Eurasian Journal of Physics and Chemistry Education

Eurasian J. Phys. & Chem. Educ. 6(2): 123-141, 2014

journal homepage: http://www.eurasianjournals.com/index.php/ejpce

The Impact of MOODLE-Supported Cooperative Learning Process on University Students' Anxiety Levels towards Chemistry Laboratory and on Their Attitudes towards Chemistry

Cemal Tosun*

Faculty of Education, Bartın University, Turkey

Received: 15 January 2014- Revised: 01 July 2014- Accepted: 05 July 2014

Abstract

The purpose of this study is to reveal the impact of MOODLE (Modular Object- Oriented Dynamic Learning Environment)-supported cooperative learning process on Elementary Science Teacher Education Program (ESTEP) undergraduate freshman students 'anxiety levels towards chemistry laboratory and on their attitudes towards chemistry. Besides, students' opinions on cooperation process are also worked on. The study was carried out on one group using both pre-and post-test experimental studies. The findings of the study were obtained through qualitative and quantitative approaches. The sample of the study was 46 first-year undergraduate students at a state university in Turkey taking General Chemistry Laboratory-I classes. The study was implemented during the autumn semester of the 2012-2013 academic years and for a period of 28 hours. The quantitative data were obtained using the "Chemistry Laboratory Anxiety Scale", "Chemistry Course Attitude Scale" and "Cooperation Process Scale". The qualitative data, on the other hand, were collected via "Questionnaire to Determine Student Opinions on MOODLE-supported Cooperation Groups". Paired sample t-test was used for the pre-and post-test comparisons. One-sample t-test was used to analyze the data obtained from the cooperation process scale. Qualitative data were subjected to descriptive analysis and then given infrequency and percent tables. The findings of the study revealed that MOODLE-supported cooperative learning process had no impact in decreasing ESTEP students' anxiety levels towards chemistry laboratory and on their attitudes towards chemistry. It is found that MOODLE- supported cooperative learning process has a positive impact on positive dependency, face-to-face supportive interaction, individual responsibility, small group skills and group process behaviors.

Keywords: MOODLE, Cooperative learning process, Chemistry laboratory, Anxiety and attitude.

Introduction

Laboratory practices have a distinctive and central role in science education (Hofstein & Lunetta, 2003). Abstract concepts are materialized in laboratory practices. Thus, students are enabled to understand the nature of knowledge. Understanding chemistry, one of the branches of sciences, better is through laboratory practices. Since laboratory work enables to make a connection between chemistry and daily life, it helps for a better understanding (Johnstone & Al-Shuaili, 2001; Lunetta, Hofstein & Clough, 2007).

Chemistry laboratory learning environment is defined as an environment equipped with necessary experiment materials, where open-ended activities are done, where the rules to be followed in laboratory are clearly stated and which is designed in a way that allows students to do both individual and group studies(Lang, Wong & Fraser, 2005; Quek, Wong & Fraser, 2002).

*Corresponding Author, Phone: 90 532 1629081, E-mail: cemaltosun22@gmail.com

ISSN: 1306-3049,

Laboratory studies, which enable students to engage in scientific research, serve as a bridge between theory and practice (Neumann & Welzel, 2007).Laboratory studies help students to learn chemistry terms and equations precisely. Students' interest, curiosity and motivation for chemistry could be triggered via laboratory studies. If students brought a positive attitude towards laboratory practices, then their success could be increased as well (Hofstein & Naaman, 2007).

In their study, Feyzioglu et al., (2011) states that students do not make enough research in laboratory practices. For laboratory practices are done with traditional methods and are not student-centered (Domin, 2007; Mc Donnell, O'Connor & Seery, 2007; Witteck, Most, Kienast & Eilks, 2007), students are not able to make a meaningful connection between the purpose of the experiment they do and the subject of the experiment. It is stated that students can not relate between the experiments with the previous practices they made, and that they face inconsistencies with concepts they and their peers have and the scientific ones (Lunetta, 1998).

In a traditional laboratory environment, students work like a technician as if they are bound to a cooking book with the laboratory activities that focus on improving psychomotor skills (Hofstein & Lunetta, 2003; Witteck et al., 2007). Laboratories should be places where discussions about the experiments are made, hypotheses are formed and tested, and new experiments are designed when needed during the testing of hypotheses. Therefore, laboratory environment should be designed well, in a way that allows students to make individual and cooperative experiments and should be the places where necessary opportunities for students' studies are provided (Shibley & Zimmaro, 2002).

Witteck et al. (2007) suggested that it is necessary to discuss the efficiency of widely used traditional laboratory practices to make chemistry laboratory practices more effective. For this,questioning approaches, instead of confirmatory approaches, should be included more in laboratory activities and thus deep learning where student is active and laboratory activities where student makes connection between the course content and the practice should be provided. In order to do that, student-student and student-teacher interaction should be improved. It will, thus, provide a more interactive learning environment and students will have an active role in learning instead of a passive one (Lang, Wong & Fraser, 2005).

There have been a number of attempts over the last 30 years to increase students' interaction in chemistry laboratory practices (McCreary, Golde, & Koeske, 2006). In chemistry education, for example, cooperative learning (McLaren et al., 2008) and peer teaching are strongly recommended (Arrington et al., 2008). Cooperative learning is defined as a learning approach in which students form heterogeneous groups in and outside the classroom environment, and help each other learn a subject with a common aim, in which their self-confidence increases, their communication, problem-solving and critical thinking skills develops, and efficient contribution into the education process is provided (Bowen, 2000; Levine, 2001).

Cooperative learning method holds its place in educational sciences with its different techniques and practices which are used in the studies of the researchers using this method. A variety of techniques have been preferred in cooperative learning method practices with respect to the number of students, social structure of the environment, physical structure of the classroom and course subject to be taught (Maloof & White, 2005). In this study, Jigsaw technique was preferred among cooperative learning techniques. The Jigsaw technique, which was first developed by Eliot Aronson in 1978 (Hedeen, 2003), consists of introduction, expert research, report preparation, remodeling, completion and evaluation stages in the implementation process.

In laboratory environments where cooperative learning is realized, students construct the information effectively (Nakhleh, Polles, & Malina, 2002) and thus, they think deep(Byers, 2002). Therefore, laboratory practices including cooperative learning environments based on social constructivism are suggested (Nakhleh, Polles, & Malina, 2002). Laboratory environments where learning is cooperative impacts students' performances and skills positively (Shibley & Zimmaro, 2002).Their success could be changed for a short-time in a positive direction (Tsaparlis & Gorezi, 2005). While positive attitudes towards laboratory increase student performance in the laboratory, anxiety could impact it negatively (Laukenmann et al., 2003).To this end, students' level of anxiety towards using laboratory equipment and chemical materials, working with other students, collecting data and using laboratory time should be identified and if there is a continuous anxiety, ways to remove this anxiety should be looked for since this anxiety will impact the performance negatively. This study aims to reveal the impact of cooperative learning process on university students' anxiety levels towards chemistry laboratory and on their attitudes towards chemistry.

