumption was met. Additionally, there were no strong correlations among the covariates as indicated in Table 4.3.

Table 4.5. *Correlations among dependent variables*

| Tests | Post-GCCT | Post-STAI-S | Post- SAQ |
|---|---|---|---|
| Post-GCCT | - | -.152 | -.098 |
| Post-STAI-S | -.152 | - | .102 |
| Post- SAQ | -.098 | .102 | - |

#### 4.3.2.6. Homogeneity of Variance-Covariance Matrices

The Box’s M test of equality of covariance matrices was used to check this assumption. Since the sig. value in the Box’ test table was larger than .05 [F (6, 110231.63) =.767, p = .596], there was no violation of this assumption. Therefore; the homogeneity of variance-covariance matrices assumption was assumed to be met.

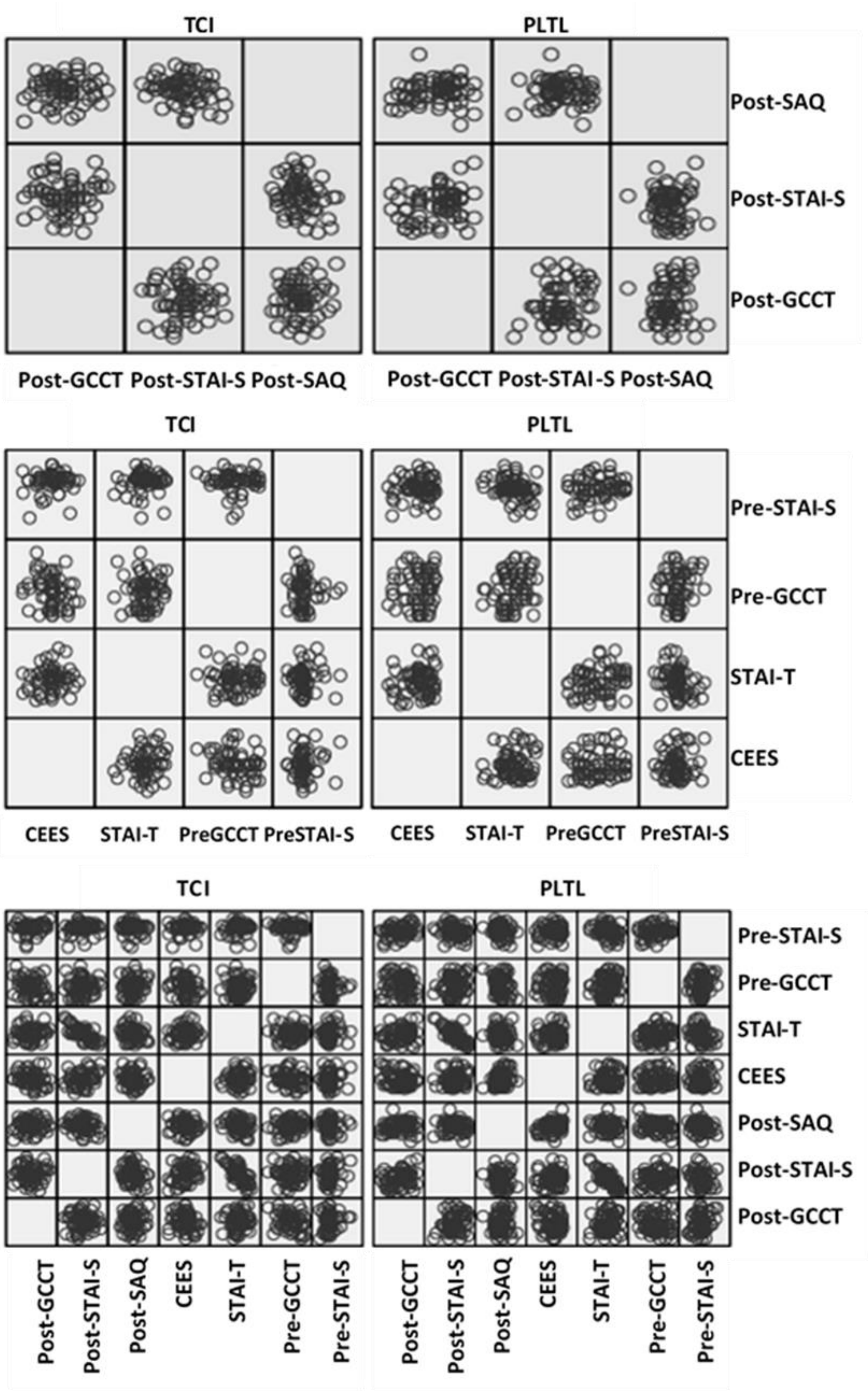


*Figure 4.3.* Scatter plots that show linearity for all the dependent variables, covariates and all dependent variables-covariate pairs in terms of groups

#### 4.3.2.7. Homogeneity of Regression Slopes

The assumption of homogeneity of regression was controlled by using custom analysis via MANCOVA so as to determine whether there were interactions between the covariates and IVs in terms of each group. In order to satisfy this assumption, it was expected to find having insignificant results that pointed out no interaction between the IV and the covariates of the study (Tabachnick and Fidell, 2013). The results were presented in Table 4.6.

Table 4.6. *Multivariate test of homogeneity of regression for the interaction between the independent variable and covariates*

| Effect | | Value | F | df | Error df | Sig. |
|---|---|---|---|---|---|---|
| GROUP * Pre-GCCT | Pillai's Trace | .121 | 2.530 | 6 | 236 | .090 |
| | Wilks' Lambda | .882 | 2.525 | 6 | 234 | .092 |
| | Hotelling's Trace | .130 | 2.520 | 6 | 232 | .094 |
| | Roy's Largest Root | .095 | 3.750 | 3 | 118 | .060 |
| GROUP * CEES | Pillai's Trace | .080 | 1.671 | 6 | 240 | .129 |
| | Wilks' Lambda | .921 | 1.672 | 6 | 238 | .128 |
| | Hotelling's Trace | .085 | 1.674 | 6 | 236 | .128 |
| | Roy's Largest Root | .071 | 2.847 | 3 | 120 | .040 |
| GROUP * Pre-STAI-S | Pillai's Trace | .075 | 1.560 | 6 | 240 | .160 |
| | Wilks' Lambda | .926 | 1.555 | 6 | 238 | .161 |
| | Hotelling's Trace | .079 | 1.549 | 6 | 236 | .163 |
| | Roy's Largest Root | .059 | 2.374 | 3 | 120 | .074 |
| GROUP * STAI-T | Pillai's Trace | .594 | 16.890 | 6 | 240 | .000 |
| | Wilks' Lambda | .408 | 22.470 | 6 | 238 | .000 |
| | Hotelling's Trace | 1.451 | 28.529 | 3 | 236 | .000 |
| | Roy's Largest Root | 1.448 | 57.937c | 3 | 120 | .000 |

First, the DVs of the study (Post-GCCT, Post-STAI-S, and Post-SAQ) were placed in the dependent variable box, the IVs of the study (Treatment) were placed in the fixed factors box, and the covariates (CEES, STAI-T, Pre-GCCT, and Pre-STAI-S) were placed in the covariates box. Then, the model and custom selections were functioned. As it was seen in Table 4.6, all significance values for the interactions between the IV and covariates were bigger than 0.05; thus, the assumption of homogeneity of regression was satisfied. However, the interaction effect of treatment with STAI-T was found significant (p=0.0001). Accordingly, it was concluded that it was appropriate to proceed with MANCOVA analysis due to the confirmation of the assumption for the other DVs.

#### 4.3.2.8. Reliability of Covariates

Since the reliability of the covariates influences the power of the study, it is a significant matter. In order to increase the reliability of the data collection tools, Pallant (2011) provides some suggestions such as looking for well-developed and validated scales and checking the internal consistency of the scale. In this study, Cronbach alpha values for GCCT, STAI-T, STAI-S, and SAQ were 0.799, 0.909, 0.915, and 0.898 respectively, which indicates high internal consistency due to the acceptable values of reliability coefficient of 0.70 or more (Pallant, 2011). The university entrance examination (CEEC) is a nationwide high-stake test that designates a clear, well-structured, and reliable instrument.

### 4.3.3. Results of One-Way Between-Group MANCOVA

Because of being no serious violations of the assumptions, one-way between-groups Multivariate Analysis of Covariance (MANCOVA) was implemented with one independent variable (treatment), three dependent variables (Post-GCCT, Post-STAI-S, Post-SAQ) and four covariates (CEES, STAI-T, Pre-GCCT, and Pre-STAI-S). After conducting a MANCOVA analysis, the results were used to test null hypothesis 1.1, null hypothesis 1.2, null hypothesis 1.3, and null hypothesis 1.4, respectively.

#### 4.3.3.1. Null Hypothesis 1.1

The first null hypothesis of this study was “There is no statistically significant effect of PLTL and TCI on the population mean of collective dependent variables of undergraduate engineering students' posttest scores of conceptual understanding and posttest scores of state anxiety and posttest scores of social anxiety in general chemistry course when pre-existing differences (pre-test conceptual understanding, pre-test state anxiety scores, trait anxiety, and college of engineering entry scores) were controlled".

Table 4.7 illustrated the results of one-way MANCOVA for the collective dependent variables of the study. They were investigated for the evidence to test null hypotheses 1.1.

Table 4.7. *Results of one-way MANCOVA for collective dependent variables*

| Effect | Wilks' Lambda | F | df | Error df | Sig. | Partial eta squared | Observed power |
|---|---|---|---|---|---|---|---|
| STAI-T | .591 | 57.75 | 3 | 120 | .000 | .591 | 1.000 |
| CEES | .937 | 2.68 | 3 | 120 | .050 | .063 | .641 |
| Pre-GCCT | .965 | 1.46 | 3 | 120 | .229 | .035 | .378 |
| Pre-STAI-S | .951 | 2.05 | 3 | 120 | .110 | .049 | .515 |
| Treatment | .764 | 5.77 | 3 | 120 | .000 | .126 | .998 |

When Table 4.7 was examined, it was found to be a statistically significant effect of PLTL and TCI on the population mean of collective DVs of undergraduate engineering students' posttest scores of conceptual understanding (Post-GCCT) and posttest scores of state anxiety (Post-STAI-S) and posttest scores of social anxiety (Post-SAQ) in general chemistry when pre-existing differences of CEES, STAI-T, Pre-GCCT, and Pre-STAI-S were controlled: $F(3,120) = 5.77$, Wilks' Lambda = 0.764, $p < 0.05$. As a result, the null hypothesis 1.1 was rejected and this difference was able to be attributed to being implemented different treatments (TCI and PLTL) between groups on general chemistry course.

The partial eta squared value of the treatment effect was 0.126. Based on the guidelines proposed by Cohen (Pallant, 2011), partial eta squared of 0.01 is small, 0.06 is medium and 0.14 is regarded as a large effect size. Thus, this value of 0.126 was considered an approximately high effect size. The treatment effect of the study explained 12.6 % of the multivariate variance on collective DVs of undergraduate engineering students' Post-GCCT, Post-STAI-S, and Post-SAQ. This high effect size also meant that the mean difference among groups stemming from the treatment had practical importance. The observed power value, which was .998 for the effect of treatment at .05 level, indicated the high probability of making the correct decision.

According to the results given in Table 4.7, there was a statistically significant contribution of STAI-T ($F(3, 120) = 57.75$, Wilk's Lambda = .591, $p<0.05$) and CEES ($F(3, 120) = 2.68$, Wilk's Lambda = .937, $p\leq 0.05$) to their combined DVs of Post-GCCT, Post-STAI-S, and Post-SAQ of undergraduate engineering students. On the other hand, Pre-GCCT ($F(3, 120) = 1.46$, Wilk's Lambda = .965, $p=.229$) and Pre-STAI-S ($F(3, 120) = 2.05$, Wilk's Lambda = .951, $p=.110$) were not significant contributors of the combined effect of DVs in this study.

In order to examine the particular effect of treatments in EG (PLTL) and CG (TCI) on each DV, a follow-up ANCOVA analysis was performed. Table 4.8 indicated the results of multiple univariate ANCOVAs. The null hypotheses 1.2, 1.3, and 1.4, could be tested by checking these follow up ANCOVA results.

Tabachnick and Fidell (2013) recommend using Bonferroni adjustment before checking the p values to decrease Type I error in the separate univariate analysis. This adjustment was conducted to determine the new adjusted alpha level that was calculated by dividing the alpha value of .05 to the number of dependent variables (N=3 for this study). Accordingly, the p-value that was less than the new adjusted alpha level of .017 (0.05/3) indicated significant results.

Table 4.8. *Results of follow-up ANCOVAs*

| Source | Dependent variable | F | Sig. | Partial eta squared | Observed power |
|---|---|---|---|---|---|
| Treatment | Post-GCCT | 5.378 | .006 | .081 | .835 |
| | Post-STAI-S | 4.665 | .011 | .071 | .776 |
| | Post-SAQ | 7.060 | .001 | .104 | .924 |

#### 4.3.3.2. Null Hypothesis 1.2

In this study, the second null hypothesis was "There is no statistically significant population mean difference in posttest conceptual understanding scores in general chemistry course between groups exposed to PLTL and TCI when pre-existing differences (pre-test conceptual understanding, pre-test state anxiety scores trait anxiety, and college of engineering entry scores) were controlled."

Based on the results presented in Table 4.8, there was no evidence to retain the null hypothesis 1.2, ($F (1,122) = 5.378$, $p < .017$). It was possible to conclude that there was a statistically significant population mean difference in posttest conceptual understanding scores (Post-GGCT) in general chemistry between groups exposed to PLTL and TCI if pre-existing differences of CEES, STAI-T, Pre-GCCT, and Pre-STAI-S were controlled. The estimated marginal means (adjusted mean scores) on Post-GGCT of to PLTL and TCI were given in Table 4.9. The PLTL group students obtained significantly higher mean scores ($M_{adj} = 9.60$, $SE = .38$) from Post-GCCT than TCI group students had ($M_{adj} = 9.14$, $SE = .40$). More specifically, engineering students in the PLTL group outperformed engineering students in the TCI group on the General Chemistry Concept Test after the intervention. It was found that the value of the partial eta squared for Post-GGCT was .081. According to Cohen (1988), this magnitude points out a medium level of difference between groups, suggesting that treatment leads to a meaningful effect on the conceptual understanding of engineering students in general chemistry. The value of power was found 0.835 with respect to post-GCCT.

Table 4.9. *Estimated marginal means for the post-GCCT scores in terms of treatment*

| Dependent Variable | Treatment | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| Post-GCCT | TCI | 9.149 | .404 | 8.349 | 9.949 |
| | PLTL | 9.604 | .379 | 8.854 | 10.355 |

#### 4.3.3.3. Null Hypothesis 1.3

The third null hypothesis was "There is no statistically significant population mean difference in posttest state anxiety scores in general chemistry course between groups exposed to PLTL and TCI when pre-existing differences (pre-test conceptual understanding, pre-test state anxiety scores trait anxiety, and college of engineering entry scores) were controlled."

The effect of treatment on state anxiety was examined in Table 4.8 to find evidence to reject the null hypothesis 1.3. After controlling the pre-existing differences resulted from CEES, STAI-T, Pre-GCCT, and Pre-STAI-S, a significant population mean difference in posttest state anxiety scores (Post-STAI-S) was found between PLTL and TCI groups ($F(1,122) = 4.665$, $p < .017$). It was obvious that the null hypothesis 1.3 was rejected because of this statistically significant evidence for the effect of treatment on Post-STAI-S of the engineering students. Furthermore, the estimated marginal means (the adjusted mean scores) of engineering students in the PLTL group ($M_{adj} = 43.26$, SE = .95) were higher than those in the TCI group ($M_{adj} = 42.22$, SE = 1.02) in term of post-test of state anxiety, as indicated in Table 4.10. The decrease of state anxiety in the Post-STAI-S test was observed in favor of the PLTL group. The value of partial eta squared was found as .071. Thus it could be implied that the proportion of variance in the students' state anxiety of Post-STAI-S explained by the treatment was 7.1%. Power value also was found as .776. Consequently, the difference between PLTL and TCI groups' students arose from the treatment effect and had practical significance too.

Table 4.10. *Estimated marginal means for the Post-STAI-S scores in terms of treatment*

| Dependent Variable | Treatment | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| Post-STAI-S | TCI | 44.217 | 1.016 | 42.205 | 46.229 |
| | PLTL | 43.264 | .954 | 41.376 | 45.153 |

### 4.3.3.4. Null Hypothesis 1.4

The fourth null hypothesis was "There is no statistically significant population mean difference in posttest social anxiety scores in general chemistry course between groups exposed to PLTL and TCI when pre-existing differences (pre-test conceptual understanding, pre-test state anxiety scores trait anxiety, and college of engineering entry scores) were controlled."

The results of the follow-up ANCOVA in Table 4.8 supported that there was a statistically significant population mean difference in posttest social anxiety scores in general chemistry course between groups exposed to PLTL and TCI when pre-existing differences of CEES, STAI-T, Pre-GCCT and Pre-STAI-S, $F(1,122) = 7.060$, $p < .017$, partial eta squared=.104. Therefore, there was statistically significant evidence to reject the null hypothesis 1.4. According to Table 4.11, the estimated marginal means (the adjusted mean scores) on Post-SAQ revealed significantly higher mean scores in the PLTL group (Madj=87.02, SE=2.42) compared to TCI group (Madj = 82.31, SE=2.58). That means the TCI group students had a lower level of social anxiety than the PLTL group students.

Table 4.11. *Estimated marginal means for the Post-SAQ scores in terms of treatment*

| Dependent Variable | Treatment | Mean | Std. Error | 95% Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| Post-SAQ | TCI | 82.314 | 2.578 | 77.210 | 87.417 |
| | PLTL | 87.017 | 2.419 | 82.228 | 91.807 |

The power value and partial eta squared value were found as .924 and .104 respectively. This large effect size indicated the practical significance of the result and high power value showed the high probability of the correct decision for the null hypothesis 1.4.

## 4.4. Statistical Analysis of Student Exam Achievements

In the analysis of students' general chemistry exam achievement (GCEA), there were two categorical independent variables (treatments and academic abilities) and one continuous dependent variable (GCEA scores of the students). Since the appropriate inferential statistics test for this type of analysis was two-way between-groups Analysis of Variance (ANOVA), it was decided to be performed. In this direction, descriptive statistics and the assumptions of ANOVA were presented in the following sections. The IBM SPSS 24.0 Program was used to conduct ANOVA at .05 significance level.

### 4.4.1. Descriptive Statistics of CEES and GCEA

Within the TCI and PLTL groups, engineering students were categorized with respect to their academic abilities as high-achievers, moderate-achievers, and low-achievers by using their CEES as discussed in the previous section of chapter 2. The number of students in each category of academic abilities was presented based on the PLTL and TCI groups in Table 4.12.

Table 4.12. *The frequency and percentage of students in terms of treatment groups and student academic abilities*

| | **Treatment** | | | | **Total** | |
|---|---|---|---|---|---|---|
| | **TCI** | | **PLTL** | | | |
| **Academic ability** | N | Percent | N | Percent | N | Percent |
| Low-achievers | 13 | 21.8 | 25 | 36.8 | 38 | 29.7 |
| Moderate-achievers | 31 | 51.6 | 27 | 39.7 | 58 | 45.3 |
| High-achievers | 16 | 26.6 | 16 | 23.6 | 32 | 25 |
| Total | 60 | 100 | 68 | 100 | 128 | 100 |

As can be seen from Table 4.12, TCI group had the highest student percentage in the moderate-achievers' category with 51.6 %, second highest one in the high-achievers with 26.6%, and then followed by the low-achievers with 21.8%. For the PLTL group, the highest percentage was observed in the moderate-achievers with 39.7%, as in the TCI group. However, unlike the TCI group, it was followed by 36.8 % of the low-achievers' category and 23.6% of the high-achievers' category.

The descriptive statistics of GCEA with respect to treatment groups and academic ability (the IVs of the study) were reported in Table 4.13 and Table 4.14 respectively. They included the mean, standard deviation, min, and max values as well as skewness and kurtosis of the GCEA scores. When Table 4.13 were examined for treatment groups, it was seen that PLTL group students (M=62.88, SD=14.71) had higher mean scores of the GCEA compared to students trained by TCI group (M=58.83, SD=16.47).

Table 4.13. *Descriptive statistics for GCEA score in terms of treatments*

| Treatment | N | Mean | SD | Min | Max | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| TCI | 60 | 58.83 | 16.47 | 29 | 91 | .385 | -.790 |
| PLTL | 68 | 62.88 | 14.71 | 24 | 93 | .060 | -.182 |

As expected from high-achieving students, they (M=73.14, SD=13.28) performed much better in general chemistry course exams than their peers in moderate-achieving, (M=59.38, SD=15.16,) and low-achieving (M=53.17, SD=11.92) categories as shown in Table 4.14.

Table 4.14. *Descriptive statistics for GCEA score in terms of student' academic abilities*

| Academic ability | N | Mean | SD | Min | Max | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| Low-achievers | 38 | 53.17 | 11.92 | 29 | 84 | .442 | .707 |
| Moderate-achievers | 58 | 59.38 | 15.16 | 24 | 92.5 | .143 | -.394 |
| High-achievers | 32 | 73.14 | 13.28 | 46.5 | 93 | -.246 | -1.110 |

Table 4.15. *Descriptive statistics results of the GCEA score in terms of students' academic abilities and treatments*

| Academic Ability | Treatment | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|
| Low-achievers | TCI | 13 | 46.15 | 10.89 | 29.0 | 62.0 |
| | PLTL | 25 | 56.82 | 10.91 | 37.0 | 84.5 |
| | Total | 38 | 53.17 | 11.92 | 29.0 | 84.5 |
| Moderate-achievers | TCI | 31 | 55.40 | 13.06 | 31.5 | 84.0 |
| | PLTL | 27 | 63.94 | 16.32 | 24.0 | 92.5 |
| | Total | 58 | 59.38 | 15.16 | 24.0 | 92.5 |
| High-achievers | TCI | 16 | 75.75 | 12.72 | 54.5 | 91.0 |
| | PLTL | 16 | 70.53 | 13.72 | 46.5 | 93.0 |
| | Total | 32 | 73.14 | 13.28 | 46.5 | 93.0 |

As seen from Table 4.15, the GCEA mean score of low achievers taught by the PLTL model (M = 56.82, SD = 10.91) were much higher than those of low achievers taught by TCI (M = 46.15, SD = 10.89). Moreover, moderate achieving students taught by the PLTL (M = 63.94, SD = 16.32) have substantially higher scores in GCEA than those taught by TCI (M = 55.40, SD = 13.06). However, the mean GCEA score of the PLTL group was lower than the mean GCEC score of TCI group for the high achievers' group of students (M = 70.53, SD = 13.72 for PLTL and M = 75.75, SD = 12.72 for TI). In order to learn whether the differences in the mean score was statistically and practically important, further analysis was performed as follows:

### 4.4.2. Assumptions of Two-Way Between-Group ANOVA

Since it was planned to apply two-way between-group ANOVA, its assumptions were needed to be met before conducting this analysis.

#### 4.4.2.1. Level of Measurements

The DVs should be measured at the interval or ratio level (i.e., continuous). Since the GCEA as a DV was continuous, this assumption was met. The IVs should also include two or more categorical independent groups. In this study, there were two categorical independent groups which were treatment (TCI and PLTL) and academic ability levels (low-achievers, moderate-achievers, and high-achievers). Thus, this assumption was met.

#### 4.4.2.2. Normality

The normality assumption was controlled by the skewness and kurtosis values in Table 4.13 and Table 4.14. Those values for this study were between -2 and +2 so it was likely to be accepted as a normal distribution (Pallant, 2011). Another way to test this assumption was by creating the histograms of each variable and checking for symmetric distribution. Figure 4.4 and Figure 4.5 presented these plots in terms of treatment and students' academic ability levels.

