Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi (EFMED)
Cilt 5, Sayı 2, Aralık 2011, sayfa 18-41

Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education
Vol. 5, Issue 2, December 2011, pp. 18-41

Understanding The Impact of Formative Assessment Strategies on First Year University Students' Conceptual Understanding of Chemical Concepts

Mehmet Aydeniz[1,*] and Aybuke Pabuccu[2]

[1]The University of Tennessee, Tennessee, USA; [2] Abant İzzet Baysal University, Bolu, Turkey

Received :15.06.2011 Accepted : 01.08.2011

Abstract - This study investigated the effects of formative assessment strategies on students' conceptual understanding in a freshmen college chemistry course in Turkey. Our sample consists of 96 students; 27 males, 69 females. The formative assessment strategies such as reflection on exams, and collective problem solving sessions were used throughout the course. Data were collected through pre and post-test methodology. The findings reveal that the formative assessment strategies used in this study led to significant learning gains for students. Our discussion focuses on implications for college science teaching and ways to change the culture of teaching in college science by reporting on a case where the teacher used formative assessment strategies in an effective manner.

Keywords: formative assessment, college science, learning.

Introduction

Conceptual understanding is one of the most important goals of science education. It has been argued that students who understand a subject conceptually do not rely on memorization techniques rather focuses on meaning making while learning; constantly asking questions about his/her state of understanding, modifying and reconstructing their knowledge structures (Gallagher, 2000; 2007; Scott, Mortimer, & Aguiar, 2006; Wandersee, Mintzes, & Novak, 1994). Despite the emphasis placed on students' conceptual understanding by science educators, many college professors fail to use instructional strategies that hold promise in helping their students to develop conceptual understanding of scientific concepts and

---

[*] Corresponding Author: Dr. Mehmet Aydeniz, A 408 Jane and Bailey Education Complex The University of Tennessee, Knoxville, 1126 Volunteer Boulevard, Knoxville, Tennessee, 37996-3442.
Email: maydeniz@utk.edu

processes. As a result, a significant number of students leave science classrooms with misconceptions even after instruction (Boo, 1998; Duit & Treagust, 2003; Duit, Treagust, & Widodo, 2008; Nicoll, 2001; Ozmen, 2008; Pabuccu & Geban, 2006; Pfundt & Duit, 1998; Taber & Watts, 2000).

Chemistry students are not exceptions to this trend. Research on student learning shows that students hold misconceptions related to numerous key chemistry concepts and processes. The argument holds that students leave science classrooms with misconceptions because teachers use instruction that primarily focuses on students' acquisition of information as recall material for the end of unit tests, as opposed to developing meaningful and durable understanding of the ideas presented to them (Driver et al, 1994; Leach & Scott, 2000; Lyons, 2006; National Research Council [NRC], 1996). This can be problematic in a field such as chemistry, where students are frequently called upon to apply scientific principles to solve complex algorithmic and conceptual problems (Bodner & Herron, 2002; Taber & Coll, 2002).

Literature on problem solving shows that when solving a chemical problem, students need to understand the chemical properties of substances, the conditions under which the two chemicals will combine, the effects of conditions such as temperature and pressure on the interactions between the chemical substances that react, the ratios at which the chemical substances can combine and the conditions under which chemical reactions reach equilibrium (Bodner & Herron, 2002). For instance, the concept of chemical equilibrium requires students to have a solid understanding of the chemical properties of the atoms that enter a reaction, the principles of thermodynamics such as the entropy of a system, the kinetics of chemical reactions and the ways in which a chemical equilibrium respond to external factors such as pressure, concentration and temperature. In other words, chemical problems involve multiple variables, and solution to those problems requires complex reasoning abilities. Solving chemistry problems requires use of complex reasoning because students need to navigate and coordinate between these interrelated variables (Bodner & Herron, 2002).

Chemical concepts are often conveyed to the students at a macroscopic level through the use of models, symbols, formulas, pictures and analogies through everyday language (Coll, France, & Taylor, 2005; Nakhleh, Samarapungavan,& Saglam, 2005). Students are expected to use these chemical models, symbols, mathematical calculations and analogies to develop understanding (Harrison & Treagust, 2000; Justi & Gilbert, 2002; Taber & Coll, 2002). The coordination between chemical concepts through the use of multiple representations of chemical concepts, such as symbols, models and analogies may not be easy for some students as it requires complex reasoning. In order for students to successfully deal with the complexity of key chemical concepts and processes, we need to use student-centered instructional approaches in teaching of chemistry (Leach & Scott, 2000; Vygotsky, 1978).