MOODLE in Chemistry Laboratory Practices

In today's world in which sharing information and presenting it has become quiet fast, new information is presented every second via this network. In the last ten years, a very fast development in using internet in education has been experienced (Wagner, 2000). The importance attached to web-supported learning environments in education has been rising every other day (Forsyth, 1996; Gordin, Gomez, Pea & Fishman, 1996; Vazques-Abad, 1999; Hoffman, Wu, Krajcik, &Soloway, 2003). The impact of internet on the improvement of learning and teaching is mentioned in many studies (e.g. Lea & Scardamalia, 1997). Internet learning environment can change the nature of learning by increasing the interaction with teaching materials (Kinzie, Larsen, Burch & Boker, 1996).It is claimed that internet-supported learning environment enables easy access to information for students and develop their problem-solving skills (Ryder & Graves, 1997).

Besides,internet has been used as a database for collaborative learning and variouseducational activities lately (Yaron, Freeland, Lang, & Milton, 2000). Internet not only provides access to information but also enables the examination and analysis of data (Krajcik, 2000; Carpi, 2001, Sanger & Badger, 2001, Tuvi & Nachmias, 2001; Ardac & Akaygun, 2004). The easiest way of presenting information on internet is via web pages. To share and manage the content in education, "Learning Management Systems" software has been developed.

Learning Management Systems are software which enables such opportunities as offering asynchronous learning materials over the network, sharing and discussing the presented learning material in different forms, enrolling to the courses, taking homework, entering the exams, providing feedbacks on the homework and exams, organizing the learning material, keeping student, teacher and system records and receiving report automatically over the network. In other words, by using all the resources of internet, Learning Management Systems provide the opportunity for students to meet in educational environments both via asynchronous and synchronous methods. The most widely used platform among open source Learning Management System platforms is the Learning Management System software called "MOODLE" (Modular Object-Oriented Dynamic Learning Environment).It is possible to provide web based distant education via MOODLE Learning Management System. Besides, it is possible to use it in formal education as a tool in a blended education.

As for Carpi (2001), compared to traditional teaching sources, internet has many advantages in teaching chemistry. It is believed that designing course where cooperative laboratory practices are supported with "MOODLE, Learning Management Systems" in order to minimize the negativities faced during traditional chemistry laboratory practices, to prepare students for extracurricular study processes, to provide efficient communication among the members of the groups and among groups, to continue learning activities outside the course hours in short to follow, manage and report the interaction between the students and teaching materials and students and the teachers will be useful.

The Purpose of the Study

It is highly important to transform the learning process in the laboratory environment into an efficient learning environment. The role and importance of laboratory in teaching chemistry is theoretically accepted. Student-student and student-teacher interaction are insufficient in traditional laboratory practices. So it is important to choose the right method in laboratory practice. There have been a number of attempts over the last 30 years to increase students' interaction in chemistry laboratory practices (McCreary, Golde, & Koeske, 2006). In chemistry education, for example, cooperative learning (McLaren et al., 2008) and peer teaching are strongly recommended methods (Arrington et al., 2008).

In this study, the impact of MOODLE-supported cooperative learning process on undergraduate students' anxiety levels towards chemistry laboratory and on their attitudes towards chemistry was researched. Additionally, students' opinions about cooperative learning process were identified. To this end, the answers to the following questions are looked for:

Research Questions

1. What is the effect of MOODLE-supported cooperative learning process on anxiety levels of students towards chemistry laboratory?

2. What is the effect MOODLE-supported cooperative learning process on the attitudes of students toward chemistry?

3. What are the opinions of undergraduate freshman students' in MOODLE-supported cooperative learning groups on the process of cooperation?

4. Are there any relationship among freshman students' anxiety towards chemistry laboratory, attitude towards chemistry, opinions about the process of cooperation and their success after the practice?

Material and Method

The research was carried out as an experimental study with a pre-test and post-test design. In addition, the research findings were obtained by means of a quantitative and qualitative approach. In the single-group pre-test-post-test design, one group of subjects is given a pre-test (Chemistry Class Attitude Scale, Chemistry Laboratory Anxiety Scale)then the treatment (MOODLE-supported cooperative learning process), and then the post-test(Chemistry Class Attitude Scale, Chemistry Laboratory Anxiety Scale). The differences between these two series of test results were examined (Fraenkel & Wallen, 2003). Single-group pre-test – post-test design are shown in Figure 1.

Grup	Pre-test	Treatment	Post-test
A	O	X	O
	Time →		

Figure 1. Single-group pre-test-post-test design

Sample

The sample of the study was 46 first-year undergraduate students at a state university in Turkey taking General Chemistry Laboratory-I classes. The sampling method chosen for the study was non-random sampling. Quantitative research data was collected using purposeful sampling and convenience sampling methods, which are among the non-random sampling methods. For convenience sampling, individuals or groups who can participate more easily or who can be more easily contacted are preferred (Johnson &Christensen, 2004).

Procedure

The implementation of the study was carried out by the researcher for 2 course hours every week for 14 weeks in ESTEP. The classes were carried out in MOODLE-supported cooperative learning groups in General Chemistry Laboratory course. First of all, students were informed about the process. Then, 12 groups were formed. There were 4 students in each group. While forming the groups, students' scores when entering the ESTEP were taken into consideration. First the students were informed about the experiments to be made during the practice. These experiments can be grouped under the following titles: i) identifying materials by looking at their physical and chemical characteristics ii) solubility of liquids and solids in water iii) identifying the melting and freezing temperatures of elements iv) utilization from density differences v) utilization from the boiling point difference vi) stoichiometry vii) examining neutralization reactions and viii) preparing solutions and examining precipitation reactions.