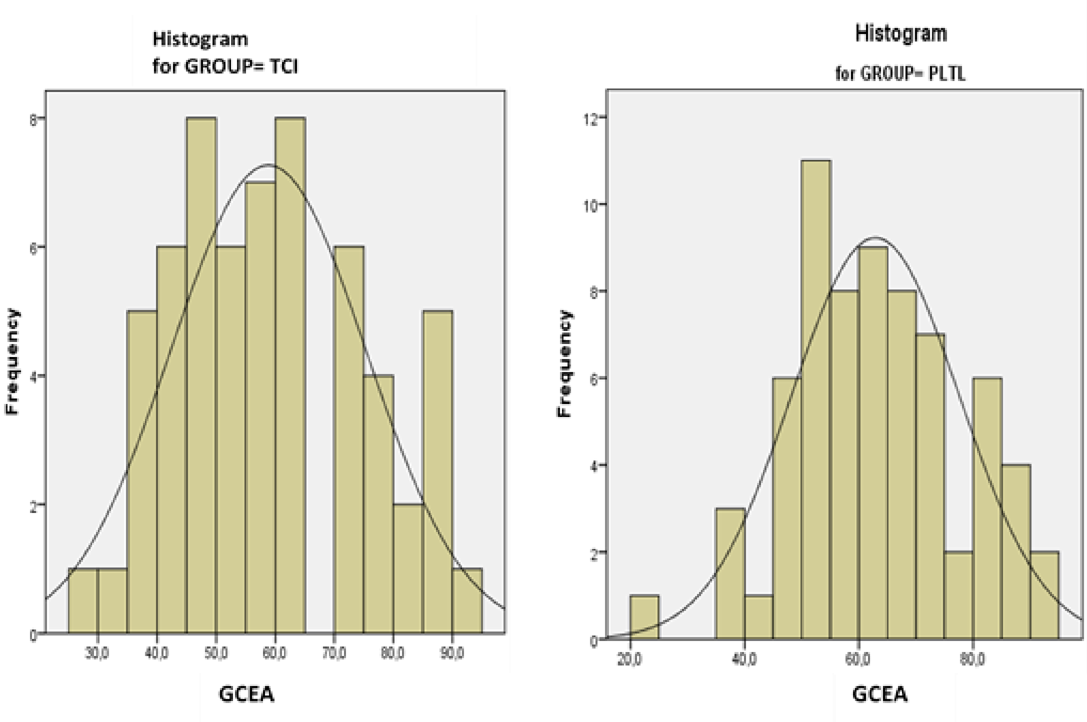


*Figure 4.4.* Histograms of the GCEA score in terms of treatment groups

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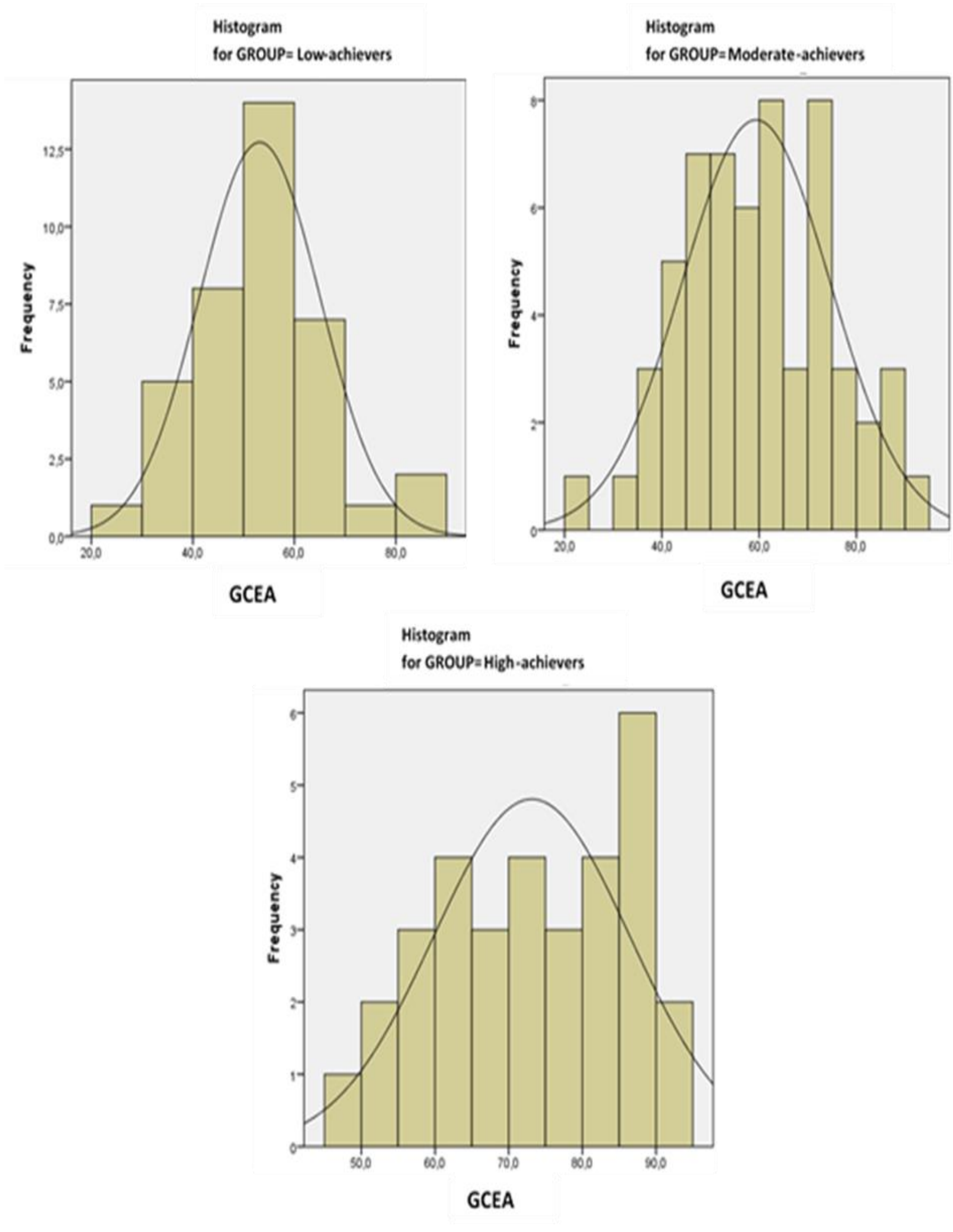



*Figure 4.5* Histograms of the GCEA score in terms of the academic abilities of students

When the histograms were examined for each IV, it could be inferred that they were normally distributed. Therefore, it was concluded that the assumption of normality was satisfied.

#### 4.4.2.3. Homogeneity of variance

The homogeneity of variance assumption means that the samples have a population of equal variances (Pallant, 2011). In other words, it refers to the similarity in the variability of the scores for each group. Levene's test of equality of variance was used to check this assumption. Since the sig. value was larger than .05 [$F$ (5, 122) =.927 $p$ = .466], there was no violation of this assumption. Therefore; the homogeneity of variance assumption was also met.

### 4.4.3. Results of Two-Way Between-Group ANOVA

After satisfying all assumptions, two-way between-groups Analysis of Variance (ANOVA) was performed with two independent variables (treatments and academic ability levels) and one dependent variable (GCEA). The results of two-way between-groups ANOVA analysis were investigated to test the null hypotheses from 2.1 to 2.6.

#### 4.4.3.1. Null Hypothesis 2.1

The fifth null hypothesis that was investigated in this study was "There is no statistically significant main effect of PLTL and TCI on population means of general chemistry exam achievement scores of undergraduate engineering students."

Based on the results of two-way ANOVA in Table 4.16, general chemistry exam achievement (GCEA) of freshman engineering students did not differ statistically in terms of the treatment groups ($F$ (1, 122) = 3.56, $p$ =.062]. This means that the null hypothesis 2.1 was failed to reject. Although PLTL group students (M=62.88, SD=14.71) had higher mean scores of the GCEA than TCI group students (M=58.83, SD=16.47), it could be inferred that engineering students in both TI and PLTL group statistically had almost equal exam achievement in general chemistry concepts regardless of the treatment.

Table 4.16. *Two-way ANOVA results of GCEA with treatment and academic abilities factors*

| Source | Sum of Squares | df | Mean Square | F | p | Partial $\eta^2$ |
|---|---|---|---|---|---|---|
| Treatment | 628.76 | 1 | 628.76 | 3.56 | .062 | .028 |
| Academic ability | 7912.69 | 2 | 3956.34 | 22.38 | .000 | .268 |
| Treatment*Academic ability | 1280.69 | 2 | 640.35 | 3.62 | .030 | .056 |
| Error | 21571,24 | 122 | 176,813 | | | |
| Total | 506935,00 | 128 | | | | |

#### 4.4.3.2. Null Hypothesis 2.2

This study examined the sixth null hypothesis that was "There is no statistically significant main effect of academic abilities (low, moderate and high) of undergraduate engineering students on population means of their general chemistry exam achievement scores".

When the main effects were examined, the results in Table 4.16 designated that there was a statistically significant mean difference in students' GCEA with respect to the academic abilities of the engineering students ($F(2, 122)=22.38$, $p=.000$). Therefore, the null hypothesis 2.2 was rejected and this difference could be attributed to the difference in achievement levels of students. The partial eta squared value was .268 which was a large effect size (Cohen, 1988). It was concluded that 26.8% of the total variance in GCEA was explained by the academic ability factor. Statistically and practically significant results were detected.

#### 4.4.3.3. Null Hypothesis 2.3

The seventh null hypothesis of the study presented that "There is no statistically significant effect of interaction between PLTL and TCI groups and academic abilities (low, moderate and high) of undergraduate engineering students on population means of their general chemistry exam achievement scores."

As it was seen from Table 4.16, evidence was found to reject the null hypothesis 2.3 due to the statistically significant treatment by academic ability interaction effect at the 0.05 significance level ($F(2,122)=3.62$, $p=.030$). It could be implied that the magnitude of the effect size (Partial $\eta^2=0.056$) was medium for the interaction effect factor, and approximately 5.6% of the variance in GCEA could be associated with the interaction between treatment and academic ability. As a result, there were both statistical significance and practical significance.

Furthermore, Figure 4.6 showed the line graph of GCEA score in terms of academic abilities as categorized in two different treatments and pointed out that there was an interaction between academic ability levels and treatments of PLTL and TCI in terms of GCEA scores of the students.

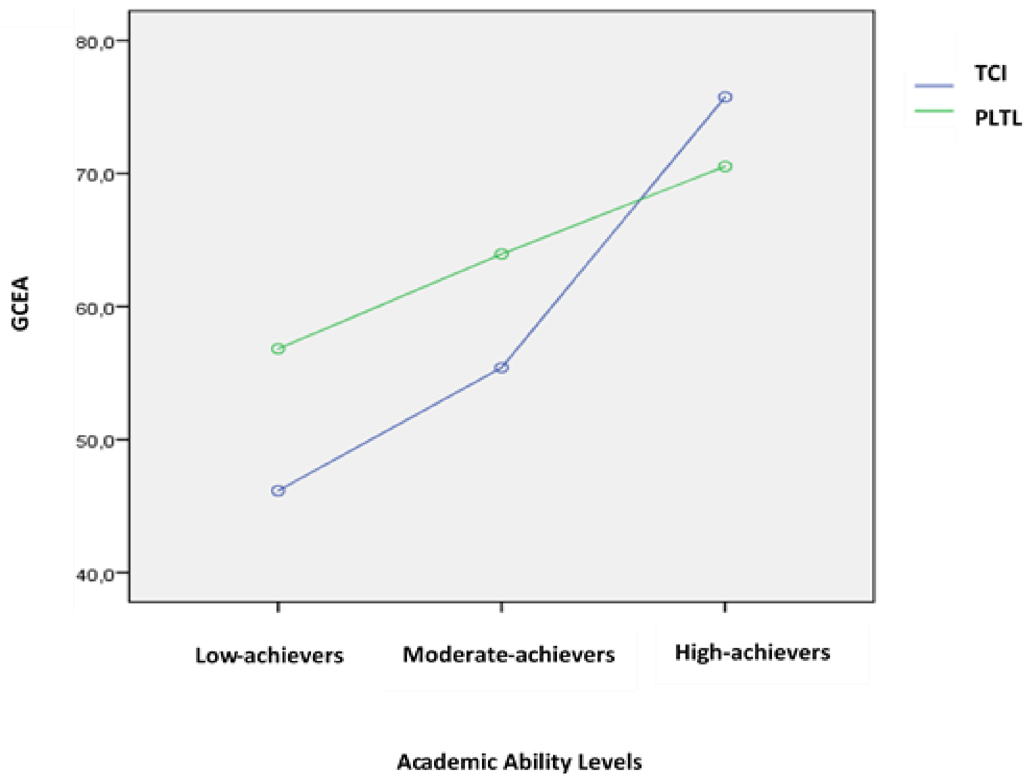



*Figure 4.6.* Line graph showing the interaction of subgroups of academic ability level factor with treatment

Because of this significant interaction, interpreting the main effects of factors in Table 4.16 that indicated the result of the two-way ANOVA was likely to be deceiving (Pallant, 2011). Thus, instead of performing a Post-Hoc test to compare the means of students with different levels of academic ability group, simple main effects were performed by using the one-way between-group ANOVA technique to learn whether the low, moderate and high levels of academic ability moderate the relationship between treatment factor and GCEA scores of the engineering students.

#### 4.4.3.4. Null Hypothesis 2.4

The eighth null hypothesis of this study was "There is no statistically significant population mean difference in general chemistry exam achievement scores of low achievers in PLTL and TCI groups."

According to the one-way ANOVA results in Table 4.17, a statistically significant difference between TI and PLTL students was found for the low achievers' group in favor of the PLTL students [$F(1, 36) = 8.18$, $p = .007$]. In light of this information, the null hypothesis 2.4 was rejected and it could be said that the low achievers in the PLTL group ($M = 56.82$, $SD = 10.91$) had better GCEA score compared to those in the TCI group ($M = 46.15$, $SD = 10.89$).

The values of the eta squared ($\eta2$) also indicated a large effect size of 0.185 for the low-achieving students' group (Cohen, 1988). The treatment accounts for 18.5% variability in GCEA for the low-achievers.

Table 4.17. *One-Way ANOVA results of GCEA score for low-achievers*

| **Academic ability** | **Source** | **Sum of Squares** | **df** | **Mean Square** | **F** | **p** | **$\eta^2$** |
|---|---|---|---|---|---|---|---|
| Low-achievers | Between groups | 973.01 | 1 | 973.01 | 8.18 | .007 | .185 |
| | Within groups | 4280.63 | 36 | 118.91 | | | |
| | Total | 5253.64 | 37 | | | | |

#### 4.4.3.5. Null Hypothesis 2.5

The ninth null hypothesis was "There is no statistically significant population mean difference in general chemistry exam achievement scores of moderate achievers in PLTL and TCI groups."

In order to analyze this hypothesis, Table 4.18 was examined. For the moderate-achievers, a statistically significant result was found in the GCEA scores of PLTL and TCI groups (F (1, 56) = 4.90, p = .080). It was, therefore, reasonable to conclude that the null hypothesis 2.5 could be rejected. In other words, moderate achieving students of the PLTL group (M = 63.94, SD = 16.32) were more successful in the general chemistry exam than those of the TCI group (M = 55.40, SD = 13.06). Another finding from this analysis was the partial eta squared reported as 0.08 which was equal to the medium effect size (Cohen, 1988). The proportion of variance in GCEA scores associated with the treatment was 8% for the moderate-achievers. Based on this effect size, the differences derived from the treatment of PLTL and TCI indicated a practical significance too.

Table 4.18. *One-Way ANOVA results of GCEA score for moderate-achievers*

| Academic ability | Source | Sum of Squares | df | Mean Square | F | p | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| Moderate-achievers | Between groups | 1052.78 | 1 | 1052.78 | 4.90 | .031 | .080 |
| | Within groups | 12040.38 | 56 | 215.01 | | | |
| | Total | 13093.16 | 57 | | | | |

#### 4.4.3.6. Null Hypothesis 2.6

The tenth null hypothesis of this study was "There is no statistically significant population mean difference in general chemistry exam achievement scores of high achievers in PLTL and TCI groups."

The difference in the mean of GCEA score between the PLTL group and TCI group was not statistically significant for the high achievers [F (1, 30) = 1.25, p = .273] as indicated in Table 4.19 so it was failed to reject the null hypothesis 2.6. This results also noted that PLTL (M = 70.53, SD = 13.72) makes no significant difference for high achievers in the understanding of general chemistry concepts over TCI (M = 75.75, SD = 12.72). The partial eta squared value determined as 0.04, showing a small effect size. Neither a statistical significance nor practical significance was found in terms of high achievers.

Table 4.19. *One-Way ANOVA results of GCEA score for high-achievers*

| Academic ability | Source | Sum of Squares | df | Mean Square | F | p | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| High-achievers | Between groups | 217.88 | 1 | 217.88 | 1.25 | .273 | .040 |
| | Within groups | 5250.23 | 30 | 175.01 | | | |
| | Total | 5468.12 | 31 | | | | |

### 4.5. Assessment of Quizzes in the Workshops

Except for the first workshop, a quiz including some individual assessment problems was implemented at the end of each workshop. Thus, engineering students took a total of five quizzes. Their results were presented in frequency and percent of students with regard to workshop number, corresponding concepts, and question type in Table 4.20.

When examining this table concerning Workshop 2, it was seen that one open-ended problem was given to the students regarding basic concepts of chemical bonding. Half of the students who attended workshop 2 (52%) could not either provide any scientifically accurate response or link to the response to that problem while 29% of them represented scientifically accurate results but not link them to the problem. However, 19% of these students provide a fully correct answer. It could be inferred that most students did not benefit from that workshop.

In Workshop 3, one open-ended problem and two multiple choice questions were given to the students about the concepts of molecular geometry and bonding theories, and gases.

Table 4.20. *The frequency and percentage of students in terms of their performance in quizzes*

| | | | Frequency (N) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Open-ended | | | Multiple choice/ short answer | | |
| Workshop | Concepts | Questions | No credit | Half-credit | Full credit | No credit | Full credit | Total |
| Workshop 1* | Electronic structure of atoms/ Periodic properties of the elements | | - | - | - | - | - | - |
| Workshop 2 | Basic concepts of chemical bonding | Q1 | 33 (52%) | 18 (29%) | 12 (19%) | | | 60 |
| Workshop 3 | Molecular geometry and bonding theories | Q1 | 37 (52%) | 23 (32%) | 11 (16%) | | | 70 |
| | Gases | Q2 | | | | 26 (37%) | 44 (63%) | 70 |
| | | Q3 | | | | 43 (61%) | 27 (39%) | 70 |
| Workshop 4 | Liquids and intermolecular forces | Q1 | | | | 8 (11%) | 62 (89%) | 70 |
| | Solids and modern materials | Q2 | | | | 21 (30%) | 49 (70%) | 70 |
| Workshop 5 | Thermochemistry | Q1 | 35(59%) | 3 (5%) | 21 (36%) | | | 59 |
| | Thermodynamics | Q2 | | | | 20 (34%) | 39 (66%) | 59 |
| Workshop 6 | Chemical kinetics | Q1 | 11 (25%) | 8 (18%) | 25 (57%) | | | 44 |
| | | Q2A | | | | 8 (18%) | 36 (82%) | 44 |
| | | Q2B | | | | 36 (82%) | 8 (18%) | 44 |
| | | Q2C | | | | 12 (27%) | 32 (73%) | 44 |
| | | Q2D | | | | 18 (41%) | 26 (59%) | 44 |
| | | Q2E | | | | 33 (75%) | 11 (25%) | 44 |
| | | Q2F | | | | 21 (48%) | 52 (63%) | 44 |
| | | | | | | 21 (43%) | 28 (57%) | |

Note: *No quiz was implemented that week

Almost half of them (48%) tried to offer a scientifically accurate answer or link to the response to problem 1 related to the concepts of molecular geometry and bonding theories. 63% and 39% of the students also properly solved problems 2 and 3 about gases concept respectively.

For the individual assessment problems in the quiz of Workshop 4, only 11% percent of the students could not answer correctly problem 1 related to the liquids and intermolecular forces and 21% of them did not solve problem 2 related to the solid and modern materials properly. It was possible to say that students either indicated an improvement from Workshop 2 to Workshop 4 or was good at the corresponding concepts.

In Workshop 5, fully accurate, partially accurate and no accurate response of the thermochemistry problem were taken from 36%, 5% and 59% of the students respectively; on the other hand, accurate and no accurate response of the thermodynamic problem was taken from 66% and 34% of the students, respectively Half of the students had some difficulties in understanding of the thermochemistry concepts. Regarding the thermodynamics, the percent of students experiencing this difficulty has decreased to 34 %.

Finally, one open-ended problem was offered to the students regarding the chemical kinetics concept and 25% of them could not provide any scientifically accurate response or link to the response to the problem while 18% represented scientifically accurate results but not link them to the problem. Nevertheless, 57 % provide a fully correct response. Besides, six short answer type questions were asked and it was seen that students have difficulty in solving only two of them (Q2B, 8%, and Q2E-25%).

When the results were examined generally, it could be said that the topic of the workshop where students were the most successful was liquids and intermolecular forces (89%), and where students were the least successful was molecular geometry and bonding theories (16%). After results were presented, peer leaders provided the necessary guidance to the students about their performance in the quizzes.

## 4.6. PLTL Model Evaluation

### 4.6.1. Researchers' Experiences

To evaluate the implementation of the PLTL model, CCR was completed by two researchers. Inter-rater reliability was used to identify the degree of agreement among these researchers. There have been many different methods to measure inter-rater reliability. But if there were two raters, it was generally measured by percent agreement, which is calculated as the number of agreement scores of raters divided by the total number of scores. The percent agreement was determined as 93 %. This means that researchers agree with each other almost all criteria except two. After discussing the discrepancies between two researchers, they resolved this disagreement and reached eventually a 100% consensus.

When we examined the CCR in terms of components, all the requirements related to the integral to the course, workshop materials and leader components were completed fully. About the faculty involvement component, the faculty member generally managed the PLTL workshops and engage in the leader training, and workshop material development in a typical PLTL study. However, in this intervention, the role of the faculty was to attend the lecture hours and check the workshop materials whether they were consistent with the chemistry concepts talked in the lecture hours. Instead of the course professor, two educational specialists supervised and trained the peer leaders, prepared the workshop materials, and organized all the arrangements. Thus, the criteria regarding the faculty involvement in the training sessions and meeting with leaders regularly only were met partially. But this situation did not form any threat to the implementation of PLTL. After examining the criteria of organizational arrangements, it was realized that the frequency and time of workshops are problematic so the requirement was completed partially. The workshops were conducted biweekly and last generally 70 minutes. Therefore, this was not consistent with the requirements stated by Gafney and Varma-Nelson (2008). Besides, in terms of administrative support criteria, we did not provide any funding for peer leaders.

Instead, Atılım University Sharing the Success Programme Certificate was provided as a motivation encouragement.

### 4.6.2. Students' Experiences

In this study, 26 students participated in all workshops filled Student Survey (SS). The results were given with regard to the percentages of agree, neutral and disagree responses in Table 4.21. Responding to items 2, 3, 6, and 8 revealed that most of the engineering students found PLTL workshops helpful for their understanding of general chemistry concepts. At least 65 percent of them agreed on any of these items. Responding to items 1 and 4 which was related to the integration of workshops to the course, students showed a high agreement with those more than 80 percent.

When the negative statements (items 12, 13, 14, and 17) were analyzed, it was seen that most of the students disagreed with those and benefited from the workshops. In addition, according to the items 15, 16, and 19 regarding the workshop leader, more than 70 percent of students agreed on the advantage of peer leader on their learning.

In general, students thought that the workshop environment provided many benefits such as asking questions, interacting with peers, and participating in problem-solving. Item 9, 10, 11, 18, and 20 were rated with a 70 percent agreement for those advantages. Responding item 21 showed that more than 50 percent of the students joined study groups related to other courses.

When the items about the materials used in the workshops were examined in Table 4.22, more than 70 percent of the students agreed that the materials had the characteristics of good problems which were well connected with the lecture, challenging, developed to review fundamentals, useful for group work, motivational and useful for reinforcing concepts.

Table 4.21. *Student evaluation about PLTL model*

| Items | | % Agree | % Neutral | % Disagree |
|---|---|---|---|---|
| 1 | The workshops are closely related to the material taught in the lectures. | 100 | | |
| 2 | Workshops help me do better on tests. | 96 | | 4 |
| 3 | Interacting with the workshop leader increases my understanding. | 96 | 4 | |
| 4 | The workshop materials are helpful preparation for exams. | 81 | 11 | 8 |
| 5 | Workshop materials are more challenging than most textbook problems. | 77 | 19 | 4 |
| 6 | I believe that the workshops are improving my grade. | 73 | 23 | 4 |
| 7 | I regularly explain problems to other students in the workshops. | 54 | 35 | 11 |
| 8 | Interacting with the other group members increases my understanding | 65 | 27 | 8 |
| 9 | I would recommend workshop courses to other students. | 85 | 15 | |
| 10 | In the workshops, I am comfortable asking questions when I do not understand something. | 92 | 4 | 4 |
| 11 | The lecturer encourages us to participate in the workshops. | 81 | 15 | 4 |
| 12 | The workshops are often dominated by one or two students. | 40 | | 60 |
| 13 | Noise or other distractions make it difficult to benefit from the workshops. | 35 | 15 | 50 |
| 14 | Students who are uninterested or unmotivated make it difficult for others to benefit from the workshops. | 29 | 18 | 53 |
| 15 | I felt comfortable with the workshop leader. | 92 | 8 | |
| 16 | The workshop leader is well prepared. | 77 | 15 | 8 |
| 17 | I am uncomfortable asking questions in the lecture. | 27 | 11 | 62 |
| 18 | The workshops are a big help in solving problems. | 81 | 11 | 8 |
| 19 | I would like to be a workshop leader in the future. | 73 | 8 | 19 |
| 20 | In the workshops, I enjoyed interacting with the other students. | 81 | 11 | 8 |
| 21 | The workshop experience led me to join formal or informal study groups related to other courses. | 58 | 34 | 8 |

Table 4.22. *Student evaluation of workshop materials*

| | The workshop materials are | % Agree | % Neutral | % Disagree |
|---|---|---|---|---|
| 23 | Well connected with the lecture | 88 | 12 | |
| 24 | Challenging | 73 | 19 | 8 |
| 25 | Developed to review fundamentals | 92 | 8 | |
| 26 | Useful for group work | 88 | 12 | |
| 27 | Motivational | 92 | 8 | |
| 28 | Helpful for individual study | 19 | | 81 |
| 29 | Useful for reinforcing concepts | 77 | 23 | |

The responses given in Table 4.23 indicated that most time of the workshops devoted to the responding of leaders to student questions and working of students on problems in pairs or small groups. Moreover, presenting the ideas and methods by the leader (67%) and presenting the solutions by students (77%) were allowed most of the time as well. However, only 12 percent of the students stated that most of the time they worked on problems alone.

Table 4.23. *Students' evaluation in terms of the time devoted to the activities*

| | | a small amount | a moderate amount | most |
|---|---|---|---|---|
| 30 | The workshop leader presents ideas and methods | 11 | 22 | 67 |
| 31 | The leader responds to student questions. | | 12 | 88 |
| 32 | Students work on problems in pairs or small groups. | | 12 | 88 |
| 33 | Students work on problems alone. | 50 | 38 | 12 |
| 34 | Students present solutions. | 12 | 11 | 77 |

### 4.6.3. Peer Leaders' Experiences

12 peer leaders completed the Leader Survey (LS) to reflect upon their experiences. It was analyzed in terms of three categories; organizational arrangements, materials, and leaders as described in Table 4.24.

Table 4.24. *Peer leaders' evaluation about PLTL model*

| | Organizational Arrangement | | | Materials | | | | Leaders | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Leader | Time | Length | Average group size | Relation to tests | Challenge | Difficulty level | Time for training | Teaching tools | Peer having difficulty | Training and supervision |
| LD 1 | Once every two weeks | 70 min | 4(4) | Mostly | Mostly | Moderate | 2 h. | Pair problem solving | Repeat and explain deeply | Subject matter knowledge/ teaching methods/student needs |
| LD 2 | Once every two weeks | 70 min | 4(4) | Mostly | Mostly | Moderate | 3 h. | Pair problem solving | Diagnose and eliminate the problem | Subject matter knowledge/ teaching methods/student needs |
| LD 3 | Once every two weeks | 70 min | 4(6) | Some of them | Mostly | Moderate | 3 h. | Round-robin | Give individual support | Subject matter knowledge/ teaching methods/leadership skills |
| LD 4 | Once every two weeks | 65 min | 5(3) | Mostly | Some of them | Some harder Some easy | 4 h. | Pair problem solving | Give clues or hints | Subject matter knowledge/ teaching methods |
| LD 5 | Once every two weeks | 60 min | 5(4) | Mostly | Mostly | Moderate | 3 h. | Pair problem solving | Give clues or hints. | Subject matter knowledge/ teaching methods/Communication skills |
| LD 6 | Once every two weeks | 60 min | 5(4) | Mostly | Mostly | Moderate | 3 h. | Round-robin/ Flowchart | Repeat and explain deeply | Subject matter knowledge/ teaching methods/ Group dynamics |

Table 4.24. *(Continued)*

| | Organizational Arrangement | | | Materials | | | | Leaders | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Leader | Time | Length | Average group size | Relation to tests | Challenge | Difficulty level | Time for training | Teaching tools | Peer having difficulty | Training and supervision |
| LD 7 | Once every two weeks | 60 min | 5(3) | Some of them | Mostly | Moderate | 3 h. | Reading and Writing | Repeat again clearly | Subject matter knowledge/ Group dynamics |
| LD 10 | Once every two weeks | 65 min | 4(4) | Mostly | Mostly | Moderate | 2 h | Round-robin /Discussion | Give individual support | Subject matter knowledge/ teaching methods/Communication skills |
| LD11 | Once every two weeks | 70 min | 5(3) | Mostly | Mostly | Moderate | 3 h. | Questioning | Give individual support | Subject matter knowledge/Student-centered methods |
| LD 12 | Once every two weeks | 60 min | 4(4) | Some of them | Mostly | Some harder Mostly Moderate | 3 h. | Flowcharts | Encourage for asking questions | Subject matter knowledge/ Group dynamics |
| LD 13 | Once every two weeks | 70 min | 4(4) | Mostly | Some of them | Moderate | 3 h. | Reading and Writing Discussion | Repeat and explain deeply | Subject matter knowledge |
| LD 14 | Once every two weeks | 70 min | 4(5) | Mostly | Some of them | Some harder Some easy | 4 h. | Round-robin | Repeat again clearly | Subject matter knowledge |

Note: The values in the brackets show the preferred number of students per group. LD8 and LD9 did not complete the study

Regarding the organizational arrangement category, peer leaders reported the structure of workshops 60-70 min workshop once every two weeks with 4 to 5 students in their teams.