According to learning scientists higher levels of mental functioning are achieved when learning occurs in a social context in which individuals interact with one another, challenge one another's understanding of the topic in hand and guide one another's thinking (Driver et al., 1994, Leach & Scott, 2000). The argument holds that students engage in the exploration of meaning both individually and collectively in such learning environments (Driver et al., 1994). As a result, they develop meaningful and durable understanding of fundamental science concepts and processes.

One of the instructional strategies that promote such learning is formative assessment (NRC, 2001). Although formative assessments strategies are widely used and discussed in secondary science, there is limited research on the impact of formative assessment strategies on students' learning of science in higher education.

The purpose of this study were: 1) to describe how we used formative assessment strategies in a college chemistry classroom to improve student learning and 2) to report on the impact of formative assessment strategies on students' conceptual understanding of key chemistry concepts.

Formative Assessment as a Tool to Enhance Student Learning

Formative assessment refers to the type of assessment used for the purpose of improving students learning during instruction (Black, Harrison, Lee, Marshall, & Wiliam, 2002). A review of literature in science education shows that formative assessment strategies are effective in enhancing the quality of student learning (Black, Harrison, Lee, Marshall & Wiliam, 2002; Furtak, 2009; Nicol & Macfarlane-Dick, 2006). Educators maintain that formative assessment strategies are effective in improving quality of student learning because teachers can identify students' misconceptions, make these misconceptions visible to the learner, and devise instructional strategies based on the feedback he/she receives from the students to address their learning needs (Black et al., 2002; Furtak, 2009; Peterson, Treagust & Garnett, 1989).

It is believed that formative assessment strategies are effective learning tools because they engage students in the process of learning; the learner is able to monitor his/her own state of understanding, recognize his/her weaknesses and strengths, and with the aid of the teacher and the peers becomes aware of learning strategies that can help him/her to develop conceptual understanding of key scientific concepts and processes (Chin, Brown & Bruce, 2002; Clark & Rust, 2006; Furtak, 2009). In other words, the students are challenged both by the teacher and by their peers to become self-regulated learners (Beeth, 1998; Furtak, 2009; Yin et al., 2008).

Self-regulated learning refers to the degree to which students can regulate their mental activity, motivation and behavior during learning to achieve a goal (Pintrich & Zusho, 2002). Research indicates that when students engage in self-assessment of their learning they generate internal feedback "as they monitor their engagement with learning, activities and tasks, and assess progress towards goals" (Nicole & Macfarlane-Dick, 2006, p. 200). Butler and Winne (1995) maintain that the learners that are "more effective at self-regulation, produce better feedback and are more able to use the feedback they generate to achieve their desired goals" (as cited in Nicole & Macfarlane-Dick, 2006, p. 200).

In spite of its potential for student learning, this is the form of assessment is least practiced by the teachers at all levels of education, especially those in higher education (Black & William, 1998; Furtak & Ruiz-Primo, 2008; NRC, 2001). This is the case because of several reasons. First, most college professors do not have access to the most current literature in education and thus little pedagogical training to implement the reform-based instructional strategies in their teaching (Balinsky, 2007; Taylor, Tobin & Gilmer, 2002). Second, because productivity in publications and grant acquisition often takes priority over the quality of teaching delivered in the classroom in higher education, professors of higher education often cannot afford the time needed to learn about and to try out new instructional strategies (Author, 2010). However, there are exceptions to this general trend in higher education. This case study is a report of such as exception, where a university professor implemented a reform-based pedagogy, more specifically, used formative assessment strategies to enhance her students' conceptual understanding of fundamental chemistry concepts.