Since the students participating in the experiment were freshmen, before starting the implementation, they were informed about the rules they need to follow in a laboratory and the safe working rules. They were also informed about the most frequently used chemicals in the laboratory, glass materials and equipment as well as the danger symbols, security symbols and precautions to be taken against accidents in the laboratory and the main activities in a chemical laboratory. All these information were also shared with students in the MOODLE platform to let them access this information whenever they want. Thus, students have gained the opportunity to revise information whenever desired. MOODLE platform provides students with the opportunity to get the necessary guidance they need on time in addition to its data storage function. The interaction among MOODLE users (students) was established through the forum pages in the platform. The students participating in the discussions on the forums had the opportunity to share and discuss their opinions, and understand their mistakes. Likewise, the interaction outside the classroom among teachers and students was achieved by providing students with the guidance they need on time through responding to the students' needs stated on forum pages. Following this step, the implementation of the study started. The first four experiments were to be made in the first 7 weeks while the remaining four experiments were scheduled to be made in the remaining 7 weeks. The first four experiments to be finished till the mid-term exam week were shared with students. In the first two weeks, groups first exchange information about the experiments within their groups. Students discussed how to do the experiment by workbook. They determined the student who will represent them in expert groups. They looked for an answer to the following questions: What do we know about the experiments? and What do we need to learn to make these experiments? They made a distribution of work on via which channels they can reach the information they need.

Towards the end of this phase, a distribution of work was done among the group members (decision was made on which group member will be sent to which expert group). Simultaneously, the teacher visited each group one by one to guide them in their group work. Students were asked express their opinions and problems systematically. MOODLE was also utilized while working outside the course hours. Students were also given the opportunity to ask questions or explain to their group members as well as to other groups via the forum pages in the MOODLE. Thus, an online platform where students shared their ideas about the experiments and find solutions to the questions they had in their minds was provided. Students collected data to find answers to their own questions as well as to their friends' questions. Students were encouraged to use science laboratory, library, and internet and ask for expert opinions in this process and thus, research for information both from electronic and written sources. Students who came together during the course hours after this phase discussed what they had learned during the independent studying phase and analyzed and synthesized what they learned.

Discussion about the experiments, sharing and exchanging information among groups is as important as interaction and information exchange among members of a group. Therefore, in the 3rd and 4th week of the implementation one student from each group joined the expert groups to exchange information on the expertise experiment. Students representing their groups in expert groups looked for answers to the questions in their minds and to the ones that their group members had in their minds and they tried to carry out the expertise experiments with their friends in the expert groups. Using they theoretical background knowledge, they discussed the data they obtained after the implementation and analyzed and synthesized them.

At the end of this phase, students in the expert groups returned to their original groups and shared what they had learned, how they did the experiment, and what kind of results they would face with their friends in their own group. Thus, each group member worked to teach about the experiment they learned in the expertise group as if they were private teachers. At the end of this process, which happened during the 5th, 6th and 7th weeks, by doing the first four experiments with the leadership of the expert group member, all groups tried to create an environment in which everyone is responsible for others' learning. Later the groups were asked to prepare their reports including the results of their experiments by forming mind maps. The process worked in the same way for the remaining four experiments.

Data Collection Tools:

Chemistry Class Attitude Scale

In order to determine the effect MOODLE-supported cooperative learning process on the attitudes of students toward chemistry, the Attitudes towards Chemistry Lessons Scale (ATCLS), developed by Cheung (2009) and adapted into Turkish by Senocak (2011), was used. It includes 12 items in 4 sub-scales: liking for chemistry theory lessons, liking for chemistry laboratory work, evaluative beliefs about school chemistry, and behavioral tendencies to learn chemistry.

Item 1- I like Chemistry lessons more than the other lessons at school in the scale is under the sub-dimension of liking for chemistry theory lessons. On the other hand, Item 6, which is *I am fond of doing chemistry experiments,* is an exemplary response given to the sub-dimension of liking for chemistry laboratory work. *Item 3- Chemistry is beneficial to solve problems in daily life* is an exemplary response given to the sub-dimension of evaluative beliefs about school chemistry. *Item 12- If I had the opportunity, I would prepare a chemistry project* is under the sub-dimension of behavioral tendencies to learn chemistry.

Five hundred and fifty-four students participated in the reliability and validity study of the instrument. The normed fit index of the adapted scale was found to be .93, the comparative fit index was found to be .95, and the approximate root mean square error was found to be .07. These results revealed a good fit between the model and the real values. The reliability of the scale was examined based on Cronbach-Alpha and item point-total point relation. While the Cronbach-Alpha value was found to be .88 for the whole scale, the values of the 4 sub-dimensions changed between .68 and .84. Item-total correlation for the 12 items ranged between .49 and .72.

Chemistry Laboratory Anxiety Scale

In order to identify students' level of anxiety towards chemistry laboratory, Chemistry Laboratory Anxiety Scale developed by Bowen (1999) was used in the study. The 5 point Likert type scale consists of 20 questions in 4 sub-dimensions, which are using the laboratory equipment and chemical materials, working with other students, data collection and using the laboratory on time. Adaptation of the scale into Turkish was done by Azizoglu and Uzuntiryaki (2006).

Item 1- I feel uneasy when I use chemical substances in the laboratory is under the sub-dimension of using the laboratory equipment and chemical materials. *Item 9- I feel at ease when I work with other students in the laboratory* is an exemplary statement given to sub-dimension of working with other students. *Item 8- I feel uneasy when I record data in the laboratory* is an exemplary statement given to the sub-dimension of data collection. *Item 10- the issue of how much time the experiment should take makes me nervous when I work in the laboratory* is an example for statements showing anxiety in the sub-dimension of using the laboratory on time allowed.

A total number of 516 university students from Faculty of Engineering, Sciences& Literature and Faculty of Education taking the chemistry laboratory course participated in the reliability and validity studies of the scale. Among these 516 students 216 were girls and 300 were boys. As a result of exploratory factor analysis, the variance explained by the first dimension was 39%, while it was 11%, 9.78% and 6.9% variance for the second, third and fourth variances, respectively. The reliability of the scale was examined via Cronbach-Alpha and item-total correlation. The reliability coefficients of the sub-dimensions of the scale was found as .88, .87,.86 and .87 for using laboratory equipment and chemical materials; working with other students; data collection and using the laboratory on time given, respectively.

Cooperation Process Scale

To find out whether the learning process in MOODLE-supported cooperation groups occurred as it should be, the "Cooperation Process Scale" developed by Bay and Cetin (2012) was used. This scale is a 5 point Likert type scale including 40 questions in 5 sub-dimensions. The sub-dimensions are; positive dependence (e.g. *Item1- group members trust each other*), face-to-face supportive interaction (e.g. *Item12- success or failure of students belong to groups rather than individuals)*, individual responsibility (e.g. *Item23- I am responsible for my own learning as much as my group mates*), small group skills (e.g. *Item27- group members shall respect each other's thoughts and efforts*) and group process behaviors (e.g. *Item33- group members complete their tasks within the specified time*). According to those who developed the scale, it can both be used as a one-dimensional and as multidimensional scale. 177 teachers participated in the reliability and validity studies of the scale. Exploratory and confirmatory factor analyses were made. According to exploratory factor analysis the factor load of the questions in the scale change between .48 and .85. Confirmatory factor analysis was made on the single factor and five factor analyses of the scale and it was found that five factor analyses had higher coefficient of fit. Coefficient of internal consistency related to positive dependence was found as .94; while individual responsibility was found as .93; face-to-face supportive interaction was found as .96; small group skills was found as .88 and group process was found as .83. The overall coefficient of consistence of the scale was calculated as .98.