They explained that the number of students attending regularly was around 4 or 5 although the group size was six or eight. Besides, more than 50% of the leaders preferred to study with four students per group.

With regard to the materials category, most leaders stated that the workshop materials were good preparation for the exams and included challenging team learning problems. For example, one leader pointed out: "*They are good and helpful for the test because they are proper examples to understand the concepts of general chemistry...they were intriguing and challenging problems and most certainly push students to think critically*." Additionally, 75 percent of the leaders expressed that the difficulty level of the problems was moderate and appropriate for their level and group work. However, the other 25 % of students claimed that some questions were easy while some of them were difficult for students.

As it could be seen from Table 4.25, the leaders also evaluated the materials. According to the evaluation made by more than 65 percent of them, the workshop materials were well connected with the lecture, challenging, developed to review fundamentals, useful for group work, motivational and useful for reinforcing concepts. On the other hand, only 50 % of the leaders found them helpful for individual study.

Table 4.25. *Leader evaluation of workshop materials*

| **The workshop materials are** | | **% Agree** | **% Neutral** | **% Disagree** |
|---|---|---|---|---|
| 20 | Well connected with the lecture | 84 | 8 | 8 |
| 21 | Challenging | 67 | 25 | 8 |
| 22 | Developed to review fundamentals | 68 | 16 | 16 |
| 23 | Useful for group work | 84 | 16 | - |
| 24 | Motivational | 68 | 16 | 16 |
| 25 | Helpful for individual study | 50 | - | 50 |
| 26 | Useful for reinforcing concepts | 84 | 16 | - |

Apart from the workshops time, most leaders generally spent at least 3 hours per week on the preparation of workshops. They said that they used different teaching methods or strategies depending on the concepts of the workshops. More specifically, pair problem-solving and round-robin was reported as the most frequently used strategies by the leader. For example, one leader explained how she applied the round-robin strategy in the workshop:

> "*I have four students and four steps to solve the problems so I assigned each step to each member of the group. Student1 solved step1 by explaining it to the other members and if everyone agreed with the solution, student2 did step 2. The group continued like that and reached the final solution…. I guided them when they had problems*."

When the activities taking place in the workshops were asked, leaders summarized and rated them in Table 4.26. According to 92 % of the leaders, students mostly work on problems in pairs or small groups. Furthermore, more than 70 % of peer leaders stated that in a large amount of workshop time, leaders presented ideas and methods while students worked on the solutions to the problems. If there were students having problems and difficulty in comprehending the solutions, all leaders provided guidance and used some strategies to help them such as giving individual support, giving clues or hints, encouraging for asking questions as well as diagnosing and eliminating the problem and repeating and explaining deeply.

Table 4.26. *Leader evaluation in terms of the time devoted to the activities*

| | | **a small amount** | **a moderate amount** | **most** |
|---|---|---|---|---|
| 10 | The workshop leader presents ideas and methods | - | 16 | 84 |
| 11 | The leader responds to student questions. | 8 | 34 | 58 |
| 12 | Students work on problems in pairs or small groups. | - | 8 | 92 |
| 13 | Students work on problems alone. | 42 | 42 | 16 |
| 14 | Students present solutions. | - | 24 | 74 |

Regarding training and supervision subtopics, leaders specified areas such as subject matter knowledge, teaching methods, student needs, leadership skills, group dynamics, and communication skills. To illustrate, one leader clarified that:

> *"Although we usually spend our time discussing the team learning problems, we talked about the student-centered methods and strategies which were suitable for collaborative work... We mentioned how we could communicate students to learn their needs and to support them to participate in the activity."*

### 4.7. Summary of the Results

The key points attained from the results of the study could be summarized as follows;

- TCI group students had a high level of prior chemistry knowledge than the PLTL group.
- Both groups had a low conceptual understanding of general chemistry concepts before training.
- TCI group students were more anxious than PLTL students in general at the outset of the study.
- PLTL group students were more anxious in social situations compared to the TCI group students at the outset of the study.
- The scores of the College of Engineering Entry Scores and the scores of State-Trait Anxiety Inventory-Trait Anxiety Scale, as well as pretest scores of General Chemistry Concept Test, and pretest scores of State-Trait Anxiety Inventory-State Anxiety Scale were taken as covariates in this study.
- There was a statistically significant effect of PLTL and TCI on collective dependent variables of posttest scores of conceptual understanding and posttest scores of state anxiety and posttest scores of social anxiety in general chemistry.
- PLTL group students indicated greater improvement in conceptual understanding in general chemistry than TCI group students.

- PLTL model was better to alleviate the state anxiety of undergraduate engineering students than TCI.
- TCI group students had a lower level of social anxiety than the PLTL group students. PLTL model did not reduce the social anxiety of undergraduate engineering students than the TCI did.
- Although the main effect of treatment was not significant, PLTL group students outperformed TCI group students on general chemistry exam achievement.
- There were statistically significant mean differences in engineering students' general chemistry exam achievement with respect to their academic abilities.
- There was a significant interaction effect between treatment and academic ability on undergraduate engineering students' exam achievement in general chemistry concepts
- The low achievers in the PLTL group had better exam achievement in general chemistry compared to those in the TCI group.
- PLTL model was better to enhance exam achievement in general chemistry concepts for moderate-achievers.
- It was found a similar improvement in general chemistry exam achievement for the high achievers of the PLTL group and TCI group.

# CHAPTER 5

# DISCUSSION, IMPLICATIONS, RECOMMENDATION, AND CONCLUSION

*"None of us is as smart as all of us."*

*(Ken Blanchard)*

It was examined under the four sections. First, the results of the study were discussed and interpreted in the light of the related literature. Next, the possible implication and recommendations for further study were presented. In the third section, the validity and possible threats to experimental validity were deliberated. Finally, the conclusion of the study was offered.

## 5.1. Discussion of the Results

The current study got inspired by the positive influences of PLTL as a widely spreading model implemented in higher education in STEM courses in the US. The need for a new pedagogy to teaching and learning for the college level in Turkey provoked this study in order to firstly examine the effectiveness of Peer-Led Team Learning (PLTL) over traditional college instruction (TCI) on the undergraduate engineering students' conceptual understanding, state anxiety, and social anxiety in general chemistry course and secondly to explore its effectiveness over TCI on their general chemistry exam achievement with respect to their different academic abilities. In this regard, a quasi-experimental pretest-posttest control group design was applied in one-semester General Chemistry (GC) course for engineering students to investigate the changes in the study constructs resulted from the intervention. The first section of the course was determined as the control group (CG) and the second section of the course was determined as the experimental group (EG). During fourteen weeks, the participants of EG were involved in PLTL workshops while the participants of CG received TCI.

PLTL group students attended two 50-minutes lecture sessions every week, three-hour laboratory sessions biweekly, and 70-minutes PLTL workshop sessions biweekly. In the other weeks in which PLTL workshops were not held, they joined three 50-minutes lecture sessions. Gafney's six essential principles were taken as a theoretical framework for the proper implementation of PLTL workshops (2001a). After discussing the particular concept in the lecture hours, students met with their trained team leader for their workshop sessions at the student study hall. In the peer-led chemistry workshops, peer leaders started with the discussion of individual review problems and then guided students to work on team learning problems by using different teaching methods and strategies discussed in the leader training sessions. They finally gave a quiz to students in their team to solve individually after learning how to solve challenging problems. On the other hand, TCI group students attended three 50-minutes lecture sessions every week and three-hour laboratory sessions biweekly, but they did not participate in PLTL chemistry workshops. The strategies or methods used in the TCI group appeared to be mostly lecturing, occasionally discussions between the professor and a few students and questioning performed by the professor. After the course professor presented the chemistry concepts in the course book, she solved some questions. However, students did not either involve in the problem-solving process or discuss these solutions with each other.

After the treatment, the results of MANCOVA and ANOVA provided some pieces of evidence about the effectiveness of PLTL over TCI in general chemistry. The discussion of results was categorized under two following sections: the undergraduate engineering students' conceptual understanding, general chemistry exam achievement by academic performances; as well as the undergraduate engineering students' state anxiety, and social anxiety by anxiety experiences.

### 5.1.1. Discussion about Academic Performances

After controlling the pre-existing differences in state anxiety, trait anxiety and college of engineering entry scores as well as pre-achievement on general chemistry concept test, statistical and practical significances in undergraduate engineering students' conceptual understanding (medium effect of 0.223) were found between the PLTL group and the TCI group in favor of PLTL. The findings regarding their conceptual understanding indicated that the students in the PLTL group performed higher in the General Chemistry Concept Test than those in the TCI group. Thus, it could be inferred that the PLTL model is more effective than TCI in the improvement of undergraduate engineering students' conceptual understanding in general chemistry.

This finding of the study is in line with the previous studies in the literature regarding that the PLTL model is able to help students develop their conceptual learning in the general chemistry in many ways that TCI cannot (Bramaje & Espinosa, 2013; Cracolice & Deming, 2004; Gafney & Varma-Nelson, 2008; Varma-Nelson & Coppola, 2005). The distinctive structure of the PLTL model may provide plausible explanations about the effectiveness of PLTL instruction in improving students' conceptual understanding. The PLTL workshops create an active learning environment where students can develop many skills and take more responsibility for their learning (Cracolice & Deming, 2004). More specifically, PLTL students engage with the team-learning problems, ask many questions to each other and peer leader, communicate and collaborate with each other, work out their solutions individually, with pair or in a group, discuss and analyze their ideas about the chemistry concepts and principles. Involving students in such a process in the active learning environments is likely to support students to evaluate their understandings about chemistry concepts, develop a deeper understanding and improve meaningful learning by retaining these concepts (Duit & Treagust, 2003; Duit et al., 2008).

Furthermore, students have an opportunity to develop their critical thinking, logical reasoning, creative thinking, analytical skills, communication skills, reasoning ability, and problem-solving skills within the PLTL workshop. All these skills might have contributed to the positive influence of PLTL on students’ conceptual understanding of chemistry concepts. For example, a significant direct relationship between students’ reasoning ability and their conceptual problem-solving ability in general chemistry was found by Deming, Ehlert, and Cracolice (2003). According to the study of Cracolice and Deming (2004), PLTL students, who are challenged to use their problem-solving skills, critical thinking skills, and reasoning abilities in workshops, could develop strong conceptual understanding. Consequently, PLTL is a prominent instructional model for a large class that incorporates many active learning strategies such as discussions, collaborative problem solving, and small-group critical analysis.

The theoretical framework of the PLTL was discussed in the previous section of this study based on the expanded view of the Zone of Proximal Development (van Lier, 1996, 2004) by the researcher. This view can explain the learning process in PLTL in a way that students are involved in the social interactions with peer leader (assistance from more knowledgeable ones, MKO) through scaffolding and numerous interactions with other team members through collaboration (interaction with academically equal peers), through teaching (interaction with less capable peers) or work alone through internalization. In this study, each team had a heterogeneous structure including students with different abilities and a peer leader to form such a ZPD environment. Consistent with the research studies related to the peer instruction (Mazur, 1997) and peer-assistant learning (Topping & Stewart, 1998) supporting the significance of using peer in students’ learning and understanding of a material or a concept, this important characteristic of PLTL concerning using peers and peer leader as learning resources might be a reason of this significant difference in conceptual understanding among the groups.

Despite its significant effect on students' conceptual understanding, the difference in mean scores of PLTL and TCI did not appear high so much as expected. The reason why this less effective result was obtained might be attributable to the chemistry workshops’ duration. In the current study, the PLTL workshops were conducted as took biweekly 70 minutes. On the other hand, Gafney and Varma-Nelson (2008) claim the ideal time for the workshops as weekly 90–120 minutes. They also express that the PLTL workshops performed in less time rather than in this ideal length have not been an effect on students' academic performance as much as reported in the literature.

When the PLTL studies were examined in terms of the duration, it was seen that some studies including workshops with weekly 60-65 minutes (Lyon & Lagowski, 2008; Preszler, 2009) indicated significant development in their students' course performances. In the light of such results of PLTL studies, Wilson and Varma-Nelson (2016) support that workshops can have flexible durations. In order to investigate the influence of PLTL on students' academic achievement with respect to the duration of an average workshop session, Zha, Estes, and Xu (2019) conducted a meta-analysis study by examining twenty-eight studies published in between 1993 and 2017. This study reported no statistical significance across the wide range of workshop duration from 50 to 180 minutes. Among all duration variation, only students participating in 60-minute sessions performed better than students participating in 120-minute sessions. Although no evidence was provided that shorter sessions of PLTL lead to an improvement in students' performances than longer sessions, shorter and more frequent class sessions were often preferred by students (Reardon, Payan, Miller & Alexander, 2008). Consequently, if PLTL workshop sessions could be performed each week even if its duration was not changed, it would be likely to increase students' understanding of conceptual knowledge.

In addition to the effect of the treatments on conceptual understanding, this study examined the significant impact of PLTL and TCI on general chemistry exam achievement (GCEA) scores with respect to different academic ability groups of engineering students. Unlike a remedial or a transition program, the PLTL model in this study was designed to improve the academic performance of all engineering students. However, within the PLTL group, high achieving students obtained a statistically higher score in the general chemistry exam. Consistent with the other studies (Muller, Shacham, & Herscovitz, 2018; Stewart, Amar & Bruce, 2007), it was found that the PLTL model contributed more to students with higher academic abilities rather than other two groups of moderate and low achievers. This causes such a probable conclusion that there was a “good student effect” (Stewart, Amar & Bruce, 2007). More specifically, higher achievers or students who would be expected to perform better in general chemistry tend to outperform students who are academically underprepared. PLTL serves as a supporting and challenging team learning environment for engineering students with higher academic capabilities.

On the other hand, when investigating the question of “do all engineering students in the PLTL group significantly make more benefit compared to those in TCI?”, it appeared a different picture among groups. Unlike the study conducted by Muller, Shacham, and Herscovitz, (2018) showing no interaction between participation in the PLTL group and students with different academic abilities based on students’ quantitative thinking score, the findings of this study revealed that the effect of the treatment (PLTL vs TCI) on GCEA scores of engineering students was moderated by their academic ability levels. This interaction between treatment and academic ability led to conduct some further analysis. According to the results of these analyses, it was possible to say that the low and moderate achievers in the PLTL group were more successful in the general chemistry exam than counterparts in the TCI group but it was not so effective for the high achievers in terms of GCEA scores. This finding related to the engineering students with lower academic abilities matches the results seen in the study of Shields et al. (2012) who employed a transition program including extended-length recitations, regular recitations, peer-led team-learning (PLTL), and peer-mentoring groups to encourage underprepared undergraduate students for their performance in general chemistry. Their study noted that the PLTL program supported the underprepared students for improving their course performance.

Among the reasons why PLTL had a different effect on students with different academic abilities may be related to the fact that low and moderate achievers feel themselves belonging to a group. Snyder, Sloane, Dunk, and Wiles (2016) explain that students who instructed with group-oriented teaching methods might have a sense of being more accessible to the learning of scientific concepts and belonging to a group. On the contrary, they feel isolated and unfortunate if traditional methods such as TCI were used. This leads to a decrease in academic achievement. It is, therefore, possible that the low- and moderate-achievers may perceive a great means of belonging in their team compared to high achievers due to their needs of having more academic support from their peers to pass the course. Through team-learning environments of PLTL, these students get a greater achievement in their course.

This finding concerning the effectiveness of PLTL on students with low and moderate academic capabilities can be explained by the characteristics and nature of PLTL that represent active and collaborative learning environments supported by a team leader. Compared to traditional instruction in college science teaching, active and collaborative learning environments are more effective to support meaningful learning (Kuh, Cruce, Shoup, Kinzie, & Gonyea, 2008; Pascarella & Terenzini, 2005). Low and moderate achievers in the PLTL group are more likely to obtain the academic support required for their learning and problem-solving processes from their peers with different abilities and peer leaders. Thus, development in academic ability and of interpersonal and small group skills would be enhanced as a result of working with teams when considering their ZPD. It is reasonable to assume that the PLTL workshops learning environment provided many advantages for those students in terms of the workshop characteristics and its members' heterogeneous structure.

PLTL model was found ineffective for high-achievers despite its benefit for other ability groups. This pattern may be attributable to some motivational or personality factors. Students attended the PLTL workshop to take support for their understanding of the chemistry concepts and passing the class with a good grade. However, students do not have either a similar need for getting involved in activities of workshops or equivalent extrinsic and intrinsic motivation of getting a good grade. Some of the students, particularly high achievers, are more likely to have high confidence in their ability, which is directly related to their self-efficacy. Thus, they may have taught that they do not need any help from others and do not actively participate in or benefit from the problem-solving process. It is deliberated that the reason may also be explained with their preference to work either individually or collaboratively (Hancock, 2004). For those who show a solid preference to work independently, it would be enormously challenging for promoting their understanding of chemistry concepts and problems discussed in PLTL workshops. If their peer leaders did not give necessary motivational support to the high achievers and did not ask for their preferences about how they would like to solve team problems such as working alone, with pairs or in groups, some problems would be faced. The importance of the "motivational" construct in leader training was discussed by Tien, Roth, and Kampmeier (2004) with competence, autonomy, and relatedness aspects of intrinsic motivation. As a result, peer leaders might not regulate properly the motivational or personality elements while leading on the problem-solving process in workshops.

### 5.1.2. Discussion about Anxiety Experiences

This study reported a significant mean difference in the state anxiety of engineering students between PLTL and TCI groups with a medium effect (0.071) after controlling some prior differences in students. It was found that the students in the PLTL group had less state anxiety than those in the TCI group. This situation has provided evidence that the PLTL model is an effective pedagogical practice to alleviate undergraduate engineering students' anxiety. It is important to note that due to its influence on students' learning, the affective outcomes are as important as the cognitive outcomes of the students (Berberoglu & Demircioglu, 2000; Osborne, Simon & Collins, 2003). It can be deduced that students are more likely to feel more comfortable, relaxed, and calm in the workshops compared to lectures in which students get anxious, or stressed. Gafney and Varma-Nelson (2008) also strengthened this claim with the notion that PLTL workshops create supportive and small-group discussion environment for students where they could share their ideas easily because rather than speaking up in front of the whole class led by a course instructor or assistants, they speak in smaller peer groups under the supervision of a peer leader. Accordingly, with the help of its characteristics and nature, the PLTL model offers a feasible solution for students who became stressful and overwhelming in larger classes during their college education. Moreover, they could consider that the large lecture classes have the ability to hinder their understanding and academic performances in the sense that it is difficult to have close interactions with course professor or other students in these settings. It is, therefore, likely to get anxious due to the probability of being a failure. On the contrary, PLTL students no longer have a high level of either fear, nervousness, or anxiety because they peer leaders are able to easily reach their peer leaders while discussing the probable solutions of challenging problems (Gafney & Varma-Nelson, 2008).

This study also provides a counter-argument for a previous study of PLTL that reported a slight increase in students' anxiety and fear of chemistry during the semester in PLTL group, and no significant difference in anxiety between PLTL and the non-PLTL students participating one of the activities such as instructor-led review sessions or office hours, self-organized study group, and tutorials led by graduate or undergraduate students majoring chemistry (Chan & Bauer, 2015).

Related to the social anxiety construct, a statistically significant mean difference in students' social anxiety among the groups were found with supporting the TCI group. Accordingly, this study noted that the PLTL model was not effective for diminishing students' social anxiety as expected despite its effectiveness in developing their conceptual understanding and exam achievements in general chemistry and lessening state anxiety. This PLTL student outcome was unanticipated since studies on cooperative and collaborative small group work emphasized their superior effect on students' self-esteem and social skills (Johnson & Johnson, 1994). In the conceptualization of social anxiety, van Dam-Bagen and Kraaimaat (1999) used the term of social skills as its behavioral component. They defined social anxiety as the extent of anxiety or uneasiness sensed in social situations (emotional component) with a deficiency in social skills (the behavioral component). Based on a growing body of literature on social anxiety, there has been a significant negative relationship between social skills and social anxiety of undergraduate students (Caballo, 1993; Caballo, Salazar, Irurtia, Olivares & Olivares, 2014; Hsu et al., 2012; Mokuolu, 2013). Thus, it was expected that undergraduate engineering students participating in workshops were more likely to develop their social skills and so they perform better and show less anxiety in such social situations such as PLTL workshops. It was almost inevitable to think that the higher the social competence and skills that students needed to solve the team problems within the PLTL workshops (problem-solving skills considered as one of the important social skills), the lower their social anxiety.

In order to decrease students' social anxiety, why was PLTL not an influential practice? This may be explained by the fact that other group, TCI students, was not involved in any alternative learning activities. Thus, they might not engage in any social conditions in which they interact with the opposite sex and relative strangers and argue their ideas and knowledge with others. In this case, they made a hypothetical and general conclusion about the phenomenon they did not experience. Thus, the comparison of groups with regard to social anxiety may not be very accurate. Another explanation may be presented related to the notion that PLTL was performed just one semester. Since, PLTL group students attended six workshops biweekly at this time, working as a team could be perceived by them as a new experience or challenge. They are probably required more time to see themselves as members of a team and get along well with other peers and their peer leader and deal with the stress or anxiety that occurred in these situations in the teams. After implementing the PLTL model over long periods of time, a more accurate outcome concerning the effect of the PLTL model on social anxiety could be found. Besides, within a workshop in this study, they generally worked on the problems of two chapters' concepts in GC due to the biweekly schedule of the PLTL workshops. Hence, PLTL students focused on understanding the chemistry knowledge and problem-solving. Rather than the interaction among students, dialogue and social interaction were mostly seen between students and team leaders. Consequently, the ability to cooperate and communicate with each other could not be well-developed for building and improving strong social skills. For such reasons, the PLTL students may not alleviate their social anxiety. A long-term successful PLTL practice has the potential to comfort students working in a group and lessen their social anxiety as their team leaders become more experienced in time to build a more productive team learning environment where peers have the ability to progress their social relations and skills.

### 5.2. Implications and Recommendations for Further Studies

Considering the performances of students in chemistry and other STEM courses in college, this study can provide many implications and recommendations for educators and researchers. Consistent with many research studies about college teaching and learning (Kuh, Kinzie, Schuh, & Witt, 2005; Pascarella & Terenzini, 2005), this study assumed that evidence-based teaching strategies were superior to traditional college instruction on enhancing students' conceptual and meaningful learning. This improvement in their understanding could be explained with the notion that they put emphasis on active and collaborative learning. The findings of the study imply that the PLTL model appears to be more effective than traditional college instruction in developing undergraduate engineering students' academic performances in general chemistry. From this point, it can be claimed that as an evidence-based teaching strategy, the PLTL model is an effective practice for supporting the active involvement of university students in their learning and problem-solving and collaborative work with the supervision of a peer-leader. However, engineering students who participated in the study did not take any retention tests at different times. Further studies could be required to analyze the retention of chemistry concepts and examine the effectiveness of the PLTL model on students' long-term achievement.

This study presented statistical and meaningful evidence that the PLTL model improved the general chemistry exam achievement of engineering students with low and moderate academic ability levels. These results imply that the academic ability of undergraduates should not be ignored when implementing the PLTL model. Their academic abilities are likely to mediate their understanding of the scientific concepts and the teaching strategies performed in the class. In addition to the studies supporting the effectiveness of the model in the related literature, the positive effect of the PLTL model on reinforcing the low and moderate achieving students in the research context revealed its different facet. When considered the PLTL studies related to the employment of in-class peer leaders instead of typical peer leaders who previously completed the course (e.g. Schray et al., 2009), the results of the study recommend that high achievers of the course can be seen a significant source as peer leaders who can lead the students with low and moderate academic abilities.

The present study also contributes to PLTL literature by providing significant information about the effectiveness of PLTL in other cultures except for the US context. In the literature, there has been no evidence for the prior implementation of the PLTL model in Turkey. For the dissemination of this model in the Turkish context, this study delivers evidence about both the benefits of PLTL on Turkish students and sufficient materials and information regarding six critical components of the model for proper adaptation. Accordingly, college professors can perceive this study as a source or guideline for the dissemination of this model in the Turkish context in order to design peer-led instruction in a general chemistry context.

In this study, the treatment was effective even though it was performed only one semester. However, in some constructs, a medium effect was obtained. To get a further increase in the students' success, it is advised that educators and researchers should probably create a sustainable mechanism. More specifically, like the studies of Lewis (2011) and Mitchell et al. (2012), PLTL interventions should be performed in successive years and disseminated to different courses at the curriculum level in Turkey to get more effective results.

There have been limited initiatives to advance the quality of higher education when compared to other levels of schooling. This study, therefore, produced a valuable and strong argument for the systematic dissemination of the PLTL model at the tertiary level due to its impact on the cognitive and affective developments of students in Turkey. Future studies can investigate the effect of the PLTL model on different chemistry or STEM courses. Although some researchers studied some students' outcomes in general chemistry and organic chemistry, there was no study on the other chemistry areas. Thus, further investigations could offer evidence in those settings.

The effect of peer leaders' understanding on the students' performance in their teams was not explored in this study. However, age, gender, understandings of peer leaders may influence the students' performance. For example, peer leaders might have some misconceptions that hinder the learning of their team members. Some leader outcomes could be integrated into further HLM studies.