Methods

Settings and Participants

This study took place in a major university in central Turkey with a population of 16,672 students. The sample was drawn from two classrooms of freshmen general chemistry, each class hosting a different group of students in terms of their academic abilities as measured through the university exam aptitude test (Track 1(n=53) and Track 2(n=43)). Our sample consists of 96 students; 27 males, 69 females. The average age of participants is 19. All students have taken at least one chemistry course at high school and have seen extensive tutoring as the majority of the students have to attend tutoring schools for at least one year in preparation for the university entrance exam in Turkey. Thus, they have extensive experience in problem solving in chemistry, physics and mathematics.

Intervention

All students attended lectures on the topics of chemical compounds; chemical reactions; solutions; the periodic table and some atomic properties; chemical bonding; liquids, solids and intermolecular forces delivered by the second author throughout the year. The intervention (i.e. frequent use of formative assessments) started in the middle of first semester and continued throughout the second semester. This decision was made purposefully 1) because the concepts covered during the first part of the first semester are very basic concepts that are covered in high school science curriculum and 2) because most students have had extensive exposure to these concepts during their preparation for the nationwide exam in Turkey.

The course professor taught the course with specific attention to students' misconceptions throughout the year. She frequently used probing and guiding questions, and engaged her students in group-work throughout her lectures. In order to diagnose her students' level of conceptual understanding and identify their misconceptions, a pre-test was administered to all students three weeks before the official midterm of the first semester (i.e. the post test). The test covered the topics of chemical compounds; chemical reaction and solution. The test was administered after the students had been exposed to the concepts covered on the test through lectures. The same procedures were followed during the second semester as well. However, different chemistry topics (the periodic table and some atomic properties; chemical bonding; liquids, solids and intermolecular forces) were emphasized during the intervention in the second semester.

The course professor graded students' pre tests and identified the concepts that they were missing exactly one week after the test was administered. Then, the course professor distributed an empty copy of the pre-test to the students and asked each student to individually reflect on the mistakes that they had made on the pretest. The professor explicitly told the students to focus on understanding the scientific principles rather than getting the right answer while working on their mistakes that they had made on the pre-test.

After students were given enough time to reflect on the questions individually, they were placed in heterogeneous groups of four and asked to answer the same questions collectively. The group diversity was achieved based on students' academic achievement and gender. Students worked on solutions to the problems in their groups for two hours. The professor instructed students to work collaboratively to read, understand and solve questions making explicit references to the underlying scientific theories. The students were instructed to take turns and explain how they went about conceptualizing the problem, the strategies that they used and explaining it to one another. They were allowed to use their textbooks, their peers and the professor as resources during these group-learning activities to answer questions. The professor walked around the room, checked on group discussions to make sure that the exchanges that took place within and between groups focused on probing each others' understanding of concepts underlying the problems and the strategies they used to solve the problems. If a specific group was believed to have a hard time answering the questions, the professor asked a member of the other group that knew how to solve the problem to volunteer and help their classmates to understand the problem and its solution.

The professor reminded her students that everyone in the group would turn in a test with all solutions and answers written on it. In addition, they were reminded that the professor would randomly pick one of the four papers (i.e. tests) for each group and give the group a score based on what she randomly picked. It was hoped that this strategy would hold the group members accountable for teaching one another and helping each other to understand the concepts and solutions to the problems.

It was hoped that these strategies collectively would encourage students to understand the source of their mistakes, use their peers, textbooks and the professor as a reference to understand the content that they had not understood previously and learn to answers the questions that are of similar nature on the follow up test.

Data

We collected multiple sets of data in this study. The first set of data includes students' pre and post-test scores. Two authors constructed the tests. Both authors have master's degrees in chemistry. First, they developed a pool of questions for each test (i.e. pre and post tests). The pool of questions consisted of 25 fill in the blank, matching, multiple-choice and open-ended questions for each test. We used qualitative item-analysis method (Zurawski, 1998) to develop the test items. The authors evaluated the quality of each question based on three criteria: the perceived level of difficulty, understandability (i.e. language), and ability to measure the target constructs. The two authors discussed the content and construct validity of each question and whether the students would be able to complete the test within the time frame given. The two authors reached a consensus for each question after several iterations of evaluations described above. The second authors' four years of experience teaching and assessing similar groups of students was of great help in determining the item difficulty level. We reduced the number of questions for each test to 11 for the first semester tests and 10 for the second semester tests after our iterative evaluations(see Appendix A for the pre and post-tests).