Achievement Test

In order to determine students' knowledge on the concepts included in the first four experiments, a mid-term exam was made in the 7th week of the implementation. A total number of 12 questions, including 5 open-ended questions, 4 short answer questions and 3 multiple-choice questions were asked. At the end of the implementation, a final exam was made. A make-up exam was made students who failed in the final exam. In both final and make-up exams, 8 open-ended questions were asked to the students. Students' pass marks for General Chemistry Laboratory-I course were calculated by counting the 40% of their mid-term exam grades and 60% of the final exam grades (and the 60% of the make-up exam of those who failed in the final exam).

Questionnaire on Determining Students' Opinions on Cooperation Process

To find out students' opinions on the functioning of the studying process of the students in the cooperative learning groups, a questionnaire including 4 open-ended questions was carried out. The aim was to find out students' opinions regarding the MOODLE Learning Management Systems, group learning process and the functioning of expert groups. In addition, students were asked "If it were you, how would you do the General Chemistry Laboratory-I?" question. This questionnaire was uploaded on Google Drive program and students were given access to this questionnaire via the link they were provided. The data obtained after students' opinions were transferred to Excel program and their descriptive analyses were made.

Data Analysis

In comparing "Chemistry Laboratory Anxiety Scale" and "Chemistry Class Attitude Scale" pre-tests and post-tests, paired samples t-test, which was done on the same sample group and which compares such features as their expectations, success, speed etc. at different times, was carried out. The statistical analysis of the study was carried out using SPSS/PC-18 (Statistical Package for Social Sciences for Personal Computers). The statistical analyses of the research were tested at .05 significance level. The data from "Cooperative Process Scale" were analyzed using one-sample t-test. The data obtained from achievement test and open-ended questionnaire were evaluated via descriptive analysis.

Findings

Analysis of Chemistry Class Attitude Scale Data

The results of the paired sample t-tests are presented in Table 1 to see if there is a statistically significant difference between the pre- and post-test results of Chemistry Class Attitude Scale to find the effect of MOODLE supported cooperative learning process on students' attitudes toward chemistry.

The findings showed that there was no a statistically significant difference between pre- and post-test results on ESTEP students' attitudes toward chemistry in all sub-dimensions: liking for chemistry theory lessons($t_{(43)} = -.768$, $p>.05$), liking for chemistry laboratory work ($t_{(43)} = -.239$ $p>.05$), evaluative beliefs about school chemistry($t_{(43)} = -.993$ $p>.05$), and behavioral tendencies to learn chemistry ($t_{(43)} = -.932$, $p>.05$).

According to the data in Table 1 MOODLE-supported cooperative learning process caused to an increase in ESTEP students' attitudes towards chemistry after it is implemented in all sub-dimensions. These sub-dimensions were: liking for chemistry theory lessons (M_{pre}=4.37; M_{post}=4.51), liking for chemistry laboratory work(M_{pre}=5.36; M_{post}=5.41), evaluative beliefs about school chemistry (M_{pre}=4.78; M_{post}=4.96) and behavioral tendencies to learn chemistry(M_{pre}=3.44; M_{post}=3.58).

Table 1. The results of paired group t-test for chemistry class attitude scale

Dimensions		N	M	SD	df	t	p
Liking for chemistry theory lessons	Pre-test	44	4.37	1.04	43	-.768	.447
	Post-test	44	4.51	1.02			
Liking for chemistry laboratory work	Pre-test	44	5.36	1.65	43	-.239	.812
	Post-test	44	5.41	1.52			
Evaluative beliefs about school chemistry	Pre-test	44	4.78	1.29	43	-.993	.326
	Post-test	44	4.96	1.29			
Behavioral tendencies to learn chemistry	Pre-test	44	3.44	1.13	43	-.932	.357
	Post-test	44	3.58	1.09			
Total (Pre-post test)	Pre-test	44	4.49	.885	43	-.963	.341
	Post-test	44	4.61	.887			

Analysis of Chemistry Laboratory Anxiety Scale Data

The results of the paired sample t-tests are presented in Table 2 to see if there is a statistically significant difference between the pre-test and post-test results of Chemistry Laboratory Anxiety Scale to find the effect of MOODLE-supported cooperative learning process on students' anxiety conditions toward chemistry.

Test results revealed that there is no statistically significant difference in all sub-dimensions in pre-test and post-test results of ESTEP students' anxiety levels towards chemistry laboratory. The sub-dimensions were: using the laboratory equipment and chemical materials($t_{(44)}$ = .533, p>.05), working with other students ($t_{(44)}$ = -1.571, p>.05), data collection ($t_{(44)}$ = 1.265 p>.05) and using the laboratory on time ($t_{(44)}$ = -.580, p>.05).

Table 2. The results of paired group t-test for chemistry laboratory anxiety scale

Dimensions		N	M	SD	df	t	p
Using the laboratory equipment and chemical materials	Pre-test	45	2.88	1.05	44	.533	.597
	Post-test	45	2.79	.90			
Working with other students	Pre-test	45	1.80	.95	44	-1.571	.123
	Post-test	45	2.08	1.01			
Data collection	Pre-test	45	2.71	.99	44	1.265	.212
	Post-test	45	2.54	.94			
Using the laboratory on time	Pre-test	45	2.65	.99	44	-.580	.565
	Post-test	45	2.78	1.03			
Total (Pre-post test)	Pre-test	45	2.57	.79	44	.017	.986
	Post-test	45	2.57	.75			

According to the data in Table 2, while MOODLE-supported cooperative learning process caused to a decrease in ESTEP students' anxiety levels towards chemistry laboratory after it is implemented in two sub-dimensions which are using the laboratory equipment and chemical materials(M_{pre}=2.88; M_{post}=2.79) and data collection(M_{pre}=2.71; M_{post}=2.54), there seems to be an increase in working with other students (M_{pre}=1.80; M_{post}=2.08) and using the laboratory on time (M_{pre}=2.65; M_{post}=2.78).