In this study, the PLTL model appears to have good potential in declining freshman engineering students' situational anxiety in general chemistry. This study implies that those who are anxious, or nervous in a classroom environment are likely to be more comfortable in PLTL workshops. Thus, instructors and professors can select to utilize the PLTL model in their course to alleviate their students' anxiety by providing an active learning environment in which students feel more relaxed through collaborative work, and thus, such settings have an ability to influence their performance positively.

## 5.3. Validity Issues in Experimental Study

Considering an experimental study in education or social sciences, validity is widely accepted as the most important term. It could be utilized in three different ways; internal validity, instrument (measurement) validity, and external (generalization) validity. In this section, the internal and external validity were examined in detail respectively.

### 5.3.1. Internal Validity

The internal validity refers to "the degree to which observed differences on the dependent variable are a direct result of manipulation of the independent variable, not some other variable" (Gay, Mills & Airasian, 2012, p.253). In other words, the observed results of a study such as student achievement gains are explained by the independent variable, PLTL model of this study. To have good internal validity, researchers try to systematically rule out or control the alternative explanations or reasons for any observed results which were called “threats to internal validity”. The possible threats to internal validity can be categorized as “subject characteristics, mortality, location, instrumentation, testing, history maturation, attitude of subjects, regression, and implementation” (Fraenkel & Wallen, 2012). In this section, the researcher analyzed and discussed such possible threats to the internal validity of the current study by providing details about the threats and eliminating or minimizing these threats as follows:

- *Subject characteristics threat* means that the characteristics or demographic differences in the participants of EG and CG could affect or explain the observed differences in the dependent variable in a study. Despite the formation of the intact groups of PLTL and TCI by random assignment, some characteristics such as gender, age, prior knowledge of chemistry concepts, and prior anxiety level could affect the results of the study. In terms of age and gender, students’ distribution in PLTL and TCI groups were found similar. Although both groups had students from different majors, it was seen that the college of engineering entry scores (CEES) of students were not different in both groups, not favoring one group because of the distributions of CEES in the same range for both groups. Besides, in order to equate the experimental group and control group, CEES, concept test scores and anxiety scores were compared to match the students in both groups. It was found that there was no difference in those scores of groups at the beginning of the intervention. Some variables in the study (CEES, STAI-T, Pre-GCCT, and Pre-STAI-S) were also used as covariates in the analysis of MANCOVA.
- Another threat to internal validity is *mortality*, which refers to the loss of subjects in a study. Some subjects could not participate in the study or may be absent when collecting data or fail to complete the questionnaires or tests due to some reasons. To eliminate the mortality threat in the current study, firstly missing data analysis was performed to determine the percentages of the

missing data in each variable. For the Pre-GCCT, the missing data was found under 5 %. This means that it can be manageable and would lead to less serious problems in the analysis. It was, therefore, possible to assume that the missing value was scattered randomly through the data (Tabachnick & Fidell, 2013) and they were replaced with the mean values. On the other hand, since the missing data was 9.4 % for Pre-STAI-S, Pre-SAQ and CEES, a dummy variable adjustment was carried out to control whether there was a pattern in the missing values of those scores (Allison, 2001). The results showed that there was no evidence to claim a statistically significant difference between missing and present participants of the study and thus, it could be accepted that there was no pattern in missing data. The missing scores in pre-tests and CEES were replaced with the mean scores of the group.

- *Location threat* was considered when particular locations in which interventions or test administration was carried out might affect the responses and results of the study. In this study, the workshops for PLTL group students were held in the study hall since the structure of the classroom is not suitable for group work. However, this difference can be attributed to the nature of the PLTL model, not an additional extraneous variable. For the location of the data collection, both group students completed data collection tools in similar classrooms which have approximately equal conditions; therefore, the location threat was controlled for this study. Consequently, it might not account for the differences in the performance of students.
- *Instrumentation threat*, which are instrument decay, data collector characteristics, and data collector bias, is likely to influence the results of the study related to the way in which instruments are used (Fraenkel & Wallen, 2012). Instrument decay refers to the changes in any of the instruments or scoring procedures. The concept test (GCCT), midterms (MT1-2) and final exam (FE) consisted of multiple-choice items that are called as objective type test and questionnaires are Likert type scale; therefore, the scoring procedure did not change in some way, or someone who evaluates the data and did not

contain any bias. The characteristics of the individuals who collect the data in a study may also affect the results of the study. This threat was controlled by performing the treatment with the same instructor/teacher for the experimental and control groups, and collecting data with the same data collector. Finally, the unconscious distortion of the data by the data collector(s) and/or scorer(s) is also a threat to internal validity. For this reason, the researcher collected data under standard procedures from both groups.

- *Testing threat* may occur in the use of a pre-test in a study. Stated differently, the significant improvement in posttest scores when compared to pretest scores may be explained by the use of the pretest, not by the intervention (Fraenkel & Wallen, 2012). Therefore, it is advised to be given an equivalent form of instrument or sufficient time for desensitization. In this study, the same instrument was administered as pretests and post-test 14 weeks apart, so the time was long enough to get students to forget the questions and distract them. This threat was controlled in this way.
- *History threat* refers to the effect of the presence of unplanned events during the study on the responses of the subjects (Fraenkel & Wallen, 2012). To handle this treat in this study, the researcher conducted observations in some of the lecture hours, talked about the course instructor and participated in the chemistry workshops. As a result, it was reported that there were no unplanned events during these observations. Moreover, since some research designs are likely to control this threat (Fraenkel & Wallen, 2012), the control group design minimizes the impact of history threat. Because the likelihood of unplanned events in both groups was equal.
- *Maturation threat* means that during an intervention, students can change based on the many factors that are attributable to growing old and being experienced rather than the intervention. Maturation can be a serious threat if the studies have continued several years. Since the current study lasted only fourteen weeks, we might assume that this threat did not influence the results of the study so much. Additionally, the control group design is the best way to

handle this threat since if the observed difference has arisen from the maturation, the students in the TCI group would be maturated too.

- *Attitude of subjects threat* can be explained as the negative or positive effect of the general view of the students on the outcomes of the study. Hawthorne effect, John Henry's effect, and demoralization can be examples of this threat. Hawthorne effect refers to the positive impact of the novelty of the treatment on the experimental group because students in the experimental group (PLTL) perform better due to taking the special attention and recognition while John Henry effect refers to the positive impact of the novelty of the treatment on the control group because students in the control group (TCI) may have a feeling that they should study hard to make better than those in experimental group. Also, demoralization can occur when students in the control group (TCI) perform poorly as a result of a feeling that students in the experimental group receive some sort of special treatment, but this is not provided for them. In order to minimize these threats in this study, the workshop materials were supplied for students in TCI via the learning management system of the university to make the intervention less novel.
- *Regression threat* could be possible if a group selected due to unusually low or high performers (Fraenkel & Wallen, 2012). In this study, both groups have students from different academic ability levels rather than extremely low or high achievers; therefore, this threat did not impact the results.
- *Implementation threats* may occur due to the differences or biases of implementers. In this study, to prevent this threat, the same instructor participated in the lecture of the general chemistry course for PLTL and TCI groups. For the treatment verification, the instructor during the intervention in both groups was observed in order to control this threat. According to the nature of the study, peer leaders led the discussion and problem-solving in the workshops. The researcher talked to the leaders about the personal bias and not talking in favor of one method over the other in the first training session

because their preference for the PLTL model may explain the higher performance of students in the PLTL group.

### 5.3.2. External Validity

The external validity refers to “the degree to which the results of a study can be generalized to groups and environments outside the experimental setting” (Fraenkel & Wallen, 2012; Gay, Mills & Airasian, 2012). The main pursuit in the social sciences is to generalize the results of a particular study to the appropriate populations. The generalizability of the findings is generally determined by two important concepts related to external validity: population generalizability and ecological generalizability (Bracht & Glass, 1968). The term “population generalizability” is related to the representativeness of a sample to the intended population of the study (generalizing to whom). Another term, ecological generalizability, is related to the generalization of the findings of a study to other settings, contexts, variables, or conditions (generalizing to what) (Fraenkel & Wallen, 2012; Gay & Airasian, 2000). The sample of this study consisted of 128 freshman engineering students who corresponds to 10.1 % of the target population and 25.6 % of the accessible population. Therefore, the findings could be generalized to the intended population since the number of students in the sample exceeds 10 % of the population. When the purposive or convenient sampling was used, the generalization of the results could be problematic, but the selection of students randomly is not commonly possible in experimental studies. To show that the sample is representative of the accessible population on at least some relevant variables, some descriptive and inferential evidence was also provided in the population and sample part in methodology. In addition to the population generalizability, the findings of the current study might be generalized to other settings such as biology, physics, mathematics, or introductory engineering courses in the first year of that university. This could be supported with the evidence that the numerous research studies indicated the effectiveness of PLTL program on students’ outcomes in introductory biology, chemistry, calculus, applied statistics and introductory engineering courses in undergraduate STEM education (Carlson et al., 2016; Muller et al., 2018; Preszler, 2009; Quitadamo et al., 2009). The experiences of researchers, students, and leaders in this study showed that the implementation of the model implemented as recommended in the literature.

Like controlling some possible threats to internal validity, researchers should check some major threats to external validity that is likely to limit the generalization of the findings. For this reason, seven threats which are pre-test treatment interaction, multiple treatment interference, selection treatment interaction, the specificity of variables, treatment diffusion, experimenter effect and reactive effects (Gay & Airasian, 2000; Gay, Mills & Airasian, 2012) were discussed in detail at this point as follows:

- *Pre-test treatment interaction* may occur when the pretesting influences the students in a way that they respond to the treatment differently and thus affecting their posttest scores. In this case, the findings could not be generalized to the non-pretested population. As specified by Gay and Airasian (2000), taking a conceptual test (GCCT) would possibly have a very small effect on students' reactions to the new teaching method (PLTL). Studies including affective measures such as attitude could be influenced by this threat. In this study, social anxiety and situational anxiety constructs were investigated as an affective variable. Since the implementation of the study lasted one semester, this effect of pretest on the posttest performance would be more likely to be reduced in time. In this way, the pretest sensitization was controlled.
- *Multiple treatment interference* threats may happen if the participants of a study consecutively take part in more than one treatment. In this study, EG students received PLTL and CG students received TCI. They took only one treatment at the same time, not successive ones. Thus, there was no multiple treatment interference threat that could limit the researcher's capability to generalize the results of the study.

- *The selection treatment interaction effect* (or interaction effects of selection biases and the experimental treatment) may be observed if the participants of a study were selected non-randomly. In the current study, the intact groups were randomly selected for PLTL and TCI treatments, but there may be some differences among groups. To overcome this problem, some descriptive and inferential analyses were performed and some demographic information was provided about the participants and nonparticipants students at Atılım University in the methodology section. It was possible to say that the actual participants (P) of the study did not react significantly differently from the potential participants (NP) in the intended population because the interaction of personal variables of participants and treatment effect tried to be minimized.
- *The specificity of the variables* might limit the generalization of the findings if the necessary detailed information in terms of the participants, operational definition of the treatment (independent variable), operational definition of the dependent variable, specific times, and specific circumstances were not provided. In this direction, clear operationalized descriptions of dependent and independent variables were included in the first three chapters of the study to deal with the threats related to the specificity.
- *Treatment diffusion* is another threat to external validity which could happen due to the interaction of students in EG and CG. It is possible to communicate with students with each other and so learning from this process can influence the nature of the study. This interaction may occur in any experimental study. University students generally communicate and work with their peers from the same departments about the course exams. In this study, PLTL and TCI groups did not have students majoring in the same engineering areas. Moreover, since their GC course and lab schedules were different, it is difficult to run into one another unless they already knew from somewhere such as high school.
- *Experimenter effects* can be explained with the notion that the experimental consciously or unconsciously influences the participants' behavior and responses to the tests. The experimental personal-attributes effects (the impact

of gender, race, age, etc.) and experimenter bias effect (expectations, feels, actions, etc.) are the kinds of this threat to external validity. The same course professor attended the course lecture sessions for both groups in this study. The PLTL workshops were led by peer leaders. The researchers took part in the study as a nonparticipant observer. The researchers did not communicate with the students in both groups or indicate any feelings about the expectations or emotions that could affect their performances or responses.

- *Reactive arrangement effects* (or participant effects) can occur when being aware of participating in a study influence the feelings, attitude, or performances of participants. This threat was also discussed in relation to the attitude of subject threat to the internal validity. Hawthorne effect, John Henry effect, placebo effect, and novelty effect are the reactive responses of the participants for being involved in a study. To handle these effects and make the PLTL intervention less novel, the PLTL workshop materials were supplied for students in the TCI group via the course learning management system.

## 5.4. Conclusion

In conclusion, PLTL is an effective evidence-based teaching strategy to advance engineering students’ conceptual understanding of the chemistry concepts of the General Chemistry Course. Besides, it was found to be an effective method to improve general chemistry exam achievements of low-achievers and moderate-achievers. However, PLTL instruction is not effective for high-achievers to improve their success in general chemistry exams. The current study also offers many conclusions related to the effectiveness of peer-led team learning on students' state anxiety, but not on social anxiety. The results of the study recommend that the PLTL model can be implemented in general chemistry to improve the cognitive and affective development of undergraduate engineering students despite its adverse effect on social anxiety. Within the assumptions and limitations of this study, it is possible to generalize these conclusions to similar settings.

# REFERENCES


Acuna, E., & Rodriguez, C. (2004). The treatment of missing values and its effect in the classifier accuracy. In D. Banks, F. R. McMorris, P. Arabie, & W. Gaul (Eds.), *Classification, clustering, and data mining applications* (pp. 639-647). Berlin: Springer-Verlag.

American Chemical Society [ACS]. (2014). U.S. national chemistry olympiad local section exam. Retrieved from https://www.acs.org/content/dam/acsorg/education/students/highschool/olympiad/pastexams/2014-usnco-local-exam.pdf.

American Chemical Society [ACS]. (2016). Chemistry olympiad exams. Retrieved from https://www.acs.org/content/acs/en/education/students/highschool/olympiad/pastexams.html.

American Psychological Association. (APA). Anxiety. Retrieved from https://www.apa.org/topics/anxiety/

American Psychiatric Association. (2003). Diagnostic and Statistical Manual of Mental Disorders ($4^{th}$ ed.), Text Revision. Washington, DC: American Psychiatric Association.

Al-Balushi, S.M., Ambusaidi, A.K, Al-Shuaili, A.H., & Taylor, N. (2012). Omani twelfth grade students' most common misconceptions in chemistry. *Science Education International*, *23*(3), 221-240.

Alger, T. D., & Bahi, S. (2004). An experiment in improving scores on ACS course-specific examinations at Southern Utah University. *Progressions: the PLTL Project Newsletter*, *5*(2), 7-10.

Allison, P. D. (2001). Missing data. *Sage University Papers Series on Quantitative Applications in the Social Sciences*, 07–136, Thousand Oaks, CA: Sage.

Amaral, K. E., & Vala, M. (2009). What teaching teaches: Mentoring and the performance gains of mentors? *Journal of Chemical Education, 86*(5), 630-633

Angélico, A. P., Crippa, J. A. S., & Loureiro, S. R. (2013). Social anxiety disorder and social skills: A critical review of the literature. *International Journal of Behavioral Consultation and Therapy, 7*(4), 16-23.

Angelo, T. A., & Cross, K. P. (1993). *Classroom assessment techniques: A handbook for college teachers* (2nd ed.). San Francisco, CA: Jossey-Bass.

Aronen, E. T., Vuontella, V., Steenari, M. R., Salmi, J., & Carlson, S. (2005). Working memory, psychiatric symptoms, and academic performance at school. *Neurobiology of Learning and Memory, 83*(1) 33-42. doi:10.1016/j.nlm.2004.06.010.

Astin, A. W. (1993). *What matters in college? Four critical years revisited*. San Francisco, CA: Jossey-Bass.

Astin, A. W., & Astin, H. S. (1993). *Undergraduate science education: The impact of different college environments on the educational pipeline in the sciences* (ERIC Report, NSF, SPA- 8955365). Los Angeles, CA: Higher Educational Research Institute. UCLA.

Ayeni, E. A., Akinsola, E. F., Ayenibiowo, K. O., & Ayeni, O. B. (2012). Assessment of social anxiety among adolescents in Lagos Metropolis. *Ife PsychologIA, 20*(2), 175-183.

Ayyıldız, Y., & Tarhan, L. (2012). The effective concepts on students' understanding of chemical reactions and energy. *Hacettepe University Journal of Education, 42*, 72-83.

Báez-Galib, R., Colón-Cruz, H., Resto, W., & Rubin, M. (2005). Chem-2-chem: A one-to-one supportive learning environment for chemistry. *Journal of Chemical Education, 82*, 1859-1863.

Balcı, C. (2006). *Conceptual change text oriented instruction to facilitate conceptual change in rate of reaction concepts* (Master's thesis). Middle East Technical University, Ankara, Turkey.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.

Barke, H. D., Hazari, A., & Yitbarek, S. (2009). *Misconceptions in chemistry: Addressing perceptions in chemical education.* Berlin: Springer-Verlag.

Beidel, D. C., Morris, T. L., & Turner, M. W. (2004). Social phobia. In J. March (Ed.), *Anxiety disorder in children and adolescents* (2$^{nd}$ ed., pp.141-164). New York: Guilford publications.

Beidel, D. C., Rao, P. A., Scharfstein, L., Wong, N., & Alfano, C. A. (2010). Social skills and social phobia: An investigation of DSM-IV subtypes. *Behav Res Ther, 48*(10), 992-1001.

Bennett, J. (2001). The development and use of an instrument to assess students' attitude to the study of chemistry. *International Journal of Science Education, 23*, 833–845.

Berberoglu G., & Demircioglu H., (2000). Factors affecting achievement in general chemistry courses among science major students. *Educ. & Sci., 25*(118), 35–42.

Berke, T. (2003). *Good students become great student leaders. Strategies for Success*. Spring, No. 39.

Bodner, G., MacIsaac, D., & White, S. (1999). Action research: Overcoming the sports mentality approach to assessment/ evaluation. *University Chemistry Education, 3*(1), 31–36.

Bögels, S. M., Rijsemus, W. & De Jong, P. J. (2002). Self-focused attention and social anxiety: The effects of experimentally heightened self-awareness on fear, blushing, cognitions, and social skills. *Cognitive Therapy & Research, 26*(4), 461-472.

Bozkoyun, Y. (2004). *Facilitating conceptual change in learning rate of reaction concepts* (Master's thesis). Middle East Technical University, Ankara, Turkey.

Bracht, G. H., & Glass, G.V. (1968). The external validity of experments. *American Educational Research Journal, 5,* 437-474.

Brainard, J. (2007). America's science test: The tough road to better science teaching. *The Chronicle of Higher Education, 53*(48), 16.

Bramaje, G. P., & Espinosa, A. A. (2013). Peer-led team learning approach: Effects on students' conceptual understanding and attitude towards chemistry. *Int. J. Learn. Teach., 5*(2), 55–77.

Brown T.L., LeMay, H.E., Bursten, B.E., .Jr, Murphy, C.J., Woodward, P.M., & Stoltzfus, M.E. (2015). *Chemistry: The Central Science* ($13^{th}$ ed.). Upper Saddle River, NJ: Pearson Education, Inc.

Bucat, R. (2004). Pedagogical content knowledge as a way forward: Applied research in chemistry education. *Chemistry Education Research and Practice, 5*(3), 215-228.

Caballo, V. E. (1993). Relationships among some behavioral and self-report measures of social skills. *Psicología Conductual, 1*, 69-91.

Caballo, V. E., Salazar, I. C., Arias, B., Irurtia, M. J., Calderero, M., & CISO-A Research Team Spain. (2010). Validation of the Social Anxiety Questionnaire for Adults (SAQ-A30) with Spanish university students: Similarities and differences among degree subjects and regions. *Behavioral Psychology/Psicología Conductual, 18*, 5–34.

Caballo, V. E., Salazar, I. C., Irurtia, M. J., Arias, B., & Hofmann, S. G. (2010). Measuring social anxiety in 11 countries: Development and validation of the Social Anxiety Questionnaire for Adults. *European Journal of Psychological Assessment, 26*, 95–107. http://dx.doi.org/10.1027/1015-5759/a000014

Caballo, V. E., Salazar, I. C., Irurtia, M. J., Olivares, P. & Olivares, J.(2014). The relationship between social skills and social anxiety and personality styles/disorders. *Behavioral Psychology / Psicología Conductual, 22(*3), 401-422.

Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research.* Boston, MA: Houghton Mifflin Company.

Carlson, K., Turvold-Celotta, D., Curran, E., Marcus, M., & Loe, M. (2016). Assessing the impact of a multi-disciplinary peer-led-team learning program on undergraduate stem education. *Journal of University Teaching & Learning Practice*, *13*(1), Article 5. Retrieved from http://ro.uow.edu.au/jutlp/vol13/iss1/5

Ceylan, E. (2004). *Effect of instruction using conceptual change strategies on students' conceptions of chemical reactions and energy* (Master's thesis). Middle East Technical University, Ankara, Turkey.

Chan, J. Y. K., & Bauer, C. F. (2015). Effect of peer-led team learning (PLTL) on student achievement, attitude, and self-concept in college general chemistry in randomized and quasi- experimental designs. *Journal of Research in Science Teaching, 52*(3), 319-346.

Chandran, S., Treagust, D., & Tobin, K. (1987). The role of cognitive factors in chemistry achievement. *Journal of Research in Science Teaching, 24(2)*, 145-160.

Christensen, P. N., Stein, M. B. & Means-Christensen, A. (2003). Social anxiety and interpersonal perception: A social relations model analysis. *Behaviour Research and Therapy, 41*, 1355-1371.

Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In R. Heimberg, M. Liebowitz, D.A. Hope & F.R. Schneier (Eds.), *Social phobia* (pp.69–93.). New York: Guilford Press.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

College Board. (2014). AP chemistry: Course and exam description. Retrieved from http://media.collegeboard.com/digitalServices/pdf/ap/ap-chemistry-course-and-exam-description.pdf

College Board. (2016). AP chemistry: The exam, retrieved from https://apcentral.collegeboard.org/courses/ap-chemistry/exam?course=ap-chemistry

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design and analysis issues for field settings.* Boston, MA: Houghton Mifflin

Connolly, M. R., & Millar, S. B. (2006) Using workshops to improve instruction in STEM courses. *Metropolitan Universities Journal, 14*(4), 53–65.

Coppola, B. P., Daniels, D. S., & Pontrello, J. K. (2001). Using structured study groups to create chemistry honors sections. In Miller, J., Groccia, J. E., & DiBiasio, D. (Eds.), *Student assisted teaching and learning* (pp. 116-122). Bolton, MA: Anker.

Cracolice, M. S., & Deming, J.  (2001). Peer-led team learning. *Science Teacher, 68*(1), 20-25.

Cracolice M. S. & Deming J. C. (2004). *Peer-led team learning: Promoting conceptual understanding and reasoning ability*. Published online for the Winter 2005 CONFCHEM: Trends and New Ideas in Chemical Education. Retrieved from https://confchem.ccce.divched.org/sites/confchem.ccce.divched.org/files/2005WinterConfChemP2.pdf.

Cracolice, M. S., & Trautmann, J.A. (2001). Vygotsky' theories of education: Theory bases for peer-led team learning. In D. K. Gosser, M. S. Cracolice, J. A. Kampmeier, V. Roth, V.S. Strozak, & P. Varma-Nelson (Eds.), *Peer-led team learning: A guidebook* (pp. 94-102). Upper Saddle River, NJ: Prentice Hall.

Crocker, L., & Algina, J. (2008). *Introduction to classical and modern test theory*. Mason, Ohio: Cengage Learning.

Czerniak, C., & Chiarelott, L. (1984, April 23-27.). *Science anxiety: An investigation of science achievement, sex and grade level factors*. Paper presented at the 68th Annual Meeting of the American Educational Research Association, New Orleans, LA.

Çelebi, Ö. (2004). *Effect of conceptual change oriented instruction on removing misconceptions about phase changes* (Master's thesis). Middle East Technical University, Ankara, Turkey.

Çetin, P.S. (2009). *Effects of conceptual change oriented instruction on understanding of gases concepts* (Doctoral dissertation). Middle East Technical University, Ankara, Turkey.

Deming, J. C., Ehlert, B. E., & Cracolice, M. S. (2003). *Algorithmic and conceptual understanding differences in general chemistry: A link to reasoning ability*. Paper presented at the American Chemical Society National Meeting, New York, NY.

Donato, R. (1994). Collective scaffolding in second language learning. In J. P. Lantolf, & G. Appel (Eds.), *Vygotskian approaches to second language* *research: Second language learning* (pp. 33-56). Norwood, NJ: Ablex Publishing Corporation.

Drane, D., Micari, M., & Light, G. (2014). Students as teachers: effectiveness of a peer-led STEM learning programme over 10 years. *Educational Research and Evaluation, 20*(3), 210–230.

Driver, R. A., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23*, 5–12.

Duit, R., & Treagust, D. F. (2003). Conceptual change: A powerful framework for improving science teaching and learning. *International Journal of Science Education, 25*, 671 –688.

Duit, R., Treagust, D., & Widodo, A. (2008). Teaching science for conceptual change: Theory and practice. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (pp. 629-646). New York: Routledge.

Eberlein, T., Kampmeier, J., Minderhout, V., Moog, R. S., Platt, T., Varma-Nelson, P., & White, H. B., (2008). Pedagogies of engagement in science: A comparison of PBL, POGIL, and PLTL. *The International Union of Biochemistry and Molecular Biology, 36*(4), 262–273.

Eng, W., Coles, M. E., Heimberg, R. G., & Safren, S. A. (2005). Domains of life satisfaction in social anxiety disorder: Relation to symptoms and response to cognitive-behavioral therapy. *Anxiety Disorders, 19*(2), 143-156.

Felder, R.M., & Brent, R. (2007). Cooperative Learning. In P. A. Mabrouk (Ed.), *Active learning: Models from the analytical sciences, acs symposium Series 970*, (pp. 34–53). Washington, DC: American Chemical Society.

Fraenkel, J. R., & Wallen, N. E. (2012). *How to design and evaluate research in education* ($8^{th}$ ed.). New York, NY: The McGraw-Hill.

Frey, R. F., Brown, P. L., & Sawyer, K. R. (2009). *An analysis of discourse in peer-led team learning (PLTL)*. St. Louis, MO: Washington University.

Frey, R. F., Fink, A., Cahill, M. J., McDaniel, M. A., & Solomon, E.D. (2018). Peer-led team learning in general chemistry I: Interactions with identity, academic preparation, and a course-based intervention. *Journal of Chemical Education, 95*(12), 2103-2113.