Second, the professor took a researcher's journal throughout the study where she recorded her observations of the nature of conversations and communications that took place between the group members during collective problem solving activities. Third, we collected data on students' perceptions of the influence of group-based learning activities on their conceptual understanding of key ideas underlying the test questions. Finally, we videotaped the group-based learning activities as a supplement to the professor's daily reflection on the instructional strategies used. The data we gathered through videos helped us understand whether students were actively engaged in learning or off task during group-based learning activities.

Data Analysis

Two groups of students, Track 1(n=53) students with high aptitude test scores and Track 2(n=43) students with low aptitude test scores participated in this study. Data analyses took place in two stages. First, we used a paired samples t-test to understand whether there is a significant difference between students' performance on each pre and post-test for all topics and each group of students that we tested. Second, we read each student's paper and identified the misconceptions that were revealed in each student's responses to the test questions (i.e. pre and post tests). However, because some students failed to answer some questions, we were only able to identify the misconceptions of students who provided an answer. Then, we counted the number of students who had developed scientifically correct responses for each concept on the pre and post-tests respectively to measure the impact of the intervention on the most common misconceptions held by the participants. However, these in-depth analyses focusing on students' misconceptions were performed only during the second semester of the intervention as we were only interested in the impact of intervention on students' test scores during the first semester. Finally, we analyzed students' responses to the open-ended questions about the perceived influence of formative assessment strategies (i.e. self-reflection and group-based learning activities) on their understanding of the chemical concepts covered during the intervention.

Results

This study took place over two academic semesters with two groups of students focusing on the concepts of chemical compounds; chemical reactions; solutions; the periodic table and some atomic properties; chemical bonding; liquids, solids and intermolecular forces. We report the results from the first semester followed by the results from the second semester for each group of students (i.e. track 1 and track 2).

First Semester: High Achieving Students

The intervention and the pre and post-tests focused on the topics of chemical compounds, chemical reactions and solutions in the first semester. The participants were able to receive a maximum of 100 points on each test. The mean score for the pre-test(n=53) is 40.25 with a standard deviation of 18.1, and 50.20 for the post-test(n=53) with a standard deviation of 19.4. The difference between the two means is 9.945. This difference is significant (*p=0.00) at 95% confidence level. The correlation between pre-test and post-test is 0.593. The results show that the intervention had a significant impact on the participants' learning of topics of chemical compounds, chemical reactions and solutions.

First Semester: Low-Achieving Students

The participants were able to receive a maximum of 100 points on each test. Our analyses indicate that students showed an improvement between pre and post-tests in the first semester. While the mean score for the pre-test(n=47) is 37.19 with a standard deviation of 14.6, the mean score for the post-test is 52.15(n=47) with a standard deviation of 14.8. The difference between the two means is 14.957. This difference is significant (*p=0.00) at 95% confidence level. The correlation between pre and post-test is 0.588. These results suggest that the interventions had a greater impact on low-achieving students' conceptual understanding (14.957 increase in the mean) than it did on conceptual understanding of high-achieving students (9.945 increase in the mean). We argue that low-achieving students made the greatest improvement because they invested a greater effort into understanding the concepts covered on the tests than their high-achieving peers. Low-achieving students invested a greater effort to benefit from the instruction as they were in most need of improving their grades. For instance, based on the second authors' observation of group-based learning activities we know that the low-achieving students consistently asked explanation-seeking questions to their peers, moved between groups when they were not satisfied with the answers of their group members and sought help from the course professor. These students exlicitly told the course professor that the group-based learning activities significantly contributed to their learning.

Second Semester: High-Achieving Students

The intervention and the pre-test and post-test focused on the topics of the periodic table and some atomic properties, chemical bonding, liquids, solids and intermolecular forces in the second semester. The participants were able to receive a maximum of 100 points on the post-test. Our analyses show that the mean score for pre-test(n=53) is 26.00 with a standard deviation of 17.00, and 42.55 for post-test(n=53) with a standard deviation of 19.05. The difference between the two means is 16.55. This difference is significant (*p=0.00) at 95% confidence level. The correlation between pre-test and post-test is 0.704. The results show that even the mean score is lower than 50, the intervention had a significant impact on the participants' learning of the periodic table and some atomic properties, chemical bonding, liquids, solids and intermolecular forces.