Analysis of Cooperative Process Scale Data

In order to find out students' opinions on cooperation process within MOODLE-supported cooperative learning groups, "Cooperation Process Scale" was implemented after the practice. To find out whether there is a statistically significant difference between the data obtained one-sample t-test was used. The results of the test are given in Table 3.

Table 3. The results of one sample t-test for cooperation process scale (*p<.05)

Dimensions	N	M	SD	t	p
Positive dependency	45	3.50	.805	4.156	.000*
Individual responsibility	45	4.42	.494	19.226	.000*
Face-to-face supportive interaction	45	3.50	.617	5.425	.000*
Small group skills	45	3.89	.485	12.304	.000*
Group process behaviors	45	3.54	.743	4.861	.000*
Total	45	3.66	.567	7.772	.000*

According to the results of Table 3, the averages of all sub-dimensions of cooperative process scale, which are positive dependency, individual responsibility, face-to-face supportive interaction, small group skills and group process behaviors, were statistically significant from the average value (the average value was considered 3)in a positive way.

Analysis of Achievement Test Data

Table 4 is formed with students' scores from mid-term exam, final exam and make-up exam, which were used as post-test in order to examine the impact of MOODLE-supported cooperative learning process on students' success levels in chemistry laboratory class. While calculating grade point average, 40% of students' mid-term exam grades and 60% of the final exam grades were counted. Make-up exam results of those who failed in the final exam were used to calculate the grade point average.

Table 4. The results of mid-term, final and make-up exam

	N	M	SD	Minimum	Maximum
Mid-term	46	56.41	9.96	35	77
Final and make-up	46	63.34	12.97	22	81
Passing grade	46	61.12	9.68	32.4	75.2

In Table 4, the lowest score on the mid-term, in which 46 students participated, was 35 over 100, whereas the highest score was 77 over 100, and the average score was 56.41. While the lowest score on the final exam was 22, the highest score was 81. The mean score of the classroom on the final exam was 63.34. Grade point average for the course was found as 61.12, with the minimum score of 32.4 and the maximum score of 75.2.

The Relation between Attitude-Anxiety-Cooperation Process and Success

In order identify the fourth research question of this study, which was whether there were any relations among freshman students' anxiety, attitude towards chemistry classes, opinions about the process of cooperation and their success after the practice, "Pearson

Correlation" analysis was carried out. With Pearson Correlation analysis, whether there was a relation between the sub-dimensions of Chemistry Laboratory Anxiety Scale-CLAS (Using the Laboratory Equipment and Chemical Materials-ULECM, Working with Other Students-WOS, Data Collection-DC and Using the Laboratory on Time-ULT), Chemistry Class Attitude Scale-CCAS (Liking for Chemistry Theory Lessons-LCTL, Liking for Chemistry Laboratory Work-LCLW, Evaluative Beliefs about School Chemistry-EBSC and Behavioral Tendencies to Learn Chemistry-BTLC)and Cooperation Process Scale-CPS (Positive Dependence-PD, Face-to-Face Supportive Interaction-FSI, Individual Responsibility-IR, Small Group Skills-SGS and Group Process Behaviors-GPB) and success was found. Table 5 only includes the significant difference between the sub-dimensions of different scales. The relation among the sub-dimensions of one scale is not included as it is an expected condition.

Table 5. Relations among anxiety, attitude, the process of cooperation and success

	LCLW	BTLC	CCAS	IR	CPS	Success
CLAS	-.330* (p=.027)					
ULECM	-.421** (p=.004)	-.341* (p=.022)	-.304* (p=.043)			
WOS				-.330* (p=.027)	-.312* (p=.037)	
CCAS						.423** (p=.004)
LCTL						.328* (p=.028)
EBSC						.404** (p=.006)

(*p<.05; **p<.01)

According to Table 5, there is a statistically significant relation in a negative direction between anxiety and liking for chemistry laboratory work(r=-.330; p<.05). There is statistically significant relation in a negative direction between using the laboratory equipment and chemical materials and liking for chemistry laboratory work(r=-.421; p<.01), behavioral tendencies to learn chemistry(r=-.341; p<.05) and attitudes (r=-.304; p<.05). There is also a statistically significant relation in a negative direction between working with other students which are sub-dimensions of anxiety scale and cooperation process, (r=-.312; p<.05) and individual responsibility, a sub-dimension of cooperation process scale(r=-.330; p<.05). On the other hand, it is found that there is a statistically significant different in a positive direction between student success and attitude (r=.423; p<.01), liking for chemistry theory lessons(r=.328; p<.05) and evaluative beliefs about school chemistry(r=.404; p<.01).

Analysis of Open-ended Questionnaire Data

After the implementation, 4 open-ended questions were asked to each student about the MOODLE-supported cooperative learning process. Students' written answers to these questions were analyzed descriptively and below-given tables. The information about students' opinions about MOODLE Learning Management Systems and their opinions regarding what can be done to make MOODLE more functional is stated in Table 6.According to Table 6, among 46 students who answered the questions, 28.3% stated that not everyone has access to internet all the time and thus, sometimes they had problems with accessing MOODLE platform.23.9% of the students stated that MOODLE enabled them to follow course notes and to keep the information in an organized way while 17.4% stated that it provided student-student and student-teacher communication and enabled everyone's participation to the courses with question-answer.Besides,17.4% of the students suggested that MOODLE platform should include interesting videos. 10.9% of the students stated that there should be activities to evaluate them during the whole process.

Table 6. Students' opinions on MOODLE Learning Management Systems (f= frequency)

Students' Opinions	f	%
We had difficulty in accessing internet under some cases since everyone did not have access to internet.	13	28.3
It enabled us to follow course and course notes and to keep the information in an organized way	11	23.9
Student-student and student-teacher communication is provided. Everyone's participation is enabled with question-answer and we had the opportunity to access the announcements on time.	8	17.4
There could have been more visuals, stories or fictional items, experiments, videos, animations and more examples and content to grasp students' interest.	8	17.4
Small tests in the form of puzzles that will make us active during the process and enable us to make evaluations can be made; and homework, research and discussion topics can be given.	5	10.9

Table 7 includes students' opinions on group learning in laboratory classes and the functioning of expert groups.