Gafney, L. (2001a). Evaluating student performance. Progressions: *The PLTL Project Newsletter, 2*(2), 3–4.

Gafney, L. (2001b). Evaluation: Specific practice. In D. K. Gosser, M. S. Cracolice, J. A. Kampmeier, V. Roth, V.S. Strozak, & P. Varma-Nelson (Eds.), *Peer-led team learning: A guidebook* (pp. 129–133). Upper Saddle River, NJ: Prentice Hall.

Gafney, L. (2001c). The impact of research on undergraduates' understanding of science. *The Council on Undergraduate Research Quarterly, 21*, 172–176.

Gafney, L. (2001d). Workshop evaluation. In D. K. Gosser, M. S. Cracolice, J. A. Kampmeier, V. Roth, V.S. Strozak, & P. Varma-Nelson (Eds.), *Peer-led team learning: A guidebook* (pp. 75–92). Upper Saddle River, NJ: Prentice Hall.

Gafney, L., & Varma-Nelson, P. (2007). Evaluating peer-led team learning: A study of long-term effects on former workshop peer leaders. *Journal of Chemical Education, 84*, 3, March, 535-539.

Gafney, L., & Varma-Nelson, P. (2008*). Peer-led team learning: Evaluation, dissemination, and institutionalization of a college level initiative* (Innovations in science education and technology: Vol. 16*)*. Dordrecht, The Netherlands: Springer Science + Business Media B. V.

Gay, L.R., & Airasian, P. (2000). *Educational Research: Competency for analysis and application* (6th ed). Upper Saddle River, NJ: Merrill/Prentice-Hall.

Gay, L. R., Mills, G. E., & Airasian, P. (2012). *Educational Research: Competency for analysis and application* (10th ed). Boston: Pearson.

Gravetter, F. J., & Wallnau, L. B. (2007). *Statistics for the behavioral sciences* (7th ed.). Belmont, CA: Thomson Wadsworth.

Gredler, M. E. (2009). *Learning and Instruction: Theory into Practice* (6th ed.). Upper Saddle River, NJ: Merrill Pearson.

Glynn, M. S, Aultman, L. P., & Owens, A. M. (2005). Motivation to learn in general education. *The Journal of General Education, 54*(2), 150-170.

Glover, R., Hammond, N. B., Smith, J., & Guerra, D. (2018). Assessing peer leader skill acquisition and group dynamics in a first-year calculus course. *International Journal for the Scholarship of Teaching and Learning, 12*(1), Article 10. https://doi.org/10.20429/ijsotl.2018.120110

Goodwin, J. A. (2002). *Development of computer-based activities for peer-led team learning in university-level general chemistry*. Paper #316 SSGRR. 2002's Conference Proceedings. Telecom Italia. Retrieved from https://cpltl.iupui.edu/doc/Goodwin_2002.pdf.

Gosser, D. K. (2001). The peer-led team learning workshop model. In D. K. Gosser, M. S. Cracolice, J. A. Kampmeier, V. Roth, V. S. Strozak, & P. Varma-Nelson (Eds.), *Peer-led team learning: A guidebook* (pp. 1–12). Upper Saddle River, NJ: Prentice Hall.

Gosser, D. K., Cracolice, M. S., Kampmeier, J. A., Roth, V. Strozak, V.S., & Varma-Nelson, P. (Eds.) (2001). *Peer-led team learning: A guidebook*. Upper Saddle River, NJ: Prentice Hall.

Gosser, D.K, Dreyfuss, A. E., & Bozzone, D. (2003). Progressions: Peer-led team learning. *The Workshop Project Newsletter,* 3-4.

Gosser, D. K., Kampmeier, J. A. &Varma-Nelson, P. (2010). Peer-led team learning: 2008 James Flack Norris award address. *Journal of Chemical Education, 87* (4), 374-380.

Gosser, D. K., & Roth, V. (1998). The workshop chemistry project: Peer-led team learning. *Journal of Chemical Education, 75*(2), 185-187.

Gosser, D.K., Roth, V., Gafney, L., Kampmeier, J. A., Strozak, V., Varma-Nelson, P., Radel S., & Weiner, M. (1996). Workshop chemistry: Overcoming the barriers to student success. *The Chemical Educator, 1*(1), 1-17. Retrieved from http://link.springer-ny.com/link/service/journals/00897/index.htm

Gosser, D. K. (2011). The PLTL boost: A critical review of research. *Progressions: The Journal of Peer-led Team Learning,* 14(1). Retrieved from, https://docs.google.com/document/d/1ePcy-1C8Rh1hizySbWG3xxeetuC4U-6lmyZyPikDZxo/edit?authkey=CM2GuN4L&hl=en_US&pli=1.

Gosser, D. K., Strozak, V. S., & Cracolice, M. S. (2006). *Peer-led team learning general chemistry* (2nd ed.). Upper Saddle River, NJ: Prentice-Hall, Inc.

Gronlund, N. E., & Lin, R. L. (1990). *Measurement and evaluation in teaching* (6th ed.). New York, NY: Macmillan Publishing.

Hancock, D. (2001). Effects of test anxiety and evaluative threat on students' achievement and motivation. *Journal of Educational Research, 94*(5), 284−290.

Hancock, D. (2004). Cooperative learning and peer orientation: Effects on motivation and achievement. The Journal of Educational Research, 97(3), 159-166.

Hembree, R. (1998). Correlates, causes, effects and treatment of test anxiety. *Review of Educational Research, 58(*1), 47−77.

Higher Education Research Institute [HERI] (2010). *Degrees of success: Bachelor's degree completion rates among initial STEM majors* (HERI/CIRP Research Brief). Los Angeles, CA: Author.

Hinckley, J. J., & Douglas, N. F. (2013). Treatment fidelity: Its importance and reported frequency in aphasia treatment studies. *American Journal of Speech-Language Pathology 22*(2), 279-84.

Hockings, S.C., DeAngelis, K.A. & Frey, R.F. (2008). Peer-Led Team Learning in General Chemistry: Implementation and Evaluation. *Journal of Chemical Education, 85*(7), 990-996.

Holme, Luxford and Brandriet (2015). Defining Conceptual Understanding in General Chemistry *Journal of Chemical Education*, *92*, 1477−1483.

Hooker, S. M. (2006). The Effectiveness of Peer-Led Team Learning Workshops: An Action Research Approach. *Education and Human Development Master's Theses.* Paper 377. State University of New York College, Brockport.

Hopkins, K.D. (1982). The unit of analysis: group means versus individual observations. *American Education Research Journal, 19(*1), 5-18.

Houston, J. S. (2007). *Future skills demands, from a corporate consultant perspective*. Presented at a workshop on Research Evidence Related to Future Skill Demands, at the National Academies Center.

Hsu, L., Woody, S. R., Lee, H., Peng, Y., Zhou, X., & Ryder, A. G. (2012). Social anxiety among East Asians in North America: East Asian socialization or the challenge of acculturation? *Cultural Diversity and Ethnic Minority Psychology, 18*, 181-191.

Hug, S., Thiry, H., & Tedford, P. (March 9−11, 2011). Learning to love computer science: peer leaders gain teaching skill, communicative ability and content knowledge in the CS classroom. In *Special Interest Group for Computer Science Education*, Proceedings of the $42^{nd}$ ACM technical symposium on

Computer science education, Dallas, TX; ACM: New York, NY.10.1145/1953163.1953225

Johnson, D. W., & Johnson, R. T. (1994). *Learning together and alone. Cooperative, competitive, and individualistic learning* (4th ed.). Edina, Minn.: Interaction Book Company.

Johnson, D. W., & Johnson, R. T. (1999). Making cooperative learning work. *Theory into Practice, 38*(2), 67–73.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1991). *Cooperative Learning: Increasing College Faculty Instructional Productivity. ASHE-ERIC Higher Education Report No. 4.* Washington, D.C.: The George Washington University, School of Education and Human Development.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). Cooperative learning returns to college: What evidence is there that it works? *Change*, 30, 27–35.

Jonassen, D. H. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm? *Educational Technology Research and Development, 39*(3), 5-14.

Katzenbach, J., & Smith, D. (1993). *The Discipline of Teams*. Harvard Business Review.

Kalisch, R., Wiech, K., Critchley, H. D., Ben, S., O'Doherty, J. P., Oakley, D. A., Allen, P., & Dola, R. J. (2005). Anxiety reduction through detachment: Subjective, physiological, and neural effects. *Journal of Cognitive Neuroscience, 17*(6), 874-883.

Kampmeier, J. A., & Varma-Nelson, P., (2009). Peer-led team learning: Organic chemistry. In N. J. Pienta, M. M. Cooper, T. J. Greenbowe (Eds.), *Chemists' guide to effective teaching* Vol. 2. Upper Saddle River, NJ: Pearson Prentice Hall.

Kaplan, R.M., & Saccuzzo, D.P. (2009). *Psychological testing: Principles, applications, and issues* (7th ed.). Belmont, CA: Wadsworth/ Cengage Learning.

Kaya, E. (2011). *The effect of conceptual change based instruction on students" understanding of rate of reaction concepts* (Doctoral dissertation). Middle East Technical University, Ankara, Turkey.

Koballa, T. R., Jr., & Glynn, S. M. (2007). Attitudinal and motivational constructs in science education. In S. K. Abell & N. Lederman (Eds.), *Handbook for research in science education*. Mahwah, NJ: Erlbaum.

Kuh, G. D., Cruce, T. M., Shoup, R., Kinzie, J., & Gonyea, R. M. (2008). Unmasking the effects of student engagement on first-year college grades and persistence. *Journal of Higher Education, 79*(5), 540–563.

Kuh, G., Kinzie, J., Schuh, J. & Witt, E. (2005). *Student success in college: Creating conditions that matter.* Washington, DC: Association for the Study of Higher Education.

Kulatunga, U., & Lewis, J.E. (2013). Exploration of peer leader verbal behaviors as they intervene with small groups in college general chemistry. *Chem. Educ. Res. Pract., 14,* 576-588.

Kulatunga, U., Moog, R. S., & Lewis, J. E. (2013). Argumentation and participation patterns in general chemistry peer-led sessions. *Journal of Research in Science Teaching, 50*(10), 1207−1231.

Kulatunga, U., Moog, R. S., & Lewis, J. E. (2014). Use of Toulmin's argumentation scheme for student discourse to gain insight about guided inquiry activities in college chemistry. *J. Coll. Sci. Teach, 43*(5), 78−87.

Jakubowski, T. G. & Dembo, M. H. (2002, April). *Social cognitive factors associated with the academic self-regulation of undergraduate college students in a* *learning and study strategies course.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

La Greca, A. M., & Lopez, N. (1998). Social anxiety among adolescents: Linkages with peer relations and friendships. *Journal of Abnormal Child Psychology, 26*, 83-94.

Leary, M. R. (1983). *Understanding social anxiety*. Beverly Hills, CA: Sage.

Leary, M. R. (1991). Social anxiety, shyness, and related constructs. In J. P. Robinson, P. R. Shaver, & L. S. Wrightsman (Eds.), *Measures of personality and social psychological attitudes* (pp. 195-290). New York: Academic Press.

Lewis, S. E., & Lewis, J. E. (2005). Departing from lectures: An evaluation of a peer-led guided inquiry alternative. *Journal of Chemical Education*, *82*(1), 135-139.

Lewis, S. E., & Lewis, J. E. (2008). Seeking effectiveness and equity in a large college chemistry course: An HLM investigation of peer-led guided inquiry. *Journal of Research in Science Teaching, 45*, 794–811.

Lewis, S. E. (2011). Retention and reform: An evaluation of peer-led team learning. *Journal of Chemical Education, 88*, 703–707.

Liebowitz, M.R. (1987). Social phobia. *Modern Problems in Pharmacopsychiatry, 22*, 141–173.

Light, R. J. (2001). *Making the most of college: Students speak their minds*. Cambridge: Harvard University Press.

Liu,Y., Raker, J.R., & Lewis, J.E. (2018). Evaluating student motivation in organic chemistry courses: moving from a lecture-based to a flipped approach with peer-led team learning. *Chem. Educ. Res. Pract., 19*, 251-264.

Lovitts, B. E. (2001). *Leaving the ivory tower: The causes and consequences of departure from doctoral study*. Lanham, MD: Rowman & Littlefield.

Luigi, M., Francesca, D., Maria, D.S., Eleonora, P., Valentina, G.D., & Benedetto, V. (2007). The role of anxiety symptoms in school performance in a community sample of children and adolescents. *BMC Public Health, 7* (347) doi: 10.1186/1471-2458-7-347.

Lyle, K.S. & Robinson, W.R. (2003). A statistical evaluation: Peer-led team learning in an organic chemistry course. *Journal of Chemical Education, 80*(2), 132-134.

Lyon, D. C. & Lagowski J. J. (2008). Effectiveness of facilitating small-group learning in large lecture classes: A general chemistry case study. *Journal of Chemical Education, 80, 85*(11), 1571–1576.

MacIntyre, P. D., & Gardner, R. C. (1991). Methods and results in the study of anxiety and language learning: A review of the literature. *Language Learning, 41*(1), 85-117.

Mallow, J. (1986). *Science anxiety: Fear of science and how to overcome it* (Revised edition). Clearwater, FL: H & H Publications.

Mallow, J.V. (2006). Science anxiety: Research and action. In J. J Mintzes, & W.H. Leonard (Eds.), *Handbook of college science teaching* (pp.3-14). Virginia: NSTA Press.

Mallow, J. V., & Greenburg, S. L. (1982). Science anxiety: Causes and remedies. *Journal of College Science Teaching, 11*(6), 356-358.

Mallow, J., Kastrup, H., Bryant, F.B., Hislop, N., Shefner, R., & Udo, M. (2010). Science anxiety, science attitudes, and gender: Interviews from a binational study. *Journal of Science Education and Technology, 19*(4), 356-369.

Mauser, K., Sours, J., Banks, J., Newbrough, J. R., Janke, T., Shuck, L., & Zhu, L. (2011). Cyber Peer-Led Team Learning (cPLTL): Development and implementation. *Educ. Rev. Online*, 1−17.

Maxfield, M. (2001). The view from industry. In D. K. Gosser, M. S Cracolice, J. A. Kampmeier, V. Roth, V. S. Strozak, & P. Varma-Nelson (Eds.), *Peer-led team learning: A guidebook* (pp. 75–92). Upper Saddle River, NJ: Prentice Hall.

Mazur, E. (1997). *Peer instruction: A user's manual.* Upper Saddle River, NJ: Prentice Hall.

McCann, S. J. H., & Meen, K. S. (1984). Anxiety, ability, and academic achievement. *The Journal of Social Psychology, 124,* 257-258.

McCraty, R. (2007). *When anxiety causes your brain to jam, use your heart*. Boulder Creek, CA: Institute of Heart Math., HeartMath Research Center.

McCreary, C. L., Golde, M. F., & Koeske, R. (2006). Peer instruction in the general chemistry laboratory: Assessment of student learning. *J. Chem. Educ., 83*(5), 804−810.

Mitchell, Y. D., Ippolito, J., & Lewis, S. E. (2012). Evaluating peer-led team learning across the two semester general chemistry sequence. *Chemistry Education Research and Practice, 13*, 378–383.

Mokuolu, B. O. (2013). Assessment of social anxiety and its correlates among undergraduates in southwestern Nigeria. *Ife Psychologia, 21*, 324-345.

Mutanyatta-Comar, J., & Mooring, S.R. (2019). Evaluation of a peer-led team learning-flipped classroom reform in large enrollment organic chemistry courses. In S.K. Hartwell & T. Gupta (Eds.), from general to organic chemistry: courses and curricula to enhance student retention (pp.145-157). Washington, DC: ACS Symposium Series, American Chemical Society.

Mulford, D. R., & Robinson, W. R. (2002). An inventory for alternate conceptions among first-semester general chemistry students. *Journal of Chemical Education, 79*(6), 739-744.

Muller, O., Shacham, M., & Herscovitz, O. (2018) Peer-led team learning in a college of engineering: First-year students' achievements and peer leaders' gains. *Innovations in Education and Teaching International*, *55*(6), 660-671. doi: 10.1080/14703297.2017.1285714

Oldfather, P., West, J., with White, J. & Wilmarth, J. (1999). *Learning through children's eyes: Social constructivism and the desire to learn*. Washington, DC: American Psychological Association

Osborne J., Simon S., & Collins S. (2003). Attitudes towards science: A review of the literature and its implications. *Int. J. Sci. Educ., 25*(9), 1049–1079

Pabuccu, A (2004). *Effect of conceptual change texts accompanied with analogies on understanding of chemical bonding concepts* (Master's thesis). Middle East Technical University, Ankara, Turkey.

Pabuccu, A., & Geban, O. (2006). Remediating misconceptions concerning chemical bonding through conceptual change text. *Hacettepe University Journal of Education, 30*, 184-192.

Pallant, J. (2011). *SPSS survival manual: A step by step guide to data analysis using SPSS* (4th ed.). Crows Nest, NSW: Allen & Unwin.

Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students: A third decade of research* (Vol. 2). San Francisco: Jossey-Bass.

Peckham, P. D., Glass, G. V., & Hopkins, K. N. (1969). The experiment unit in statistical analysis. *The Journal of Special Education, 3*(4), 337-349.

Phillips, D. C. (2000). An opinionated account of the constructivist landscape. In D. C. Phillips (Ed), *Constructivism in education: Ninety-ninth yearbook of the National Society of the Study of Education*, Part 1 (pp. 1-16). Chicago: University of Chicago Press.

Pink, D. H. (2005). A whole new kind of mind. New York: Berkley.

Pittenger, A. L., & LimBybliw, A. L. (2013). Peer-led team learning in an online course on controversial medication issues and the US healthcare system. *Am. J. Pharm. Educ.*, *77*(7), 150.

Preszler, R. W. (2009). Replacing lecture with peer-led workshops improves student learning. *CBE Life Sciences Education, 8*(3), 182–192.

Puntambekar, S., & Hübscher, R. (2005). Tools for scaffolding students in a complex learning environment: What have we gained and what have we missed? *Educational Psychologist, 40*, 1–12.

Pyburn, D.T., Pazicni, S., Benassi, V.A., & Tappin, E.M. (2014). The testing effect: an intervention on behalf of low-skilled comprehenders in general chemistry. *J. Chem. Educ.*, *91*, 2045−2057

Quitadamo, I. J., Brahler, C. J., Crouch, G.J. (2009). Peer-led team learning: A prospective method for ıncreasing critical thinking in undergraduate science courses. *Science Educator*, 18 (1), 29-39.

Rani, G. (2000). Measuring change in students‟ attitudes toward science over time: An application of latent variable growth modeling. *Journal of Science Education and Technology*, *9*(3), 213-225.

Reardon, J., Payan, J., Miller, C., & Alexander, J. (2008). Optimal class length in marketing undergraduate classes: An examination of preference, instructor evaluations, and student performance. *Journal of Marketing Education*, *30*(1), 12–20. doi:10.1177/0273475307312193

Reiss, M. J. (2004). Students' attitudes toward science: A long term perspective. *Canadian Journal of Science, Mathematics and Technology Education, 4*(1), 97-109.

Robert, J., Lewis, S.E., Oueini, R., & Mapugay, A. (2016). Coordinated implementation and evaluation of flipped classes and peer-led team learning in general chemistry. *J. Chem. Educ., 93*, 1993−1998.

Roth, V., Cracolice, M.S., Goldstein, E. & Snyder, V. (2001). Workshop leader training. In D. K. Gosser, M. S Cracolice, J. A. Kampmeier, V. Roth, V. S. Strozak, & P. Varma-Nelson (Eds.), *Peer-led team learning: A guidebook* (pp. 35–60). Upper Saddle River, NJ: Prentice Hall

Roth, V., Goldstein, E., & Marcus, G. (Eds.). (2001). *Peer-led team learning: A handbook for team leaders*. Upper Saddle River, NJ: Prentice Hall.

Russel, M. (2017). *How to study for the American Chemical Society (A.C.S.) final exam.* Retrieved from http://mhchem.org/223/classroom/wlExACS.htm

Russell, G., & Shaw, S. (2009). A study to investigate the prevalence of social anxiety in a sample of higher education students in the UK. *Journal of Mental Health, 18*(3), 198–206.

Russell, G., & Topham, P. (2012). The impact of social anxiety on student learning and well-being in higher education. *Journal of Mental Health*, *21*(4), 375–385.

Salta, K., & Tzougraki, C. (2004). Attitudes toward chemistry among 11th grade students in high schools in Greece. *Science Education, 88*, 535-547.

Sarquis, J. L., Dixon, L. J., Gosser, D. K., Kampmeier, J. A., Roth, V., Strozak, V. S., & Varma-Nelson, P. (2001). The workshop project: Peer-led team learning in chemistry. In, J. E. Miller, J. E. Groccia, & M. Miller (Eds.), *Student-assisted teaching: A guide to faculty-student teamwork* (pp. 150–155), Bolton, MA: Anker Publishing Company.

Schray, K., Russo, M. J., Egolf, R., Lademan, W., & Gelormo, D. (2009). Are in-class peer leaders effective in the peer-led team-learning approach? *J. Coll. Sci. Teach.*, *38*(4), 62−67.

Seligman, M., Walker, E., & Rosenhan, D. (2001). *Abnormal psychology* (4th ed). New York, NY: W.W. Norton & Company, Inc.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview.

Shields, S. P., Hogrebe, M. C., Spees, W. M., Handlin, L. B., Noelken, G. P., Riley, J. M., & Frey, R. F. (2012). A transition program for underprepared students in general chemistry: Diagnosis, implementation, and evaluation. *Journal of Chemical Education, 89*, 995–1000.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi experimental designs for generalized causal inference*. Boston, MA: Houghton Mifflin

Shulman, L. S (1987). Knowledge and Teaching: Foundations of the new reform. *Harvard Educational Re*view. *57*(1), 1–22.

Shunk, D. H. (2012). *Learning theories: An educational perspective* (6th ed.). Boston, MA: Pearson Education Inc.

Simon, M. K., & Goes, J. (2013). *Dissertation and scholarly research: Recipes for success* (2nd ed.). WA: Dissertation Success, LLC.

Simpson, R. D., Koballa, T. R., Oliver, J. S., & Crawley, F. E. (1994). Research on the affective dimension of science learning. In D. Gabel (Ed.), *Handbook of research in science teaching and learning*. New York: Macmillan.

Simpson, R. D. & Oliver, J. S. (1990). A summary of the major influences on attitude toward and achievement in science among adolescent students. *Science Education, 74*(1), 1-18.

Smith, J., Wilson, S., Banks, J., Zhu, L., &Varma-Nelson, P. (2014). Replicating peer-led team learning in cyberspace: Research, opportunities, and challenges. *Journal of Research in Science Teaching, 51*(6), 714–740.

Snyder, J. J., Sloane, J. D., Dunk, R.D.P., & Wiles, J. R. (2016). Peer-Led Team Learning Helps Minority Students Succeed. *PLoS Biol 14*(3): e1002398. doi:10.1371/journal.pbio.1002398

Snyder, J. J., & Wiles, J. R. (2015). Peer-led team learning in introductory biology: Effects on critical thinking skills. *PLoS One, 10*(1), 1−18.

Spielberger, C. D. (1971). The effects of manifest anxiety on the academic achievement of college students. In E. Gaudry, & C. D. Spielberger (Eds.) *Anxiety and educational achievement* (pp. 118-125). Sydney: John Wiley & Sons

Spielberger, C. D. (1972). Anxiety as an emotional state. In C. D. Spielberger (Ed.). *Anxiety: current trends in theory and research.* Vol 1 (pp. 33-46). New York: Academic Press.

Spielberger, C. D. (1975). Anxiety: State-trait process. In C. D. Spilberger & I. Sarason (Eds.), *Stress and anxiety* (Vol. I, pp. 115-143). NY: John Wiley & Sons.

Spielberger, C. D. (1983). *Manual for the state-trait anxiety inventory (Form Y)*. Palo Alto, CA: Consulting Psychological Press.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). *Manuel for the state-trait anxiety inventory*. Palo Alto, CA: Consulting Psychologist.

Spielberger, C. D., & Vagg, P. R. (1995). Test anxiety: A transactional Process Model. In C. D. Spielberger & P. R. Vagg (Eds.), *Test anxiety: Theory, assessment, and treatment*. (pp. 3-14). Washington, D.C.: Taylor & Francis.

Stein, M.B., & Kean, Y. M. (2000). Disability and quality of life in social phobia: Epidemiologic findings. *American Journal of Psychiatry, 157*(10), 1606–1613.

Stephenson, N. S., Miller, I. R., & Sadler-McKnight, N. P. (2019). Impact of peer-led team learning and the science writing and workshop template on the critical thinking skills of first-year chemistry students. *Journal of Chemical Education, 96*(5), 841-849.

Stewart, B. N., Amar, F. G., & Bruce, M. R. M. (2007). Challenges and rewards of offering peer led team learning (PLTL) in a large general chemistry course. *Aust. J. Educ. Chem*, *67*, 31−36.

Strahan, E. Y. (2003). The effects of social anxiety and social skills on academic performance. *Personality and Individual Differences, 34*(2), 347-366.

Streitwieser, B., & Light, G. (2010). When undergraduates teach undergraduates: Conceptions of and approaches to teaching in a peer led team learning intervention in the STEM disciplines: Results of a two-year study. *The International Journal of Learning in Higher Education, 22*(3), 346−356.

Strozak, V. S., & Wedegaertner, D.K. (2001). Writing workshop materials. In D. K. Gosser, M. S Cracolice, J. A. Kampmeier, V. Roth, V. S. Strozak, & P. Varma-Nelson (Eds.), *Peer-led team learning: A guidebook* (pp. 20–34). Upper Saddle River, NJ: Prentice Hall.

Snyder, J. J., Sloane, J. D., Dunk, R. D. P., & Wiles, J. R. (2016). Peer-led team learning helps minority students succeed, *PLoS Biology, 14*(3): e1002398. Retrieved from https://doi.org/10.1371/journal.pbio.1002398

Tabachnick, B. G., & Fidell, L.S. (2013). *Using multivariate statistics* (6th ed.). Upper Saddle River. NJ: Pearson.

Tenney, A., & Houck, B.(2004) Learning about leadership: Team learning's effect on peer leaders. J. *Coll. Sci. Teach, 33*(6), 25−29.

Tien, L. T., Roth, V., & Kampmeier, J. A. (2002). Implementation of a peer-led team learning instructional approach in an undergraduate organic chemistry course. *Journal for Research in Science Teaching, 37,* 606–632.

Tien, L. T., Roth, V., & Kampmeier, J. A. (2004). A course to prepare peer leaders to implement a student-assisted learning method. *Journal of Chemical Education, 81*, 1313.