Table 7. Students' opinions on group learning process and the functioning of expert groups (f= frequency)

Students' opinions	f	%
While choosing the group members, I would try to choose students who has higher possibility to gather together	23	50
It was good that program entrance scores were taken into consideration in forming the groups	11	23.9
For everyone did not fulfill their responsibility in expert groups, some functional problems (expert groups to come together, to inform each other) were experienced	20	43.5
I am glad with how expert groups work, we are able to share information and thus, learn what we don't know	20	43.5
I would control expert groups more in order to overcome the problems in the functioning of expert groups. I would even evaluate them if needed.	6	13.0

Looking at Table 7, we see that while half of the students stated that their opinions should be considered while forming the groups, 23.9% stated that it was a good decision to consider program entrance scores and gender while forming the groups. While 43.5% of the students expressed that there had been some problems in the functioning of expert groups, another 43.5% students stated that they were glad with the functioning of these expert groups. 13% of the students expressed that in order to overcome the problems in the functioning of expert groups, students who learned the expertise subject in-depth should first be evaluated seriously before s/he teaches the information on expertise experiments.

Table 8 is formed in accordance with students' responses to the question: "If it were you, how would you teach General Chemistry Laboratory-I course?".

Table 8. Students' opinions on how the course is taught (f= frequency)

Students' Opinions	f	%
I am glad with how the lesson is taught	18	39.1
I would do the explanations about the experiment. I would do the experiment myself first, as a teacher and then I would ask students to do the experiment	16	34.8
I would utilize technology more in order to make the course more interesting and use more videos and slides.	4	8.7
I believe that doing the experiments individually would be more beneficial.	5	10.9

When Table 8 is examined, 39.1% of the students stated that they are glad with how the course is taught while 34.8% expressed that some explanatory information would be useful before the experiment is made and that experiments should first be done by teachers. 10.9% of the students suggested that the experiments should be done individually while 8.7% stated that the course should be supported with videos and slides to make it more interesting and visual.

Result and Discussion

For students are exposed to far too much information in traditional laboratory teaching, in-depth learning does not occur. Since students work independently, student-student interaction, which activates high-order thinking skills and deep learning, is too little. Students spend most of their time for searching the right result instead of how they will plan and do the experiment (Stewart, 1988). In addition, students who are not ready for laboratory classes have difficulty in making connections between their chemistry knowledge and laboratory experiments.

Because of these problems experienced in traditional laboratory teaching, this study aimed to reveal the impact of MOODLE-supported cooperative learning process on ESTEP, undergraduate students' anxiety levels towards chemistry laboratory and on their attitudes towards chemistry. The findings of the study reveal that there is an increase in liking for chemistry theory lessons, liking for chemistry laboratory work, evaluative beliefs about school chemistry, behavioral tendencies to learn chemistry, which are the sub-dimensions of determining students' attitude levels towards chemistry, after the implementation but this increase is not statistically significant. This shows that although the implementation of the study took 14 weeks, MOODLE-supported cooperative learning process did not reason any increase in students' attitude levels towards chemistry.

Besides, when ESTEP freshman students' anxiety levels towards chemistry laboratory course is examined, it is seen that their anxiety levels both before and after the implementation was average; 2.57 in a 5-point Likert scale. Although there has not been a statistically significant difference in the sub-dimensions of anxiety scale after the implementation, there has been a decrease in using the laboratory equipment and chemical materials and data collection sub-dimensions after the implementation; and an increase in working with other students and using the laboratory on time sub-dimensions. Crowded classrooms(Cheung, 2007), absence of sufficient and effective materials (Cheung, 2007; Deters, 2005),insufficient time for laboratory practices (Backus, 2005; Cheung, 2007; Deters, 2005; Jones, Gott & Jarman, 2000) or not including enough laboratory practices in the program and weekly course hours (Hackling, Goodrum & Rennie, 2001) and examples from everyday life (Lechtanski, 2000) do not allow the implementation of laboratory activities in which students are active (Witteck et al., 2007). Because of all above mentioned reasons, students who are not used to laboratory environment might have some anxieties towards laboratory in their first years at university. Despite not being statistically significant, the anxiety seen in our students towards laboratory equipment and chemical materials at the beginning of the implementation showed a decrease in MOODLE-supported cooperative learning process. The increase in working with other students and using time efficiently could be interpreted as an indicator of some problems within groups during the cooperative learning process. This is also an indicator of the coordination difficulty among students who have to work in a group that they don't know or know a little about in a laboratory environment for the first time (Azizoglu and Uzuntiryaki, 2006).

When the results obtained from students' opinions about the MOODLE-supported cooperative process in analyzed, it is seen that students show a positive dependency, engage in face-to-face supportive interaction, fulfill small group skills and fulfill their responsibilities in group process behaviors. It is also seen that these sub-dimensions are evaluated between 3.50-3.89 average range in a 5-point Likert scale. However, the average of the individual responsibility sub-dimension is found as 4.42. This is an indicator showing that students consider individual studies more important than group works in cooperation process.

Whether there was a relationship between freshmen students' anxiety levels towards chemistry laboratory, their attitudes towards chemistry course, students' opinions about cooperation process and their success, after the implementation was found out in this study.It is found that there is a statistically significant relationship in a negative direction between anxiety towards chemistry laboratory and liking for chemistry laboratory work. Also, there is a statistically significant relationship in a negative direction between using the laboratory equipment and chemical materials, a sub-dimension of anxiety and attitude and liking for chemistry laboratory work which are both sub-dimensions of attitude, and behavioral tendencies to learn chemistry. This result is similar to the result of Kurbanoglu & Akin, (2010; 2012) in which they found a significant relationship in a negative direction between the attitudes towards chemistry and the anxiety towards chemistry laboratory and organic chemistry.

There is also a statistically significant relation in a negative direction between working with other students, a sub-dimension of anxiety scale and cooperative process, and individual responsibility, and a sub-dimension of cooperative learning process scale. Another statistically significant relation in a positive direction is found between student success and attitude and liking for chemistry theory lessons and evaluative beliefs about school chemistry, sub-dimensions of attitude scale. As for Mattern and Schau (2002) positive attitude towards science is directly proportionate to success. If students' attitude levels towards science courses are increased, that will impact the quality of the study and reaching the acquisitions positively.

When we analyze open-ended questionnaire data, we see that half of the students expressed that while choosing the group members, students who have a higher change to gather together should be in the same group. While almost half of the students (43.5%) expressed that there were problems in the functioning of expert groups, another group at the same rate expressed that they were glad with the functioning of these expert groups. Some students, on the other hand, stated that these expert groups should be control more in order to increase their functioning. Almost half of the students (39.1%) expressed that they were glad with how the lesson is taught while one third stated that the explanations regarding the experiment should first be made and done by the teacher. With the concern of not being able to ensure the necessary safety in the laboratory environment, teachers want to make the experiments themselves (Deters, 2005). In addition, because some teachers see science as a collection of objective information to be transferred to the student, they feel more responsible in open-ended experiment practices (Roehrig & Luft, 2004). Science is only taught by the teacher and therefore, students should follow the directives of the teachers (Cheung, 2007).Teachers' having similar beliefs mentioned above in laboratory practices leads to insufficient motivation and skills in students (Brown, Abell, Demir, & Schmidt, 2006; Cheung, 2007), and thus students cannot get used to active learning methods and cannot escape from teacher-centered teaching approach in which the teacher is active.

Almost one third of the students (28.3%) stated that they did not have access to internet all the time to reach MOODLE-supported cooperative process while almost half of them (23.9% + 17.4%) stated that MOODLE enabled them to follow course notes, increased student-student and student-teacher communication and enabled everyone's participation to the course. Students stated that to make MOODLE-supported cooperative process more functional there should be more activities to evaluate them during the process and that more videos and animations that will attract their attention should be shared.

Conclusion and Suggestions

Traditional laboratory practices have been continued to be used in our country even at the college level. Such laboratory practices generally focus on improving students' psychomotor skills. It has been observed that as education is tried to be conducted based on the "cookbook method" in such environments by giving some clues to the students in individual and small groups, the students cannot gain enough experience for group work. To this end, those who are not familiar with the cooperation process need training about how to establish communication with the purpose of creating an efficient intra-group solidarity before they start doing laboratory practices. Additionally, students should be given the understanding that they should feel responsible for each other's learning in the laboratory work conducted with a group.

It is necessary for students to understand completely the subject they are supposed to learn before they start doing experiments in a hurry. Laboratory environments must be places where discussions are held about experiments, hypotheses are formed and tested, and even new experiments are designed when necessary. To this end, teachers must design laboratory practices well within the cooperative learning environments in laboratories in order to enable students understand the subject matter effectively, and must provide them with necessary facilities to get them to study. In addition to a final evaluation may be suggested to test whether expert groups have actually gained substantial knowledge on their fields upon coaching by the teacher.

Acknowledgements

Since this project (with No. BAP-2012-1-48) was financially supported by Bartın University Research Projects Fund; the author would like to thank the Bartın University for supporting this project. The author also wishes to thank all the participants of the study, and the reviewers and editor of the Journal.

References

Ardac, D. & Akaygun, S. (2004). Effectiveness of multimedia-based instruction that emphasizes molecular representations on students' understanding of chemical change.*Journal of Research in Science Teaching,* 41, 317–337.

Arrington, C.A., Hill, J.B., Radfar, R., Whisnant, D.M., & Bass, C.G. (2008).Peer mentoring in the general chemistry and organic chemistry laboratories. *Journal of Chemical Education,85*(2), 288–290.

Azizoglu, N. & Uzuntiryaki, E. (2006).Chemistry laboratory anxiety scale. *Hacettepe University Journal of Education,* 30, 55-62.

Backus, L. (2005). A year without procedures, *The Science Teacher,72*(7), 54-58.

Bay, E. & Cetin, B. (2012).Development of cooperative learning process scale (CLPS). *International Journal of Human Sciences,9*(1), 533-545.

Bowen, C.W. (1999). Development and score validation of a chemistry laboratory anxiety instrument (CLAI) for college chemistry students. *Educational and Psychological Measurement,59*(1), 171-187.

Bowen, C.W. (2000). A quantitative literature review of cooperative learning effects on high school and college chemistry achievement. *Journal of Chemical Education*, 77, 116-119.

Brown, P.L., Abell, S.K., Demir, A. & Schmidt, F.J. (2006). College science teachers' views of classroom inquiry. *Science Education,* 90, 784-802.

Byers, W. (2002). Promoting active learning through small group laboratory classes. *University Chemistry Education,* 6, 28-34.

Carpi, A. (2001). Improvements in undergraduate science education using web-based instructional modules: the natural science pages. *Journal of Chemical Education,* 78, 1709–1712.

Cheung, D. (2007). Facilitating chemistry teachers to implement inquiry-based laboratory work. *International Journal of Science and Mathematics Education, 6*(1), 107-130.

Cheung, D. (2009). Developing a scale to measure students' attitudes towards chemistry lessons. *International Journal of Science Education, 31*(16), 2185-2203.

Deters, K.M. (2005). *Student opinions regarding inquiry-based chemistry experiments.* Hong Kong: Government Logistics Department.

Domin, S.D. (2007). Students' perceptions of when conceptual development occurs during laboratory instruction. *Chemistry Educational Research and Practice,8*(2), 140-152.

Feyzioglu, B., Demirbag, B., Ates, A., Cobanoglu, I., Altun, E. & Akyildiz, M. (2011). Students' views on laboratory applications: Izmir sample. *Elementary Education Online, 10*(3), 1208-1126.

Forsyth, J. (1996). *Teaching and learning materials and the internet*, London, Kogan Page.

Fraenkel, J.R. & Wallen, N.E. (2003). *How to design and evaluate research in education:* London: McGraw Hill.

Gordin, D.N., Gomez, L.M., Pea, R.D. & Fishman, B.J. (1996). Using the world wide web to build learning communities. *Journal of Computer-Mediated Communication, 2*(3), Available online at: http://www.usc.edu/dept/annenberg/vol2/issue3/gordin.html.

Hackling, M., Goodrum, D. &Rennie, L. (2001).The state of science in Australian secondary schools. *Australian Sciences Teachers' Journal, 47*(4), 12-17.

Hedeen, T. (2003) The Reverse Jigsaw: A process of cooperative learning and discussion. *Teaching Sociology, 31*(3), 325-332.

Hoffman, J.L., Wu, H.K., Krajcik, J.S. & Soloway, E. (2003).The nature of middle school learners' science content understandings with the use of on-line resources. *Journal of Research in Science Teaching, 40*(3), 323–346.

Hofstein, A. & Naaman, R.M. (2007). The laboratory in science education: The state of the art. *Chemistry Education Research and Practice, 8*(2), 105-107.

Hofstein, A. & Lunetta, V.N. (2003). The laboratory in science education: Foundations for the twenty-first century. *Science Education,* 88, 28-54.

Jones, M.E., Gott, R. & Jarman, R. (2000). Investigations as part of the key stage 4 science curriculum in Northern Ireland. *Evaluation and Research in Education, 14*(1), 23-37.

Johnson, B. & Christensen, L. (2004).*Educational research: Quantitative, qualitative and mixed approaches.* Pearson Education, Inc., Second Edition, 562 p, Boston.

Johnstone, A.H. & Al-Shuaili, A. (2001). Learning in the laboratory; some thoughts from the literature. *University Chemistry Education,5*(2), 42-51.