Tinto, V. (1975). Dropout from Higher Education: A Theoretical Synthesis of Recent Research. *Review of Educational* Research, 89-125.

Tinto, V. (1987). *Leaving College: Rethinking the Causes and Cures of Student Attrition.* The University of Chicago Press: Chicago.

Tobias, S. (1990). *They're not dumb, they're just different: Stalking the second tier*. Tucson, A Z: Research Corporation.

Tobias, S. (1992). *Revitalizing College Education*. Tucson, AZ: Research Corporation

Topham, P., & Russell, G. (2012). Social anxiety in higher education. *Psychologist, 25*(4), 280-282.

Topping, K. & Stewart, E. (1998). *Peer-assisted learning*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Tsai, C.-C., & Chou, C. (2002). Diagnosing students' alternative conceptions in science. *Journal of Computer Assisted Learning, 18,* 157-165.

Uzuntiryaki, E. (2003). *Effectiveness of constructivist approach on students' understanding of chemical bonding concepts* (Doctoral dissertation). Middle East Technical University, Ankara, Turkey.

van Dam-Baggen, R., & Kraaimaat, F. (1999). Assessing social anxiety: The Inventory of Interpersonal Situations (IIS). *European Journal of Psychological Assessment, 15,* 25-38.

van Lier, L. (1996). *Interaction in the language curriculum: Awareness, autonomy and authenticity*. London: Longman.

van Lier, L. (2004) *The ecology and semiotics of language learning*. Dordrecht: Kluwer Academic.

Varma-Nelson, P. (2006). Peer-led team learning: The model, its dissemination and its future. *Metropolitan Universities Journal, 14*(4), 19–29.

Varma-Nelson, P., & Coppola, B. P. (2005). Team learning. In N. J. Pienta, M. M. Cooper, & T. J. Greenbowe (Eds.), *Chemists' guide to effective teaching: Volume I* (pp. 155-169). Upper Saddle River, NJ: Pearson.

Varma-Nelson, P. & Cracolice M.S. (2001). *Peer-led Team Learning: General, Organic, and Biological Chemistry.* Upper Saddle River, N.J.: Prentice Hall.

Varma-Nelson, P., Cracolice, M., & Gosser, D. (2004). Peer-led team learning: A student-faculty partnership for transforming the learning environment. In S. Cunningham, & Y. George (Eds.), *Invention and impact: Building in undergraduate science, technology, engineering, and mathematics education* (pp. 43-48). Washington, DC: American Association for the Advancement of Science.

Vitasari, P. Wahab, M. N. A., Herawan, T., Othman, A. & Sinnadurai, S. K. (2011). Re-test of state trait anxiety inventory (STAI) among engineering students in Malaysia: Reliability and validity tests. *Procedia-Social and Behavioral Sciences, 15,* 3843-3848.

Vitasari, P., Wahab, M. N. A., Othman, A., Herawan, T., & Sinnadurai, S. K. (2010). The relationship between study anxiety and academic performance among engineering students. *Procedia-Social and Behavioral Sciences, 8*, 490-497. http://dx.doi.org/10.1016/j.sbspro.2010.12.067.

Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Vygotsky, L.S. (1986). *Thought and language* (A. Kozulin, Trans.). Cambridge, MA: MIT Press.

Walqui, A., & van Lier, L. (2010). *Scaffolding the academic success of adolescent English language learners: A pedagogy of promise*. San Francisco: WestEd.

Weiss, C. H. (1998). *Evaluation: Methods for studying programs and policies* ($2^{nd}$ ed.). Upper Saddle River, NJ: Prentice Hall

Williams, R., & Zimmerman, D. (1989). Statistical Power Analysis and Reliability of Measurement. *Journal of General Psychology, 116*(4), 359- 369.

Wilson, S. B., & Varma-Nelson, P. (2016). Small groups, significant impact: A review of peer-led team learning research with implications for STEM education researchers and faculty. *J. Chem. Educ., 93,* 1686–1702.

Wittchen, H.U., Stein, B., & Kessler, R.C. (1999). Social fears and social phobia in a community sample of adolescents and young adults: Prevalence, risk factors and co-morbidity. *Psychological Medicine, 29*, 309–323.

Woldeamanuel, M., Atagana, H., & Engida, T. (2013). Students' anxiety towards the learning of chemistry in some Ethiopian universities. *AJCE, 3*(2), 28-38.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology & Psychiatry & Allied Disciplines,17*(2), 89–100.

Yalçınkaya, E. (2010). *Effect of case based learning on 10th grade students' understanding of gas concepts, their attitude and motivation* (Doctoral dissertation). Middle East Technical University, Ankara, Turkey.

Zeidner, M. (1998). *Test anxiety: The state of the art.* New York, NY: Plenum Press.

Zha, S., Estes, M. D., & Xu, L. (2019). A meta-analysis on the effect of duration, task, and training in peer-led learning. *Journal of Peer Learning, 12,* 5-28. Available at:https://ro.uow.edu.au/ajpl/vol12/iss1/2

# APPENDICES

## A. Voluntary Participation and Acceptance Student Form

### Araştırmaya Gönüllü Katılım Öğrenci Formu

Bu araştırma, ODTÜ Matematik ve Fen Bilimleri Eğitimi Bölümü Araş. Gör. N. Ece Eren Şişman tarafından Prof. Dr. Ömer Geban ve Yrd. Doç. Dr. Ceyhan Çiğdemoğlu danışmanlığındaki doktora tezi kapsamında yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

**Çalışmanın Amacı Nedir?**

Araştırmanın amacı, Akran Liderliği Takım Öğrenmesi (ALTÖ) modelinin Türkiye bağlamına uyarlanması ve bu modelin üniversite birinci sınıf mühendislik öğrencilerinin genel kimya dersindeki başarıları, kavramsal öğrenmeleri ve kaygı durumları üzerindeki etkisini incelemektir.

**Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?**

Araştırmaya katılmayı kabul ederseniz, sizden 6 ila 8 kişiden oluşan bir çalıştay grubuna iki hafta bir 70 dk katılmanız beklenmektedir. Bu çalıştayda grubunuza liderlik etmesi için belirlenen bir kişiyle beraber genel kimya dersinizin konularıyla paralel olarak hazırlanan problemleri ve ders materyallerini tartışmanız istenecektir. Dönem başı ve sonunda size bazı anketler uygulanıp sorular sorulacaktır. Daha sonra değerlendirilmek üzere çalıştaydaki grup dinamiğinizi inceleyebilmek için video kaydı alınacaktır.

**Sizden Topladığımız Bilgileri Nasıl Kullanacağız?**

Araştırmaya katılımınız tamamen gönüllülük temelinde olmalıdır. Çalışmada elde edilecek tüm bilgiler tamamıyla gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir. Katılımcılardan elde edilecek bilgiler toplu halde değerlendirilecek ve bilimsel yayımlarda kullanılacaktır.

Katılımınızla ilgili bilmeniz gerekenler:

Çalıştay, genel olarak kişisel rahatsızlık verecek sorular veya uygulamalar içermemektedir. Ancak, katılım sırasında herhangi bir nedenden ötürü kendinizi rahatsız hissederseniz çalışmayı yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda çalışmayı uygulayan kişiye çalışmadan çıkmak istediğinizi bildirmeniz yeterli olacaktır.

**Araştırmayla ilgili daha fazla bilgi almak isterseniz:**

Çalıştay sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için Araş. Gör. Ece Eren (E-posta: neren@metu.edu.tr) ile iletişim kurabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.

İsim Soyisim Tarih ---/----/----- İmza

## B. Voluntary Participation and Acceptance Leader Form

### Araştırmaya Gönüllü Katılım Lider Formu

Bu araştırma, ODTÜ Matematik ve Fen Bilimleri Eğitimi Bölümü Araş. Gör. N. Ece Eren Şişman tarafından Prof. Dr. Ömer Geban ve Yrd. Doç. Dr. Ceyhan Çiğdemoğlu danışmanlığındaki doktora tezi kapsamında yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

**Çalışmanın Amacı Nedir?**

Araştırmanın amacı, Akran Liderliği Takım Öğrenmesi (ALTÖ) modelinin Türkiye bağlamına uyarlanması ve bu modelin üniversite birinci sınıf mühendislik öğrencilerinin genel kimya dersindeki başarıları, kavramsal öğrenmeleri ve kaygı durumları üzerindeki etkisini incelemektir.

**Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?**

Araştırmaya katılmayı kabul ederseniz, sizden 6 ila 8 kişiden oluşan bir çalıştay grubuna iki hafta bir 70 dk katılmanız beklenmektedir. Bu çalıştayda grubunuza liderlik etmesi için belirlenen bir kişiyle beraber genel kimya dersinizin konularıyla paralel olarak hazırlanan problemleri ve ders materyallerini tartışmanız istenecektir. Dönem başı ve sonunda size bazı anketler uygulanıp sorular sorulacaktır. Daha sonra değerlendirilmek üzere çalıştaydaki grup dinamiğinizi inceleyebilmek için video kaydı alınacaktır.

**Sizden Topladığımız Bilgileri Nasıl Kullanacağız?**

Araştırmaya katılımınız tamamen gönüllülük temelinde olmalıdır. Çalışmada elde edilecek tüm bilgiler tamamıyla gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir. Katılımcılardan elde edilecek bilgiler toplu halde değerlendirilecek ve bilimsel yayımlarda kullanılacaktır.

**Katılımınızla ilgili bilmeniz gerekenler:**

Çalıştay, genel olarak kişisel rahatsızlık verecek sorular veya uygulamalar içermemektedir. Ancak, katılım sırasında herhangi bir nedenden ötürü kendinizi rahatsız hissederseniz çalışmayı yarıda bırakıp çıkmakta serbestsiniz. Böyle bir durumda çalışmayı uygulayan kişiye çalışmadan çıkmak istediğinizi bildirmeniz yeterli olacaktır.

**Araştırmayla ilgili daha fazla bilgi almak isterseniz**:

Çalıştay sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için Araş. Gör. Ece Eren (E-posta: neren@metu.edu.tr) ile iletişim kurabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.
(Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

İsim Soyisim Tarih ---/----/----- İmza

## C. General Chemistry Concept Test

**Dear Participant,**

General Chemistry Concepts test is designed to be used in a research project in general chemistry course. The purpose of this project is to investigate the effectiveness of the Peer-led Team Learning (PLTL) model over traditional chemistry teaching in undergraduate general chemistry courses of engineering students.

This inventory aims to measure the extent of freshman students' conceptual understanding, alternate conceptions or difficulties about topics found in many general chemistry courses. In this regard, conceptual questions will be presented at the inventory. The answer you give on them will be used to improve the quality of teaching and learning in general chemistry courses. All information that is collected in this study will be treated confidentially. Thank you very much for your cooperation.

Name- Surname: ________________________

Section: ________________________________

Department: ____________________________

## General Chemistry Concepts Test

There are 30 multiple choice questions. Carefully consider each question and indicate the one best answer for each. Some of the questions are paired. In these cases, first question asks about a chemical or physical effect and second question then asks for the reason for the observed effect.

*GOOD LUCK*

**Q 1** Heat is given off when hydrogen gas burns in air according to the equation below.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

Which of the following is responsible for the heat?

- **a.** Breaking hydrogen bonds gives off energy.
- **b.** Breaking oxygen bonds gives off energy.
- **c.** Forming hydrogen-oxygen bonds gives off energy.
- **d.** Both (a) and (b) are responsible.
- **e.** (a), (b), and (c) are responsible.

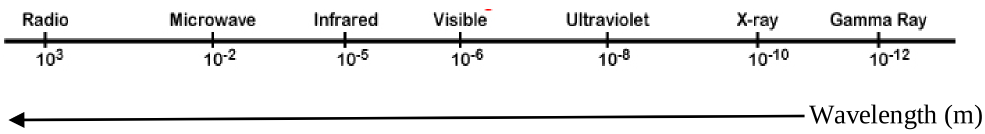
**Q 2** *A 100 g sample of a metal was heated to 100 °C and then quickly transferred to an insulated container holding 100 g of water at 22 °C. The temperature of the water increased to reach a final temperature of 35 °C. Which of the following <u>can be concluded</u>?

- **a.** The metal temperature changed more than the water temperature did; therefore the metal lost more thermal energy than the water gained.
- **b.** The metal temperature changed more than the water temperature did; but the metal lost the same amount of thermal energy as the water gained.
- **c.** The metal temperature changed more than the water temperature did; therefore the heat capacity of the metal must be greater than the heat capacity of the water.
- **d.** The final temperature is less than the average starting temperature of the metal; therefore the total energy of the metal and water decreases.
- **e.** The final temperature is higher than the average starting temperature of the water; therefore the total energy of the metal and water increases.

**Q 3** Which one of the following statements about chemical reactions and energy <u>is true</u>?

**a.** At constant temperature, the heat supplied to the system increases the system's potential energy.
**b.** Burning of a candle is an endothermic reaction.
**c.** An intervention is needed from outside such as heat to occur a chemical reaction.
**d.** The bond formation consumes the energy while bond dissociation releases energy
**e.** A spontaneous reaction is always exothermic.

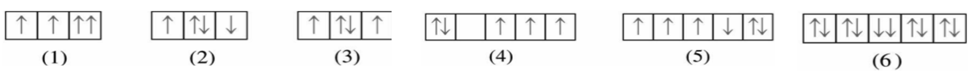
**Q 4** *The electromagnetic spectrum displays the various types of electromagnetic radiation arranged in order of increasing wavelength.




Which one of the following statements answers to the question "*Is it possible for a fluorescent material to emit radiation in the ultraviolet (UV) region after absorbing visible light*?"

**a.** No, ultraviolet light has higher energy than visible light.
**b.** No, fluorescent materials only emit purple and green visible light.
**c.** Yes, fluorescent materials emit a broad spectrum of light.
**d.** Yes, after storing enough visible light energy, fluorescent material can emit ultraviolet light.
**e.** Yes, fluorescent materials emit radiation in a higher frequency.

**Q 5** *The following portions of orbital diagrams represent the ground-state electron configurations of certain elements.




Which of the above orbital diagrams violate the <u>Pauli Exclusion Principle</u>?

**a.** (2) and (5)
**b.** (1) and (6)
**c.** (4) and (5)
**d.** (1), (3) and (6)
**e.** (2), (5) and (6)

**Q 6** **The energy change for the following reaction is referred to the ____ for fluorine.

$$F\ (g) + e- \rightarrow F^{-}(g)$$

- **m.** Oxidation energy
- **n.** Electron affinity
- **o.** Electronegativity energy
- **p.** First ionization energy
- **q.** Second ionization energy

**Q 7** Which one of the following statements about chemical bonding is true?

- **b.** In all covalent bonds, each atom shares the same number of electrons, so the attraction of electrons from atoms participating in the bond is equal.
- **c.** There is a hydrogen bond between the oxygen atom and the sulphur atom in $H_2SO_4$.
- **d.** The type of bond between oxygen atom and sulphur atom in sulphuric acid is an ionic bond.
- **e.** Water is partially polar, because oxygen has high electronegativity and attracts the shared electrons between it and the two hydrogen atoms.
- **f.** Hydrogen bonds form when a hydrogen atom of one water molecule is attracted to the oxygen atom of a neighboring water molecule.

**Q 8** When sodium chloride dissolves in water, there is still ionic bonds between sodium and chlorine ions in solution. ($_{11}$Na, 1A; $_{17}$Cl, 7A)

- **a.** True
- **b.** False

**Q 9** What is the reason for your answer to question *8*?

- **a.** NaCl exists as discrete pairs of $Na^+$ and $Cl^-$.
- **b.** Ionic bond is broken during the dissolving process.
- **c.** Positive charge on sodium ions must be neutralized by gaining of electrons from chloride ions in the solution.
- **d.** NaCl is still molecular in water.

**Q 10** According to Pauling's electronegativities scale, the electronegativity of Hydrogen is 2.1 and the electronegativity of Chloride is 3.0. What is the type of bond between hydrogen and chloride in hydrogen chloride, HCl. ($_1$H,1A; $_{17}$Cl,7A)

- **m.** ionic bond
- **n.** covalent bond
- **o.** hydrogen bond
- **p.** metallic bond

**Q 11** What is the reason for your answer to question 10?

- **a.** Hydrogen atom and chlorine atom each share one electron in the compound.
- **b.** Hydrogen is bonded to a highly electronegative atom such as F, Cl and O
- **c.** HCl is a strong acid, and it decomposes to its ions when it dissolves in water
- **d.** Hydrogen transfers one electron to chlorine to form a compound.

**Q 12** Nitrogen combines with bromine to form a molecule. This molecule is likely to have a shape described as ($_7$N,5A; $_{35}$Br,7A)

- **b.** Trigonal planar
- **c.** Trigonal pyramidal
- **d.** Tetrahedral

**Q 13** What is the reason for your answer to question 12?

- **b.** Nitrogen forms three bonds, which equally repel each other to form a trigonal planar shape.
- **c.** The tetrahedral arrangement of the bonding and nonbonding electron pairs around nitrogen results in the shape of the molecule.
- **d.** The polarity of the nitrogen-bromine bond determines the shape of the molecule.
- **e.** The difference in electronegativity values for bromine and nitrogen determine the shape of the molecule.
- **f.** Nonbonding electron pairs in nitrogen determines the shape of the molecule.

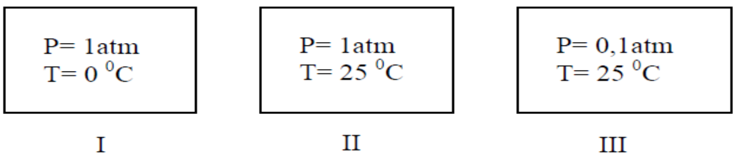
**Q 14** What can be said about the polarities of $CCl_4$ and $CHC1_3$? ($_1$H,1A; $_6$C,4A; $_{17}$Cl,7A)

- **a.** Both of them are polar
- **b.** Both of them are nonpolar
- **c.** $CHC1_3$ is polar and the other $CCl_4$ is nonpolar
- **d.** $CHC1_3$ is nonpolar and the other $CCl_4$ is polar

**Q 15** What is the reason for your answer to <u>question 14?</u>

- **a.** A molecule is nonpolar, only if atoms of molecule have same electronegativities.
- **b.** If molecule has tetrahedral shape, it is nonpolar
- **c.** If molecule contains polar bonds, it is a polar molecule.
- **d.** Polarity of molecule depends on the polarity of its bonds and shape of the molecule.

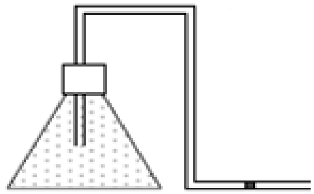
**Q 16** The figure below represents three closed 1.0 L vessels containing $H_2$ gases at different temperature and pressure.




Which one of the following shows the correct arrangement of those according to how the behavior of a real gas more nearly approaches that of the ideal gas?

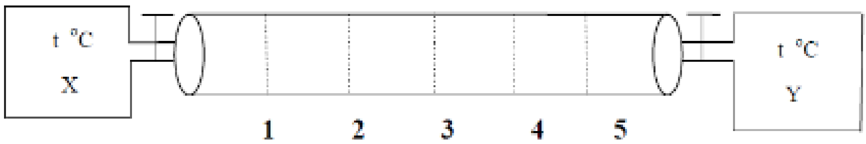
- **a.** I < II < III
- **b.** III < II < I
- **c.** II < III < I
- **d.** II < I < III
- **e.** I < III < II

**Q 17** The figure illustrates a system which has a drop of mercury in the glass tube. Depending on the pressure and temperature changes in the container, mercury drop is moving right or left. If the temperature of system changes from 25 ° C to 5 ° C, which of the following is correct regarding the movement of mercury?



**a.** It remains stable, because atmospheric pressure is constant.
**b.** First left, then moves right.
**c.** Moves left, because decrease in temperature results in decrease in pressure in the Erlenmeyer flask.
**d.** Moves right, because when temperature decreases, pressure decreases in Erlenmeyer flask and so volume increases.
**e.** Moves right, because when temperature decreases, volume decreases and so pressure increases in the Erlenmeyer flask.

**Q 18**




When X and Y gases in the figure above released at the same time and same temperature, the first encounter of the gases have been in the section 5. According to this, which one/s of the following statements is/are true?

I. The diffusion rate of X is greater than that of Y.
II. The molecular weight of X is greater than that of Y.
III. For encountering of these two gases in the middle of the tube, the container having Y gas must be heated.

**a.** Only I
**b.** I and II
**c.** I and III
**d.** II and III
**e.** I, II, III

**Q 19** A glass of cold milk sometimes forms a coat of water on the outside of the glass. How does most of the water get there?

- **a.** Water evaporates from the milk and condenses on the outside of the glass.
- **b.** The glass acts like a semi-permeable membrane and allows the water to pass, but not the milk.
- **c.** Water vapor in the air encounter with cold glass and condenses.
- **d.** The coldness causes oxygen and hydrogen from the air combine on the glass forming water.
- **e.** Air around the glass condenses and turns into liquid.

**Q 20** A certain amount of ice is received and heated continuously in a closed system. During this process, our material is going through two points of phase change: melting and boiling points. How do density and weight of the water vary in these points?

- **a.** The density increases in melting point and decreases in the boiling point but weight remains constant in both points
- **b.** The density decreases in both points but weight remains constant in both points
- **c.** The density increases in both points but weight remains constant in both points
- **d.** The density and weight decreases in both points
- **e.** The density and weight increases in both points

**Q 21** Cl, Br and I elements are in 7A group. They found in nature as diatomic and show similar chemical properties. What is the reason that Chlorine ($Cl_2$) is gas, Bromine ($Br_2$) is liquid, and Iodine ($I_2$) is solid at room temperature?

- **a.** Cl-Cl, Br-Br and I-I bond have not equal strength.
- **b.** $Cl_2$, $Br_2$, and $I_2$ molecules have different numbers of electrons.
- **c.** Electronegativity of Chloride, Bromine and Iodine are different from each other.

**Q 22** What is the reason for your answer to <u>question 21?</u>

- **a.** The intermolecular forces between the $I_2$ molecules, which have more electrons among them, are stronger than the others.
- **b.** The most electronegative one is Cl. Electronegative atoms are more active so Cl move faster and it is in gas state.
- **c.** Because Iodine has more protons, its nuclei pull electrons more strongly than the others.
- **d.** I-I covalent bond is stronger than the others so $I_2$ is in solid state at room temperature.

**Q 23** *Pure gold is often alloyed with other metals such as Cu and Ag to make gold stronger and harder. Based on the information in the table below, which of the following is the best explanation for the fact that the Au/Cu alloy is harder than the Au/Ag for same mole fraction of Au?

| Element | Metallic Radius (pm) | Melting point (°C) | Common Oxidation state |
|---|---|---|---|
| Au | 144 | 1064 | 1+, 3+ |
| Cu | 128 | 1085 | 1+, 2+ |
| Ag | 144 | 961 | 1+ |

**a.** Cu has two common oxidation states but Ag has only one.
**b.** Cu has a higher melting point than Au has, but Ag has a lower melting point than Au has.
**c.** Cu atoms are smaller than Ag atoms, thus Cu atoms displace more with atoms in the alloy.
**d.** Cu atoms are less polarizable than Au or Ag atoms, thus Cu has weaker interparticle forces.

**Q 24**

$$A(g) + B(g) \xrightarrow{C} D(g) + E(g)$$

Related with the role of C in the reaction, which one of the following statements is correct?
**a.** It is needed to initiate the reaction.
**b.** If it is used, pathway with a higher activation energy is disappear
**c.** If it is used, it produces higher yield of product.
**d.** It increases the rate of reaction but does not change or participate in the reaction.
**e.** If it is used, it uses a pathway with a lower activation energy to increase reaction rate.

**Q 25**

I. $CH_3CHO(g) \longrightarrow CH_4(g) + CO(g)$ $Ea_1$
II. $H_2(g) + I_2(g) \longrightarrow 2\,HI(g)$ $Ea_2$

All conditions are the same for both reactions and it is known that second reaction occurs faster than the first reaction. According to this, which one(s) of the following statements is/are true?

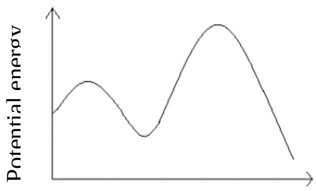
I. In second reaction, all molecular collision resulted with reaction.
II. Activation energy of a first reaction ($Ea_1$) is greater than the activation energy of the second reaction ($Ea_2$).
III. Rate of second reaction is greater than the first reaction.

**a.** Only I **b.** Only II **c.** I, II **d.** II, III **e.** I, II, III

**Q 26** Which one of the following statements is correct about the effect of temperature on rate of reaction?

- **a.** When temperature decreases, rate of endothermic reactions decreases but rate of exothermic reactions increases.
- **b.** When temperature decreases, rate of reactions decreases.
- **c.** When temperature increases, rate of reaction decreases
- **d.** Increase in temperature increases reaction rates of only substances in gas phase
- **e.** Change in temperature does not affect reaction rate

**Q 27** The graph below shows the potential energy versus reaction coordinate for multistep reactions. Which one of the following statements is wrong?




- **a.** Step 1 in the reaction mechanism determines the reaction rate.
- **b.** The reaction occurs in a two-step mechanism.
- **c.** Activation energy for step 2 is greater than that of step 1.
- **d.** Step 1 is faster than step 2.
- **e.** It is an exothermic reaction.

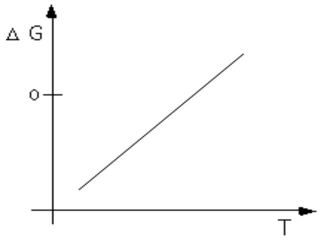
**Q 28** Which one of the following statements is correct about the spontaneity of a reaction?

- **a.** Spontaneous reactions occur when heat evolves from the system to the surroundings.
- **b.** All natural reactions are exothermic.
- **c.** Endothermic chemical reactions cannot occur spontaneously.
- **d.** A spontaneous process occurs in one direction only, and the reverse of any spontaneous process is always nonspontaneous.
- **e.** A reaction cannot be spontaneous if there is negative entropy change.

**Q 29** Which of the following processes will have a negative change in entropy?

- **a.** $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
- **b.** $N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$
- **c.** $H_2O(s) \rightarrow H_2O(l)$
- **d.** $N_2O_4(g) \rightarrow 2NO_2(g)$
- **e.** $2Na_2O_2(s) + 2H_2O(l) \rightarrow 4NaOH(aq) + O_2(g)$

**Q 30** The following graph illustrates the change in Gibbs free energy ($\Delta G$) vs temperature (T) at which a reaction occurs. Since $\Delta G$ depends not only on temperature but also on enthalpy and entropy change, which of the following situations best explains these changes for the given reaction?




**a.** $\Delta H > 0$ $\Delta S < 0$
**b.** $\Delta H > 0$ $\Delta S > 0$
**c.** $\Delta H < 0$ $\Delta S < 0$
**d.** $\Delta H < 0$ $\Delta S > 0$
**e.** $\Delta H = 0$ $\Delta S < 0$

.........................................................................................................END OF TEST



| GCCT-Answer Key | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| C | B | A | A | B | B | E | B | B | B |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| A | B | B | C | D | A | C | C | C | C |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| B | A | C | E | D | B | A | D | B | C |

## D. Student Background Questionnaire

| Student Background Questionnaire |
|---|

**Dear Participants,**

Student background questionnaire is designed to be used in a research project in general chemistry course. The purpose of this project is to investigate the effectiveness of the Peer-led Team Learning (PLTL) model over traditional college chemistry teaching in undergraduate general chemistry courses of engineering students.

This questionnaire aims to get information about your demographic information and your anxiety level in many situations. In this regard, surveys will be implemented in this questionnaire. The answer you give on them will be used to improve the quality of teaching and learning in general chemistry courses.

There are three sections:

Section I: Student Demographic Information

Section II: State-Trait Anxiety Inventory

Section III: Social Anxiety Questionnaire for Adults

Please complete all sections in the questionnaire by answering the questions as accurately as possible. All information that is collected in this study will be treated confidentially. Thank you very much for your cooperation.

Name-Surname: ____________________

Section: ___________________________

## SECTION I: STUDENT DEMOGRAPHIC INFORMATION

**Directions:** Please answer each question as accurately as possible by marking the correct answer or filling in the space provided.

**1.** Name- Surname: ______________________________________________
**2.** Section: _____________________________________________________
**3.** Department: __________________________________________________
**4.** Gender:

| Male | Female |
|---|---|
| ☐1 | ☐2 |

**5.** Birth Date: _____/______/_______ (Month/day/year)
**6.** Type of your High School:

| Public High Schools | Vocational High Schools | Anatolian High Schools | Science High Schools | Private High Schools | Others |
|---|---|---|---|---|---|
| ☐1 | ☐2 | ☐3 | ☐4 | ☐5 | ☐6 |

**7.** University Entrance Year:_________________________________________
**8.** Undergraduate Placement Examination Score (LYS-MF):______________
**9.** Scholarships (Burs):

| None | 25 fully funded | 50 fully funded | 75 fully funded | 100 fully funded |
|---|---|---|---|---|
| ☐1 | ☐2 | ☐3 | ☐4 | ☐5 |

**10.** Level of Education of Mother:

| No formal schooling | Primary school | High School | University | Postgraduate (MS, PhD) |
|---|---|---|---|---|
| ☐1 | ☐2 | ☐3 | ☐4 | ☐5 |

**11.** Level of Education of Father:

| No formal schooling | Primary school | High School | University | Postgraduate (MS, PhD) |
|---|---|---|---|---|
| ☐1 | ☐2 | ☐3 | ☐4 | ☐5 |

**12.** Family Income (in TL for month):

| Lower Class (≥3.000.00) | Working Class (3.000.00-7.000.00) | Middle Class (7.000.00-12.000.00) | Upper middle Class (12.000.00-16.000.00) | Upper Class (16.000.00<) |
|---|---|---|---|---|
| ☐1 | ☐2 | ☐3 | ☐4 | ☐5 |

**SECTION II: STATE-TRAIT ANXIETY INVENTORY**

**State Anxiety Scale (STAI-S)**

**Directions:** A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right now*, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best**.**

| No | Statements | Not At All | Somewhat | Moderately So | Very Much So |
|---|---|---|---|---|---|
| 1 | I feel calm | (1) | (2) | (3) | (4) |
| 2 | I feel secure | (1) | (2) | (3) | (4) |
| 3 | I am tense | (1) | (2) | (3) | (4) |
| 4 | I feel strained | (1) | (2) | (3) | (4) |
| 5 | I feel at ease | (1) | (2) | (3) | (4) |
| 6 | I feel upset | (1) | (2) | (3) | (4) |
| 7 | I am presently worrying over possible misfortunes. | (1) | (2) | (3) | (4) |
| 8 | I feel satisfied. | (1) | (2) | (3) | (4) |
| 9 | I feel frightened | (1) | (2) | (3) | (4) |
| 10 | I feel comfortable | (1) | (2) | (3) | (4) |
| 11 | I feel self-confident | (1) | (2) | (3) | (4) |
| 12 | I feel nervous | (1) | (2) | (3) | (4) |
| 13 | I am jittery | (1) | (2) | (3) | (4) |
| 14 | I feel indecisive | (1) | (2) | (3) | (4) |
| 15 | I am relaxed | (1) | (2) | (3) | (4) |
| 16 | I feel content | (1) | (2) | (3) | (4) |
| 17 | I am worried | (1) | (2) | (3) | (4) |
| 18 | I feel confused | (1) | (2) | (3) | (4) |
| 19 | I feel steady | (1) | (2) | (3) | (4) |
| 20 | I feel pleasant | (1) | (2) | (3) | (4) |

**Trait Anxiety Scale (STAI-T)**

**Directions:** A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your feelings generally best.

| No | Statements | Almost Never | Sometimes | Often | Almost Always |
|---|---|---|---|---|---|
| 21 | I feel pleasant | (1) | (2) | (3) | (4) |
| 22 | I feel nervous and restless | (1) | (2) | (3) | (4) |
| 23 | I feel satisfied with myself | (1) | (2) | (3) | (4) |
| 24 | I wish I could be as happy as others seem to be | (1) | (2) | (3) | (4) |
| 25 | I feel like a failure | (1) | (2) | (3) | (4) |
| 26 | I feel upset | (1) | (2) | (3) | (4) |
| 27 | I am "calm, cool, and collected" | (1) | (2) | (3) | (4) |
| 28 | I feel that difficulties are piling up so that I cannot overcome them | (1) | (2) | (3) | (4) |
| 29 | I worry too much over something that really doesn't matter | (1) | (2) | (3) | (4) |
| 30 | I am happy | (1) | (2) | (3) | (4) |
| 31 | I have disturbing thoughts | (1) | (2) | (3) | (4) |
| 32 | I lack self-confidence | (1) | (2) | (3) | (4) |
| 33 | I feel secure | (1) | (2) | (3) | (4) |
| 34 | I make decisions easily | (1) | (2) | (3) | (4) |
| 35 | I feel inadequate | (1) | (2) | (3) | (4) |
| 36 | I am content | (1) | (2) | (3) | (4) |
| 37 | Some unimportant thoughts runs through my mind and bothers me. | (1) | (2) | (3) | (4) |
| 38 | I take disappointments so keenly that I can't put them out of my mind | (1) | (2) | (3) | (4) |
| 39 | I am a steady person | (1) | (2) | (3) | (4) |
| 40 | I get in a state of tension or turmoil as I think over my recent concerns and interests | (1) | (2) | (3) | (4) |

**SECTION III: SOCIAL ANXIETY QUESTIONNAIRE FOR ADULTS (SAQ)**

**Directions:** Below are a series of social situations that may or may not cause you unease, stress or nervousness. Please circle the number next to each social situation that best reflects your reaction. If you have never experienced the situation described, please imagine what your level of unease, stress, or nervousness might be if you were in that situation. Please do so **honestly** and do not worry about your answer because there are no right or wrong ones.

| No | Statements | Not At All or very slight | Slight | Moderate | High | Very high or extremely high |
|---|---|---|---|---|---|---|
| 1 | Greeting someone and being ignored | (1) | (2) | (3) | (4) | (5) |
| 2 | Having to ask a neighbor to stop making noise | (1) | (2) | (3) | (4) | (5) |
| 3 | Speaking in public | (1) | (2) | (3) | (4) | (5) |
| 4 | Asking someone attractive of the opposite sex for a date | (1) | (2) | (3) | (4) | (5) |
| 5 | Complaining to the waiter about my food | (1) | (2) | (3) | (4) | (5) |
| 6 | Feeling watched by people of the opposite sex | (1) | (2) | (3) | (4) | (5) |
| 7 | Participating in a meeting with people in authority | (1) | (2) | (3) | (4) | (5) |
| 8 | Talking to someone who isn't paying attention to what I am saying | (1) | (2) | (3) | (4) | (5) |
| 9 | Refusing when asked to do something I don't like doing | (1) | (2) | (3) | (4) | (5) |
| 10 | Making new friends | (1) | (2) | (3) | (4) | (5) |
| 11 | Telling someone that they have hurt my feelings | (1) | (2) | (3) | (4) | (5) |
| 12 | Having to speak in class, at work, or in a meeting | (1) | (2) | (3) | (4) | (5) |
| 13 | Maintaining a conversation with someone I've just met | (1) | (2) | (3) | (4) | (5) |
| 14 | Expressing my annoyance to someone that is picking on me | (1) | (2) | (3) | (4) | (5) |
| 15 | Greeting each person at a social meeting when I don't know most of them | (1) | (2) | (3) | (4) | (5) |
| 16 | Being teased in public | (1) | (2) | (3) | (4) | (5) |
| 17 | Talking to people I don't know at a party or a meeting | (1) | (2) | (3) | (4) | (5) |

| | | | | | | |
|---|---|---|---|---|---|---|
| 18 | Being asked a question in class by the teacher or by a superior in a meeting | (1) | (2) | (3) | (4) | (5) |
| 19 | Looking into the eyes of someone I have just met while we are talking | (1) | (2) | (3) | (4) | (5) |
| 20 | Being asked out by a person I am attracted to | (1) | (2) | (3) | (4) | (5) |
| 21 | Making a mistake in front of other people | (1) | (2) | (3) | (4) | (5) |
| 22 | Attending a social event where I know only one person | (1) | (2) | (3) | (4) | (5) |
| 23 | Starting a conversation with someone of the opposite sex that I like | (1) | (2) | (3) | (4) | (5) |
| 24 | Being reprimanded about something I have done wrong | (1) | (2) | (3) | (4) | (5) |
| 25 | While having dinner with colleagues, classmates or workmates, being asked to speak on behalf of the entire group | (1) | (2) | (3) | (4) | (5) |
| 26 | Telling someone that their behavior bothers me and asking them to stop | (1) | (2) | (3) | (4) | (5) |
| 27 | Asking someone I find attractive to dance | (1) | (2) | (3) | (4) | (5) |
| 28 | Being criticized | (1) | (2) | (3) | (4) | (5) |
| 29 | Talking to a superior or a person in authority | (1) | (2) | (3) | (4) | (5) |
| 30 | Telling someone I am attracted to that I would like to get to know them better | (1) | (2) | (3) | (4) | (5) |

## E. Critical Components Rubric

| Workshop Chemistry: Critical Components Rubric | | None (0) | Partially (1) | Fully (2) | Comments |
|---|---|---|---|---|---|
| Components | Criteria | | | | |
| Integral to the Course | 1. Did the workshop cover the lecture material for that week? | | | | |
| | 2. Were workshops sometimes used to remediate or cover prerequisite skills? | | | | |
| | 3. Had lecture time been changed with the introduction of workshops? | | | | |
| | 4. Were students required to attend the workshops? | | | | |
| The Workshop Materials | 5. Were the workshop materials designed and prepared to review fundamentals? | | | | |
| | 6. Were they related to the lecture and to the textbook? | | | | |
| | 7. Were workshop problems helpful preparation for exams? | | | | |
| | 8. Did workshop problems encourage collaborative learning? | | | | |
| | 9. Did workshop materials include challenging non-routine problems? | | | | |
| The Workshop Leaders | 10. Was knowledge of chemistry needed provided to leader in training session? | | | | |
| | 11. Were collaborative teaching/learning skills developed in leader in training? | | | | |
| | 12. Was a good supervision provided to peer leaders? | | | | |
| | 13. Were activities planned for exploratory discussions? | | | | |
| | 14. Were different kind of team/collaborative learning activities or methods used to get students working together? | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | 15. Were less able students and more able students taken into account for assigning to groups? | | | | |
| The faculty Involvement | 16. Does the professor meet regularly with peer leaders? | | | | |
| | 17. Did other faculty and professional resources contribute to the workshops? | | | | |
| | 18. Is someone else delegated to train and supervise the peer leaders? | | | | |
| | 19. Has the workshop approach led to revisions in the assessment of student performance? | | | | |
| | 20. Did the workshops continue smoothly without any administrative obstacles? | | | | |
| Organizational Arrangements | 21. Is the frequency of workshops appropriate? | | | | |
| | 22. Is the space adequate? | | | | |
| | 23. Is noise a problem? | | | | |
| | 24. Is workshops time adequate? | | | | |
| | 25. Is the size appropriate for cooperative group learning? | | | | |
| Administrative Support | 26. Is logistic support provided for workshop courses? | | | | |
| | 27. Is on-going funding available for workshop leaders? | | | | |
| | 28. Are space and time adjustments made to suit workshop courses? | | | | |
| | 29. Are courses in pedagogy included for student leaders | | | | |

Description of scores:

| |
|---|
| None: No attempt was made to complete the requirements<br>Partially: Some of the requirements were completed well<br>Fully: All the requirements were completed well |

## F. PLTL Student Survey

**Peer Led Team Learning**
**Student Survey**

**A.** For each item, circle the number that corresponds to your response:

| | | strongly disagree | disagree | Neutral | agree | strongly agree |
|---|---|---|---|---|---|---|
| 1 | The workshops are closely related to the material taught in the lectures. | (1) | (2) | (3) | (4) | (5) |
| 2 | Workshops help me do better in tests. | (1) | (2) | (3) | (4) | (5) |
| 3 | Interacting with the workshop leader increases my understanding. | (1) | (2) | (3) | (4) | (5) |
| 4 | The workshop materials are helpful preparation for exams. | (1) | (2) | (3) | (4) | (5) |
| 5 | Workshop materials are more challenging than most textbook problems. | (1) | (2) | (3) | (4) | (5) |
| 6 | I believe that the workshops are improving my grade. | (1) | (2) | (3) | (4) | (5) |
| 7 | I regularly explain problems to other students in the workshops. | (1) | (2) | (3) | (4) | (5) |
| 8 | Interacting with the other group members increases my understanding | (1) | (2) | (3) | (4) | (5) |
| 9 | I would recommend workshop courses to other students. | (1) | (2) | (3) | (4) | (5) |
| 10 | In the workshops I am comfortable asking questions when I do not understand something. | (1) | (2) | (3) | (4) | (5) |
| 11 | The lecturer encourages us to participate in the workshops. | (1) | (2) | (3) | (4) | (5) |
| 12 | The workshops are often dominated by one or two students. | (1) | (2) | (3) | (4) | (5) |
| 13 | Noise or other distractions make it difficult to benefit from the workshops. | (1) | (2) | (3) | (4) | (5) |
| 14 | Students who are uninterested or unmotivated make it difficult for others to benefit from the workshops. | (1) | (2) | (3) | (4) | (5) |
| 15 | I felt comfortable with the workshop leader. | (1) | (2) | (3) | (4) | (5) |
| 16 | The workshop leader is well prepared. | (1) | (2) | (3) | (4) | (5) |
| 17 | I am uncomfortable asking questions in the lecture. | (1) | (2) | (3) | (4) | (5) |
| 18 | The workshops are a big help in solving problems. | (1) | (2) | (3) | (4) | (5) |
| 19 | I would like to be a workshop leader in the future. | (1) | (2) | (3) | (4) | (5) |
| 20 | In the workshops I enjoyed interacting with the other students. | (1) | (2) | (3) | (4) | (5) |
| 21 | The workshop experience led me to join formal or informal study groups related to other courses. | (1) | (2) | (3) | (4) | (5) |
| | | 0–2 h | 2–4 h | 4–6 h | 6–8 h | 8–10 h |
| 22 | On average, I spend the following number of hours per week studying ( in addition to time spent at lectures and workshops) | (1) | (2) | (3) | (4) | (5) |

**B.** These items are about the materials used in the workshops. Rate the following objectives how well the materials meet each of them.

The materials are:

| | | Not at all | somewhat | rather well | very well | excellent |
|---|---|---|---|---|---|---|
| 23 | Well connected with the lecture | (1) | (2) | (3) | (4) | (5) |
| 24 | Challenging | (1) | (2) | (3) | (4) | (5) |
| 25 | Developed to review fundamentals | (1) | (2) | (3) | (4) | (5) |
| 26 | Useful for group work | (1) | (2) | (3) | (4) | (5) |
| 27 | Motivational | (1) | (2) | (3) | (4) | (5) |
| 28 | Helpful for individual study | (1) | (2) | (3) | (4) | (5) |
| 29 | Useful for reinforcing concepts | (1) | (2) | (3) | (4) | (5) |

**C.** Rate each of the following activities according to the amount of workshop time devoted to it.

| | | almost no time | a small amount of time | a moderate amount of time | a large amount of time | most of the time |
|---|---|---|---|---|---|---|
| 30 | The workshop leader presents ideas and methods. | (1) | (2) | (3) | (4) | (5) |
| 31 | The leader responds to student questions. | (1) | (2) | (3) | (4) | (5) |
| 32 | Students work on problems in pairs or small groups. | (1) | (2) | (3) | (4) | (5) |
| 33 | Students work on problems alone. | (1) | (2) | (3) | (4) | (5) |
| 34 | Students present solutions. | (1) | (2) | (3) | (4) | (5) |
| 35 | Hands-on activities. | (1) | (2) | (3) | (4) | (5) |
| 36 | Technology and computer simulations. | (1) | (2) | (3) | (4) | (5) |

Thank you for your participation.

## G. PLTL Leader Survey

| Peer Led Team Learning<br>Leader Survey |
|---|

**A.** Please answer the following questions below.

| | |
|---|---|
| 1 | How often do workshops meet? |
| 2 | What is the scheduled length of a workshop meeting? |
| 3 | For how long do you usually meet? |
| 4 | How many students are enrolled in your workshop? |
| 5 | On average, how many students usually attend a workshop? |
| 6 | What do you think is the best number of students for a workshop? |
| 7 | Attendance at workshops (is, is not) a course requirement. |
| 8 | About how much of your time per week is taken by workshop preparation and activities, not including the workshop itself? |
| 9 | Please describe the activities as they take place in a typical workshop? |

**B.** Rate each of the following activities according to workshop time devoted to it.

| | almost no time | a small amount of time | a moderate amount of time | a large amount of time | most of the time |
|---|---|---|---|---|---|
| 10. The workshop leader presents ideas and methods. | (1) | (2) | (3) | (4) | (5) |
| 11. The leader responds to student questions. | (1) | (2) | (3) | (4) | (5) |
| 12. Students work on problems in pairs or small groups. | (1) | (2) | (3) | (4) | (5) |
| 13. Students work on problems alone. | (1) | (2) | (3) | (4) | (5) |
| 14. Students present solutions. | (1) | (2) | (3) | (4) | (5) |
| 15. Hands-on activities such as use of models | (1) | (2) | (3) | (4) | (5) |
| 16. Use of technology or computer simulations | (1) | (2) | (3) | (4) | (5) |

17. What methods are used to get students working together?

18. What did you do for students having difficulty?

19. Did students sometimes discuss personal problems with you? If so, how did you respond to them?

**C.** The next items refer to the materials used in workshops. Rate the following objectives how well the materials meet each of them.

The materials are:

| | Not at all | somewhat | rather well | very well | excellent |
|---|---|---|---|---|---|
| 20. Well connected with the lecture | (1) | (2) | (3) | (4) | (5) |
| 21. Challenging | (1) | (2) | (3) | (4) | (5) |
| 22. Developed to review fundamentals | (1) | (2) | (3) | (4) | (5) |
| 23. Useful for group work | (1) | (2) | (3) | (4) | (5) |
| 24. Motivational | (1) | (2) | (3) | (4) | (5) |
| 25. Helpful for individual study | (1) | (2) | (3) | (4) | (5) |
| 26. Useful for reinforcing concepts | (1) | (2) | (3) | (4) | (5) |
| 27. Are workshop problems good preparation for tests? Please describe. | | | | | |
| 28. Do workshop materials include challenging problems? Please describe. | | | | | |
| 29. Were the workshop materials too difficult or too easy for students in your group? If so, what did you do? | | | | | |

| |
|---|
| 30. What training and support are provided to leaders in how to run workshops, for example in group dynamics or instructional processes? |
| 31. What training and support are provided to the workshop leaders in the knowledge of the discipline? |
| 32. What training and support are provided to the workshop leaders in theories of learning and related methods of teaching? |
| 33. What parts of student leader training have been most useful? What do you need more of? |
| 34. How do you interact with the professor teaching the workshop course? |

Thank you for your participation.

## H. Approval of Ethical Commission

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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07 EKİM 2016

Sayı: 28620816 / 376

Konu: Değerlendirme Sonucu

Gönderilen: Prof.Dr. Ömer GEBAN

Eğitim Bilimleri

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın : Prof.Dr. Ömer GEBAN;

Danışmanlığını yaptığınız doktora öğrencisi N.Ece EREN'in "Development and Implementation of the Peer- Led Team Learning (PLTL) To Turkısh Context: Effect on Students Achievement and Anxiety in Undergraduate General Chemistry Courses" başlıklı araştırması İnsan Araştırmaları Kurulu tarafından uygun görülerek gerekli onay **2016-EGT-142** protokol numarası ve **20.10.2016-18.06.2017** tarihleri arasında geçerli olmak üzere verilmiştir

Bilgilerinize saygılarımızla sunarız.

Prof. Dr. Canan SÜMER

İnsan Araştırmaları Etik Kurulu Başkanı

Prof. Dr. Meliha ALTUNIŞIK
İAEK Üyesi

Prof. Dr. Ayhan SOL
İAEK Üyesi

Prof. Dr. Mehmet UTKU
İAEK Üyesi

Prof. Dr. Ayhan Gürbüz DEMİR
İAEK Üyesi

Yrd .Doç.Dr. Pınar KAYGAN
İAEK Üyesi

Yrd. Doç. Dr. Emre SELÇUK
İAEK Üyesi

**BU BÖLÜM, İLGİLİ BÖLÜMLERİ TEMSİL EDEN İNSAN ARAŞTIRMALARI ETİK ALT KURULU TARAFINDAN DOLDURULACAKTIR.**

Protokol No: 2016-FEN-ST-142

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**İAEK DEĞERLENDİRME SONUCU**

**Sayın Hakem,**

**Aşağıda yer alan üç seçenekten birini işaretleyerek değerlendirmenizi tamamlayınız. Lütfen "<u>Revizyon Gereklidir</u>" ve "<u>Ret</u>" değerlendirmeleri için gerekli açıklamaları yapınız.**

Değerlendirme Tarihi: 07-10-2016

Ad Soyad: Metin girmek için tıklayın

---

☒ **Herhangi bir değişikliğe gerek yoktur. Veri toplama/uygulama başlatılabilir.**

☐ **Revizyon gereklidir**

- ☐ Gönüllü Katılım Formu yoktur.
- ☐ Gönüllü Katılım Formu eksiktir.

  Gerekçenizi ayrıntılı olarak açıklayınız: Metin girmek için tıklayın
- ☐ Katılım Sonrası Bilgilendirme Formu yoktur.
- ☐ Katılım Sonrası Bilgilendirme Formu eksiktir.

  Gerekçenizi ayrıntılı olarak açıklayınız: Metin girmek için tıklayın
- ☐ Rahatsızlık kaynağı olabilecek sorular/maddeler ya da prosedürler içerilmektedir.

  Gerekçenizi ayrıntılı olarak açıklayınız: Metin girmek için tıklayın
- ☐ Diğer.

  Gerekçenizi ayrıntılı olarak açıklayınız: Metin girmek için tıklayın.

☐ **Ret**

Ret gerekçenizi ayrıntılı olarak açıklayınız: Metin girmek için tıklayın

## I. Sample Workshop Materials

**PLTL WORKSHOP MATERIALS: CHEMICAL KINETICS**

# Peer-Led General Chemistry Workshop

## Contents

- *Thermochemistry*
- *Electronic Structure of Atoms*
- *Periodic Properties of the Elements*
- *Basic Concepts of Chemical Bonding*
- *Molecular Geometry and Bonding Theories*
- *Gases*
- *Liquids and Intermolecular Forces*
- *Solids and Modern Materials*
- *Thermodynamics*
- ***Chemical Kinetics***

## UNIT 14 CHEMICAL KINETICS

## A. Content Outline and Objectives

| | |
|---|---|
| 14.1 Factors that Affect Reaction Rates<br>14.2 Reaction Rates<br>14.3 Concentration and Rate Laws<br>14.4 The Change of Concentration with Time<br>14.5 Temperature and Rate<br>14.6 Reaction Mechanisms and Catalysis | 14.1.1 Students will be able to identify the factors affecting rate of heterogeneous reaction.<br>14.1.2 Students will be able to identify the factors affecting rate of reaction by relating its rate law.<br>14.2.1 Students will be able to determine the rate law by measuring the change in concentration of a reactant or product with time.<br>14.3.1 Students will be able to formulate the rate law by using initial rates of reaction and initial concentrations of the reactants.<br>14.3.2 Students will be able to calculate the rate constants.<br>14.3.3 Students will be able to explain the effect of concentration change on rate of reaction.<br>14.4.1 Students will be able to write rate law based on the given rate equations order.<br>14.4.2 Students will be able to relate the change in concentration to the time passed for this change in first and second order reaction.<br>14.4.3 Students will be able to determine the half-life for first and second order reaction.<br>14.5.1 Students will be able to determine the activation energy by using Arrhenius equation.<br>14.6.1 Students will be able to recognize the mechanism of multistep reaction and catalyst<br>14.6.2 Students will be able to determine the molecularity of elementary step.<br>14.6.3 Students will be able to determine intermediates in multistep mechanism.<br>14.6.4 Students will be able to determine catalyst in multistep mechanism.<br>14.6.5 Students will be able to formulate rate for a multistep mechanism with a slow initial step<br>14.6.6 Students will be able to formulate the rate for a multistep mechanism with a fast initial step |

## B. General Chemistry Workshop Problems

Part 1: Individual review problems → Part 2: Team learning problems → Part 3: Individual assessment problems

## PART I: Individual Review Problems


**Q.1** The rate of a stoichiometric reaction between a solid and a gas in a container may be increased by increasing all of the following factors EXCEPT the (LO.14.1.1)

- **a.** Pressure of the gas.
- **b.** Temperature of the gas.
- **c.** Volume of the container.
- **d.** Surface area of the solid.