Kinzie, M.B., Larsen, V. A., Burch, J.B. & Boker, S.M. (1996). Frog dissection via the World Wide Web: implication for widespread delivery of instruction. *Educational Technology Research and Development,44* (2), 59–69.

Kurbanoglu, N.I. & Akin, A. (2010).The relationship between university students' chemistry laboratory anxiety, attitudes, and self-efficacy beliefs. *Australian Journal of Teacher Education, 35*(8), 48-59.

Kurbanoglu, N.I. & Akin, A. (2012). The relationship between university students' organic chemistry anxiety, chemistry attitudes, and self-efficacy: A structural equation model. *Journal of Baltic Science Education, 11*(4), 347-356.

Krajcik, J.S. (2000).*Advantages and challenges of using the World Wide Web to foster sustained science inquiry in middle and high school classrooms.* Keynote Speech, Taipei, Taiwan.

Lang, Q.C., Wong, A.F.L. & Fraser, B.J. (2005). Student perceptions of chemistry laboratory learning environments, student-teacher interactions and attitudes in secondary school gifted education classes in Singapore. *Research in Science Education,* 35, 299-321.

Laukenmann, M., Bleicher, M., Fu, S., Glaser-Zikuda, M., Mayring & P. Ve Von Rhöneck, C. (2003). An investigation of the influence of emotional factors on learning in physics instruction.*International Journal of Science Education,25* (4), 489-507.

Lea, N.S. & Scardamalia, M. (1997).Progressive curriculum and knowledge building uses of networked multimedia resources. *Paper Presented at the Meeting of the American Education Research Association AERA,* Chicago, IL.

Lechtanski, V.L. (2000). *Inquiry-based experiments in chemistry.* Washington, DC: American Chemical Society/Oxford University.

Levine, E. (2001). Reading your way to scientific literacy. *Journal of College Science Teaching*, 31, 122-125.

Lunetta, V.N. (1998). *The school science laboratory: Historical perspectives and contexts for contemporary teaching*. In J. B. Fraser & K. G. Tobin (Eds.), International handbook of science education (pp. 249–262). Dordrecht, The Netherlands: Kluwer.

Lunetta, V.N., Hofstein, A., & Clough, M. (2007).*Learning and teaching in the school science laboratory: An analysis of research, theory, and practice*. In N. Lederman & S.

Abel (Eds.), Handbook of research on science education (pp. 393–441). Mahwah, NJ: Lawrence Erlbaum.

Maloof, J. & White, V.K.B. (2005). Team study training in the college biology laboratory. *Journal of Biological Education*, *39*(3), 120-124.

McCreary, C.L., Golde, M.F. & Koeske, R. (2006). Peer instruction in the general chemistry laboratory: Assessment of student learning. *Journal of Chemical Education*, *83*(5), 804–810.

McLaren, B. M., Rummel, N., Pinkwart, N., Tsovaltzi, D., Harrer, A., & Scheuer, O. (2008).Learning chemistry through collaboration: A wizard-of-Oz studt of adaptive collaboration support. Proceedings of the International Conference on Computers in Education (ICCE 06). Beijing, China.

Mattern, N. & Schau, C. (2002).Gender differences in science attitude-achievement relationships over time among white middle school students. *Journal of Research in Science Teaching,39*(4), 324-340.

Mc Donnell, C., O'Connor, C. & Seery, M. K., (2007) Developing practical chemistry skills by means of student-driven problem based learning mini-projects, *Chemistry Education Research and Practice, 8*(2), 130-139.

Nakhleh, M.B., Polles, J. & Malina, E. (2002). *Learning chemistry in a laboratory environment.* In J. K. Gilbert, O. De Jong, R. Justi, D. F. Treagust& J. H. Van Driel (Eds.). Chemical education: Towards research-based practice (pp. 69-94). The Netherlands: Kluwer Academic Publishers.

Neumann, K. & Welzel, M. (2007). A new labwork course for physics students: Devices, methods and research projects. *European Journal of Physics,* 28, 61–69.

Quek, C.L., Wong, A.F.L.& Fraser, B.J. (2002). Gender differences in the perceptions of chemistry laboratory classroom environments. *Queensland Journal of Educational Research, 18*(2), 164-182.

Roehrig, G.H. & Luft, J.A. (2004). Constraints experienced by beginning secondary science teachers in implementing scientific inquiry lessons. *International Journal of Science Education, 26*(1), 3-24.

Ryder, R. J. & Graves, M. F. (1997). Using the internet to enhance students' reading, writing, and information-gathering skills. *Journal of Adolescent and Adult Literacy*, 40, 244–254.

Sanger, M.J. & Badger, S.M. II (2001).Using computer-based visualization strategies to improve students' understanding of molecular polarity and miscibility, *Journal of Chemical Education,* 78, 1412–1416.

Senocak, E. (2011). A study on adaptation of the attitudes towards chemistry lessons scale into Turkish. *Journal of Turkish Science Education, 8*(2), 114-129.

Shibley, Jr. I.A. & Zimmaro, D.M. (2002). The influence of collaborative learning on student attitudes and performance in an introductory chemistry laboratory. *Journal of Chemical Education,79*(6), 745-748.

Stewart, B.Y. (1988). The surprise element of a student-designed laboratory experiment.*Journal of College Science Teaching,* 17, 269–270.

Tsaparlis G. & Gorezi M.(2005). A modification of a conventional expository physical chemistrylaboratory to accommodate an inquiry/project-based component: method and students' evaluation.*Canadian Journal of Science, Mathematics, and Technology Education,* 5, 111-131.

Tuvi, I. & Nachmias, R. (2001). Current state of web sites in science education focus on atomic structure. *Journal of Science Education and Technology,* 10, 293–303.

Vazques-Abad, J. (1999). 'Hebdo-Chim', a web application to support learning in a chemistry methods pre-service course. *Journal of Science Education and Technology,* 8, 283–290.

Wagner, E.P. (2000). Customized internet assessments. *Journal of College Science Teaching,* 30, 454–459.

Witteck, T., Most, B., Kienast, S. & Eilks, I. (2007). A lesson plan on 'methods of separating matter' based on the learning company approach: A motivating frame for self-regulated and open lab-work in introductory secondary chemistry lessons, *Chemistry Education Research and Practice,8*(2), 108-119.

Yaron, D., Freeland, R., Lang, D. & Milton, J. (2000).*Using simulations to transform the nature of chemistry homework.* A progress report, Department of Chemistry, Carnegie Mellon University, Pittsburgh, PA.