**Q.2** The rate law of the overall reaction is R = k $[A]^2$.

$$A + B \rightarrow C$$

Which of the following will <u>not</u> increase the rate of the reaction? (LO.14.1.2)

- **a.** increasing the concentration of reactant A
- **b.** increasing the concentration of reactant B
- **c.** increasing the temperature of the reaction
- **d.** adding a catalyst for the reaction

**Q.3** Nitrogen dioxide decomposes to nitric oxide and oxygen via the reaction:

$$2NO_2\ (g) \rightarrow 2NO\ (g) + O_2\ (g)$$

In a particular experiment at 300°C, the concentration of $NO_2$ drops from 0.0100 to 0.00650 M in 100 s. What is the rate of appearance of oxygen in M/s? (M=mol/L) (LO.14.2.1)

- **a.** $1.8 \times 10^{-5}$
- **b.** $3.5 \times 10^{-5}$
- **c.** $7.0 \times 10^{-5}$
- **d.** $3.5 \times 10^{-3}$

**Q.4** For the reaction below, the rate law is rate = $k[H_2][NO]^2$

$$2\ H_2(g) + 2\ NO(g) \rightarrow N_2(g) + 2\ H_2O(g)$$

At a given temperature, what is the effect on the reaction rate if the concentration of $H_2$ is doubled and the concentration of NO is halved? (LO.14.3.3)

- **a.** The reaction rate is halved.
- **b.** The reaction rate is unchanged.
- **c.** The reaction rate is doubled.
- **d.** The reaction rate increases eightfold.

**Q.5** A first-order reaction has a rate constant of $k = 0.320\ min^{-1}$. For an initial reactant concentration of 1.22 M, how long does it take for its concentration to fall to 0.150 M? (LO.14.4.2)

**a.** 0.671 min
**b.** 2.60 min
**c.** 6.55 min
**d.** 25.4 min

**Q.6** The decomposition of $N_2O_5$ in solution in carbon tetrachloride proceeds via the reaction

$$2N_2O_5\ (aq) \rightarrow 4NO_2\ (aq) + O_2\ (aq)$$

The reaction is determined as first order experimentally and has a rate constant of $4.82 \times 10^{-3}\ s^{-1}$ at 64°C. What is the rate law for this reaction? (LO.14.4.1)

**a.** $k[N_2O_5]^2$
**b.** $k\dfrac{[NO_2]^4[O_2]}{[N_2O_5]^2}$
**c.** $k[N_2O_5]$
**d.** $k\dfrac{[N_2O_5]^2}{[NO_2]^4[O_2]}$

**Q.7** Hydrogen peroxide decomposes into water and oxygen in a first-order process.

$$2H_2O_2(I) \rightarrow 2H_2O(l) + O_2(g)$$

A solution originally at 0.600 M $H_2O_2$ is found to be 0.075 M after 54 min. What is the half-life for this reaction in min? (LO.14.4.3)

**a.** 6.8
**b.** 18
**c.** 14
**d.** 28

**Q.8** Which statement about chemical reaction mechanisms is correct? (LO.14.6.1)

**a.** The overall rate law can be determined from any step in the mechanism.
**b.** The rate of a reaction is the rate of the fastest elementary step of its mechanism.
**c.** The chemical equation for the sum of all the elementary steps is the chemical equation of the overall reaction.
**d.** Species that are produced and subsequently consumed in the mechanism serve as catalysts for the reaction.

**Q.9** The reaction of nitrogen dioxide with carbon monoxide

$$NO_2(g) + CO(g) \rightarrow CO_2(g) + NO(g)$$

has been studied and the following mechanism has been proposed:

$$NO_2(g) + NO_2(g) \rightarrow NO_3(g) + NO(g) \quad \text{slow}$$
$$NO_3(g) + CO(g) \rightarrow NO_2(g) + CO_2(g) \quad \text{fast}$$

What rate law corresponds to this mechanism? (LO.14.6.5)
**a.** Rate = $k[NO_2]$
**b.** Rate = $k[NO_2][CO]$
**c.** Rate = $k[NO_2]^2$
**d.** Rate = $k[NO_2]^2[CO]$

## PART II: Team Learning Problems


**Q 1** The following experimental data was measured for the reaction below at 904 °C:

$$2\ NO(g) + 2\ H_2(g) \rightarrow N_2(g) + 2\ H_2O(g)$$

Answer the following questions by using rate data. (LO.14.3.1-LO.14.3.2)

| | **Initial Reactant Concentration (M)** | | |
|---|---|---|---|
| **Experiment number** | **[NO]** | **[$H_2$]** | **Initial Rate (M/s)** |
| 1 | 0.42 | 0.12 | 0.136 |
| 2 | 0.21 | 0.12 | 0.034 |
| 3 | 0.21 | 0.24 | 0.068 |

**a.** Determine the order of each reactant and the overall reaction order

**b.** Write the rate equation for the reaction.

**c.** Calculate the rate constant for the reaction.

**d.** Find the rate at the instant when [NO] = 0.35 M and [$H_2$] =0.20 M.

**Q.2** Butadiene, $C_4H_6(g)$ reacts to form its dimer according to the equation as follows:

$$2\ C_4H_6(g) \rightarrow C_8H_{12}(g)$$

The following data were collected for this second order reaction at a high temperature: (LO.14.3.2-LO.14.4.1- LO.14.4.2-LO.14.4.3)

| $[C_4H_6]$ (M) | Time (s) |
|---|---|
| **0.01000** | 0 |
| **0.00625** | 1000 |
| **0.00476** | 1800 |
| **0.00313** | 3600 |

**a.** Write and discuss the rate law expression.

**b.** Determine the value of the rate constant for this reaction?

**c.** Determine the half-life for the reaction under the conditions of this experiment?

**d.** How long does it take for 75 % of butadiene to react?

**Q.3** The data in the table below shows the temperature dependence of the rate constant for the reaction: ($R$ = 8.314 J/K·mol)

$$N_2O_5(g) \rightarrow 2\ NO_2(g) + 1/2\ O_2(g)$$

Answer the following questions by using the data given below. (LO.14.5.1)

| T (K) | k($s^{-1}$) |
|---|---|
| **338** | ? |
| **318** | $4.98 \times 10^{-4}$ |
| **298** | $3.46 \times 10^{-5}$ |
| **273** | $7.87 \times 10^{-7}$ |

**a.** Calculate the activation energy for the reaction and interpret $E_a$ term for the rate of that reaction.

**b.** Calculate the rate constant at 338 K. How does the rate constant affect reaction rate?

**Q.4** Nitric oxide is formed at high temperature in the presence of oxygen and nitrogen. A proposed mechanism for its formation is shown: (LO.14.6.2- LO.14.6.3- LO.14.6.4- LO.14.6.6)

| | | |
|---|---|---|
| Step 1 : | $O_2(g) \rightleftharpoons 2\ O(g)$ | fast |
| Step 2: | $N_2(g) + O(g) \rightarrow NO(g) + N(g)$ | slow |
| Step 3: | $N(g) + O(g) \rightarrow NO(g)$ | very fast |

**a.** Write the equation for overall reaction.

**b.** Write the molecularity of each step.

**c.** If any, identify all intermediates in the mechanism. State your reason.

**d.** If any, identify the catalyst in the mechanism. State your reason.

**e.** Identify the rate determining step of this mechanism and outline your reasoning.

**f.** Write the rate law for overall reaction.

**g.** Determine the overall order of the reaction

## PART III: Individual Assessment Problems

Yes you can

**Q.1** The following data were measured for the reaction of chlorine dioxide with fluorine gases. (LO.14.3.1-LO.14.3.2-LO.14.1.2)

$$F_{2\,(g)} + 2\,ClO_{2\,(g)} \rightarrow 2FClO_{2\,(g)}$$

| | Initial Reactant Concentration (M) | | |
|---|---|---|---|
| **Experiment Number** | **[$F_2$] (M)** | **[$ClO_2$] (M)** | **Initial rate (M/s)** |
| **1** | 0.10 | 0.10 | $1.2 \times 10^{-3}$ |
| **2** | 0.10 | 0.40 | $4.8 \times 10^{-3}$ |
| **3** | 0.20 | 0.10 | $2.4 \times 10^{-3}$ |

**a.** Determine the rate law for this reaction.

**b.** Calculate the rate constant, k.

**c.** How does increasing the concentration of $F_{2\,(g)}$ affect the rate of reaction? Explain briefly?

**Q.2** The following mechanism has been proposed for the reaction: $2SO_2 + O_2 \rightarrow 2SO_3$. (LO.14.6.3-LO.14.6.4-LO.14.6.5)

Step 1: $2NO + O_2 \rightarrow 2NO_2$ slow

Step 2: $2NO_2 + 2SO_2 \rightarrow 2NO + 2SO_3$ fast

**a.** Which is the rate determining step? Why?

_______________________________________

**b.** Identify the catalyst with your reason.__________________________________

**c.** Identify the intermediate with your reason

_______________________________________

**d.** Write the rate law for the reaction.

_______________________________________

**e.** What is the overall reaction order?

## C. Answer Key

### Individual Review Problems

1. C
2. B
3. A
4. A
5. C
6. C
7. B
8. C
9. C

### Team Learning Problems

**Q.1**

**a.** The rate law for the reaction is given by:
Rate (M/min) = k $[NO]^{x}[H_2]^{y}$

Taking the ratio of the rates of runs 1 and 2 one finds:

$$\frac{Rate\ 1}{Rate\ 2} = \frac{k[NO]^{x}{}_{1}\,[H_2]^{y}{}_{1}}{k[NO]^{x}{}_{2}\,[H_2]^{y}{}_{2}}$$

$$\frac{0.136}{0.034} = 4 = \frac{k[0.42]^{x}{}_{1}\,[0.12]^{y}{}_{1}}{k[0.21]^{x}{}_{2}\,[0.12]^{y}{}_{2}}$$

x=2

Taking the ratio of the rates of runs 3 and 2 one finds:

$$\frac{Rate\ 3}{Rate\ 2} = \frac{k[NO]^{x}{}_{3}\,[H_2]^{y}{}_{3}}{k[NO]^{x}{}_{2}\,[H_2]^{y}{}_{2}}$$

$$\frac{0.068}{0.034} = 2 = \frac{k[0.21]^{x}{}_{3}\,[0.24]^{y}{}_{3}}{k[0.21]^{x}{}_{2}\,[0.12]^{y}{}_{2}}$$

y=1

2+1= overall order

**b.** Rate = k $[NO]^2[H_2]$

**c.** k = rate/ $[NO]^2[H_2]$=0.136/$(0.42)^2$(0.12)=6.424 $M^{-2}s^{-1}$

**d.** Rate = k $[NO]^2[H_2]$= 6.424 $(0.35)^2$(0.20)=0.157 M/s

**Q.2**

**a.** The rate law expression.

$$Rate = \frac{-\Delta[C_4H_6]}{\Delta t} = k[C_4H_6]$$

**b.** It is a second order reaction so we use

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0} \qquad A = C_4H_6$$

$$\frac{1}{0.00313} = k(3600) + \frac{1}{0.01000}$$

320=k(3600)+100 $\qquad k = 6.11 \times 10^{-2}\ M^{-1}.s^{-1}$

**c.** Half-life:

$$t_{1/2} = \frac{1}{k[C_4H_6]_0}$$

$$t_{1/2} = \frac{1}{6.11 \times 10^{-2} \times 0.01} = 1636\ s$$

**d.**

$$\frac{1}{2.5 \times 10^{-3}} = t(6.11 \times 10^{-2}) + \frac{1}{0.01000}$$

t=4910 s

**Q.3**

**a.** The activation energy for the reaction.

$$\ln\frac{k_2}{k_1} = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) \qquad \ln\frac{3.46\times10^{-5}}{7.87\times10^{-7}} = \frac{E_a}{8.314}\left(\frac{1}{273} - \frac{1}{298}\right)$$

$E_a$=102.36 kJ/mol

**b.** The rate constant at 338 K.

$$\ln\frac{k_2}{7.87\times10^{-7}} = \frac{102360}{8.314}\left(\frac{1}{273} - \frac{1}{338}\right)$$

$k_2 = 4.59\times10^{-3}$

**Q.4**

**a.** The equation for overall reaction.

$N_2(g) + O_2(g) \rightarrow NO(g)$

**b.** Unimolecular for step 1 and bimolecular for step 2 and 3

**c.** Intermediates should be produced in one step and consumed in other step in reaction mechanism. Also, they are not included in overall reaction.
O element and N element

**d.** Catalyst is not used in the mechanism because no substance was used and produced.

**e.** Slowest step determines the rate of reaction because whatever the rate of fast step, without finishing the slow step, overall process cannot be finished. In addition, the change in the rate of fast step is so small since it is fast and so it influence the overall process slightly. In contrast, when we increase the rate of slow step, change in the rate is big and so it influence the overall process greatly.

**f.** For the slow step, Rate = $k_2 [N_2][O]$ but O is intermediate so we cannot use it in rate law

In step 1, there is an equilibrium where forward and reverse reaction rates are equal so

$k_1[O_2]=k_{-1}[O]^2$

$[O]=(k_1/k_{-1})^{1/2} [O_2]^{1/2}$ substitute it to the rate law

Rate= $k_2 (k_1/k_{-1})^{1/2} [O_2]^{1/2}[N_2]$ $k_2 (k_1/k_{-1})^{1/2}=k$

Rate = $k[N_2][O_2]^{1/2}$

**g.** Overall order of the reaction=1+1/2=3/2

## Individual Assessment Problems

**Q.1**

**a.** The rate law for this reaction.

From 1 → 3 $[F_2]$ doubles, $ClO_2$ is constant, and Rate doubles:

$2^x = 2$ x = 1 = order for $[F_2]$

From 1 → 2 $[ClO_2]$ quadruples, $F_2$ is constant, and Rate quadruples:

$4^y = 4$ y = 1 = order for $[ClO_2]$

Overall Reaction Order: 1 + 1 = 2

Rate = $k[F_2][ClO_2]$

**b.** The rate constant, k = Rate /[F ][$ClO_2$ ] = $1.2 \times 10^{-3}$ $M.s^{-1}$/ (0.10M)(0.10M) = 0.12 $M^{-1}$ $s^{-1}$

**c.** The rate of reaction increases as amount of the increasing in concentration of $F_2$ (g)

**Q.2**

**a.** Rate determining step is step 1 because it is slow step.
**b.** termolecular
**c.** NO
**d.** NO2
**e.** Rate = $k[NO]^2$ [O2]
**f.** The overall reaction order=2 + 1 = 3

## J. PLTL Workshop Leader Contract

Date/ Tarih:...../...../..........

A Workshop leader

1. Conducts weekly one-hour workshop sessions as scheduled.
2. Attends weekly the workshop training session and completes all assigned work.
3. Prepares for workshop sessions.
4. Informally evaluates the progress of individual group members
5. Maintains attendance records for your group member in the workshop
6. Participates in debriefing surveys and discussions about the workshop

Workshop leaders will be given a Certificate of participation in Atılım University Sharing the Success Programme at the end of the semester.

I can meet the responsibilities of a workshop leader defined above for the general chemistry course (CEAC 105) in fall semester of 2016-2017 education year.

Lider

1. Planlandığı gibi haftalık 1 saatlik çalıştayları yürütür.
2. Haftalık eğitim toplantılarına katılır ve verilen görevleri yerine getirir.
3. Çalıştaylara hazırlıklı gelir.
4. Bireysel grup üyelerinin kaydettikleri ilerlemeyi gayri resmi olarak değerlendirir.
5. Grup üyelerinin çalıştaydaki yoklama kayıtlarını tutar.
6. Çalıştaylarla ilgili yapılan anket ve tartışmalara katılırlar.

Çalıştay liderine dönem sonunda Atılım Üniversitesi başarıyı paylaşım programı katılım sertifikası verilecektir.

2016-2017 eğitim-öğretim yılı güz yarıyılında genel kimya dersi (CEAC 105) için yukarıda tanımlanan bir çalıştay sorumlusunun sorumluluklarını yerine getirebilirim

Name/İsim:
Phone/Tel:
E-mail/E-Posta:

Signature/İmza:

Faculty/Öğretim Elemanı:

Signature/Imza:

## K. Leader Demographic Information

**Directions:** Please answer each question as accurately as possible by marking the correct answer or filling in the space provided.

**1.** Name- Surname: ______________________________________________

**2.** Department: __________________________________________________

**3.** Grade level:

| Freshman (1st year) | Sophomore (2nd year) | Junior (3rd year) | Senior (4rd year) |
|---|---|---|---|
| □$_1$ | □$_2$ | □$_3$ | □$_4$ |

**4.** Gender:

| Female | Male |
|---|---|
| □$_1$ | □$_2$ |

**5.** Birth Date: _____/______/_______ (Month/day/year)

**6.** Type of your High School:

| Public High Schools | Vocational High Schools | Anatolian High Schools | Science High Schools | Private High Schools | Others |
|---|---|---|---|---|---|
| □$_1$ | □$_2$ | □$_3$ | □$_4$ | □$_5$ | □$_6$ |

**7.** University Entrance Year : ________________________________________

**8.** Undergraduate Cumulative GPA: ___________________________________

**9.** General Chemistry Course Score:___________________________________

**10.** Scholarships (Burs):

| None | 25 fully funded | 50 fully funded | 75 fully funded | 100 fully funded |
|---|---|---|---|---|
| □$_1$ | □$_2$ | □$_3$ | □$_4$ | □$_5$ |

**11.** Level of Education of Mother:

| No formal schooling | Primary school | High School | University | Postgraduate |
|---|---|---|---|---|
| □$_1$ | □$_2$ | □$_3$ | □$_4$ | □$_5$ |

**12.** Level of Education of Father:

| No formal schooling | Primary school | High School | University | Postgraduate |
|---|---|---|---|---|
| □$_1$ | □$_2$ | □$_3$ | □$_4$ | □$_5$ |

**13.** Family Income (in TL for month):

| Lower Class (≥3.000.00) | Working Class (3.000.00-7.000.00) | Middle Class (7.000.00-12.000.00) | Upper middle Class (12.000.00-16.000.00) | Upper Class (16.000.00<) |
|---|---|---|---|---|
| □$_1$ | □$_2$ | □$_3$ | □$_4$ | □$_5$ |

## L. PLTL Leader Training Program

*Aim:* These sessions are designed to provide training and support to Workshop leaders. Our discussion will include basic review of the workshop materials and practical and theoretical aspects of workshop leaders. It will also offer all of us the opportunity to explore individual topics of interest.

*Duration:* 90-120 min

*Reading Materials:* Most of our reading will be distributed in class.

*References:* The books used in the discussion.


1. Gosser, D. K., Cracolice, M. S., Kampmeier, J. A., Roth, V. Strozak, V.S., & Varma-Nelson, P. (2001). Peer-led team learning: A guidebook (pp. 75–92). Upper Saddle River, NJ: Prentice Hall.
2. Roth, V., Goldstein, E., & Marcus, G. (2001). Peer-led team learning: A handbook for team leaders. Upper Saddle River, NJ: Prentice Hall.
3. Schunk, D. H. (2012). Learning Theories: An Educational Perspective (6th Ed). Boston, MA: Pearson.


**Schedule**

| **Sessions** | **Topic** | **Explanation** |
|---|---|---|
| Session 1 | Peer Led Team Learning (PLTL) Model<br>Reviewing the syllabus<br>Understanding the attendance system<br>Group dynamics | Understanding the role of the leader<br>Confirming schedule<br>Observation of students' interaction in teams and reaction to workshop problems<br>Feedbacks |
| Session 2 | Preparing for the Workshop 1<br>Learning Theories<br>Learning styles | Chapter 6 Electronic Structure of Atoms<br>Chapter 7 Periodic Properties of the Elements<br>Social Constructivism<br>Vygotsky's Social Development Theory<br>Cooperative Learning |
| Session 3 | Preparing for the Workshop 2<br>Conceptual understanding<br>Teaching strategies and tools 1 | Chapter 8 Basic Concepts of Chemical Bonding<br>Concept mapping<br>Flowcharts<br>Pair problem solving<br>Round-robin |

| | | |
|---|---|---|
| Session 4 | Preparing for the Workshop 3<br>Conceptual understanding<br>Teaching strategies and tools 2 | Chapter 9 Molecular Geometry<br>Chapter 10 Gases<br>Writing to learn<br>Inquiry Based Learning<br>Analogy |
| Session 5 | Preparing for the Workshop 4<br>Listening skills, questioning techniques and explanations | Chapter 11 Liquids and Intermolecular Forces<br>Chapter 12 Solid and Modern Materials |
| Session 6 | Preparing for the Workshop 5<br>Motivation, Interest | Chapter 5 Thermochemistry<br>Chapter 19 Thermodynamics |
| Session 7 | Preparing for the Workshop 6<br>Ethics<br>Equal opportunity | Chapter 14 Chemical Kinetics<br>Race, class and gender and the Workshop |
| Session 8 | General debriefing<br>Surveys and discussions about the workshop | |

## CURRICULUM VITAE

### PERSONAL INFORMATION


| | |
|---|---|
| Surname, Name | : Eren Şişman, Nuran Ece |
| Nationality | : Turkish (TC) |
| Date and Place of Birth | : 13 Eylül 1987, Tirebolu-Giresun |
| Phone | : +90 312 210 4086 |
| E-mail | : n.ece.eren@gmail.com |


### EDUCATION

| **Degree** | **Institution** | **Year of Graduation** |
|---|---|---|
| Ph. D. | METU, Secondary Science and Mathematics Education | 2020 |
| BS-Minor | METU, Chemical Engineering, Chemical Reaction Engineering Program | 2012 |
| Integrated BS with MS | METU Chemistry Education | 2012 |
| High School | Beşikdüzü IMKB Anatolian Teacher High School, Trabzon | 2005 |

### WORK EXPERIENCE

| **Year** | **Place** | **Enrollment** |
|---|---|---|
| 2002-2020 | METU, Mathematics and Science and Education | Research Assistant |
| 2012 February-June | T.C. MEB Mehmet Emin Resulzade Anatolian High School, Ankara | Intern Chemistry Teacher |
| 2011 September-December | METU GV Private High School, Ankara | Intern Chemistry Teacher |

### FOREIGN LANGUAGES

Advanced English

**PUBLICATIONS**

**Book Chapters**

1. Köseoğlu, F. & **Eren-Şişman, E. N.** (2019). Bilimin doğasına bir yolculuk: Bilim nedir, ne değildir? (A journey to nature of science: What is science, what is not?) In F. Köseoğlu & U. Kanlı (Eds), Okul Duvarlarının Ötesine Öğrenme Yolculuğu: Bilim-Teknoloji Merkezleri ve Bilim Müzeleri (A Learning Journey Beyond School Walls: Science-Technology Centers and Science Museums)(pp. 121-158). Ankara: Nobel.

2. Köseoğlu, F. & **Eren-Şişman, E. N.** (2019). Okul ve okul dışı öğrenme ortamlarında bilimin doğası öğretimi ve uygulama örnekleri (Nature of science teaching in school and out-of-school learning environments and samples for implementation). In F. Köseoğlu & U. Kanlı (Eds), Okul Duvarlarının Ötesine Öğrenme Yolculuğu: Bilim-Teknoloji Merkezleri ve Bilim Müzeleri (A Learning Journey Beyond School Walls: Science-Technology Centers and Science Museums) (pp. 159-192). Ankara: Nobel.

**Journal Articles**

1. **Eren-Sisman, E. N.,** & Köseoğlu, F. (2019). Designing a magic flask: A new activity for teaching nature of science in both formal and informal learning environments. Science Activities, 56(3), 108-118. DOI: 10.1080/00368121.2019.1702914

2. **Eren-Sisman, E. N.,** Cigdemoglu, C. & Geban, O. (2018). The effect of peer-led team learning on undergraduate engineering students' conceptual understanding, state anxiety, and social anxiety. Chemistry Education Research and Practice, 19(3), 694-710. DOI: 10.1039/C7RP00201G

3. **Eren-Sisman, E. N**., Cigdemoglu, C. & Geban, O. (2018). Investigation of the effect of peer-led team learning model on university students' exam achievement in general chemistry. Bartın University Journal of Faculty of Education, 7(2), 636-664. DOI: 10.14686/buefad.412614

4. **Eren-Sisman, E. N.,** Cigdemoglu, C. & Geban, O. (2018). Determinants of general chemistry success of engineering students in PLTL and traditional classroom: state anxiety and test anxiety. SHS Web of Conferences, 48, 01051. DOI: 10.1051/shsconf/20184801051

**Conference Papers**

1. **Eren-Sisman, E. N.,** Cigdemoglu, C. & Geban, O. (2019, May 2-4). Takım çalışmasına yönelik üst düzey kimya problemi geliştirme: Temel bileşenler çerçevesi (Developing high-level chemistry problems for teamwork: Basic components framework). Presented 6th National Chemistry Education Congress (UKEK 2019), Ankara, Turkey.

2. **Eren-Sisman, E. N**., Cigdemoglu, C. & Geban, O. (2018, October 4-6). Akran liderliğinde takım öğrenmesi modeli ile eğitim gören mühendislik öğrencilerinin genel kimya başarısının akran liderlerin bazı özellikleri açısından incelenmesi (Examining general chemistry performances of engineering students instructed with the peer-led team learning model in terms of some characteristics of peer leaders). Presented at 13th National Science and Mathematics Education Congress (UFBMEK 2018), Denizli, Turkey.

3. **Eren-Sisman, E. N.,** Cigdemoglu, C. & Geban, O. (2018, June 28- July 1). Determinants of general chemistry success of engineering students in PLTL and traditional classroom: State anxiety and test anxiety. Presented at ERPA International Congresses on Education (ERPA 2018), Istanbul, Turkey.

**PROJECTS**

1. Development and implementation of the peer-led team learning (PLTL) to Turkish context: Effect on student achievement and anxiety in undergraduate general chemistry courses, METU scientific research project, Project No: BAP-07-02-2014-007-780, 2017. Researcher.

2. Akran liderli takım öğrenme modeli ile kimya öğretmen adaylarının problem yazma ve problem çözme becerilerinin incelenmesi (Investigation of the pre-service chemistry teachers' workshop problem writing skills and problem solving skills through Peer-Led Team Leaning model). METU scientific research project, Project No: GAP-501-2018-3055, 2019. (June 20 2018, Dec 03 2019) Researcher.

3. BILMER mesleki gelişim projesi: Bilim merkezlerinin bilim-toplum iletişiminde ve bilim eğitiminde etkinliğini artırmaya yönelik bir öğretmen ve eğitmen mesleki gelişim modeli (BILMER professional development project: A teacher and explainer professional development model aimed at increasing the effectiveness of science centers in science-society communication and science education). The Scientific and Technological Research Council of Turkey (TUBITAK) 1001 project, Project No: 114K646.

**AWARDS**

June 04, 2015 METU Graduate (PhD) Courses Performance Award (I finished the doctorate courses with first place in two semesters (4.00 /4.00)

**PROGRAMS**

MS Office Programs, MS Visio Program, IBM SPSS Statistics,