The participants made significant learning gains especially on questions 2,6,7,9,10. The questions that the participants had the most difficulty with were related to intermolecular forces and molecular geometry. Although the majority of the students made gains on questions 2,6,7,9,10 between pre-test and post-test, still 50 % of students incorrectly answered question 10 that dealt with intermolecular forces, question 2 that dealt with molecular geometry, question 6 that dealt with polarity, question 7 and question 9 that also dealt with intermolecular forces. However, students still made gains between pre-test and the post-test. These gains are summarized in Table 1.

Table 1. Percent of high achieving students' receiving 50% or more credit for each question between pre and post-test.

Question#	Pre-test (%)	Pre-test (%)	Gain(%)
Q2	18.9	45.3	26.4
Q6	13.3	60.3	47.0
Q7	7.6	37.8	30.2
Q9	9.5	60.4	50.9
Q10	18.9	35.8	16.9

Note: This table only includes questions on which participants made a significant progress.

Second Semester: Low-Achieving Students

The participants were able to receive a maximum of 100 points on the pre and post-tests. Our analysis show that the mean score for pre-test (n=43) is 23.56 with a standard deviation of 16.7, and 40.49 for post-test(n=43) with a standard deviation of 14.391. The difference between the two means is 16.930. This difference is significant ((*p=0.00) at 95% confidence level. The correlation between pre-test and post-test is 0.522. The concepts covered during the second semester included the periodic table and some atomic properties, chemical bonding, liquids, solids and intermolecular forces.

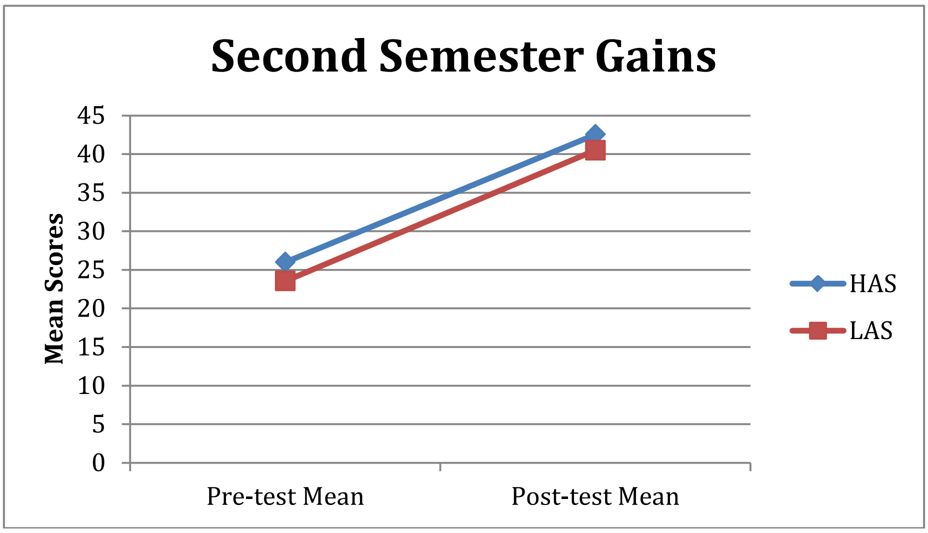
The participants made significant learning gains especially on questions 1,4,5,7,10. Although the majority of the students made gains on questions 1,4,5,7,10 between pre-test and post-test, still 63,6 % of students incorrectly answered question 10 that dealt with intermolecular forces, question 1 that dealt with the periodic table and question 4 that dealt with lewis structure, question 5 that dealt with molecular geometry and question 7 that dealt with intermolecular forces.

Table 2. Percent of low-achieving students’ receiving 50% or more credit for each question between pre and post-test.

Question#	**Pre-test (%)**	**Post-test(%)**	**Gain(%)**
Q1	46.5	69.8	23.3
Q4	30.3	69.8	39.5
Q5	37.3	72.1	34.8
Q7	21.0	65.2	44.2
Q10	7.0	32.2	25.2

Note: This table only includes questions on which participants made a significant progress.

The overall results fort he second semester are summarized in Figure 1.



HAS: High-Achieving Students, LAS:Low-Achieving Students
Figure 1. Students' Learning Gains.

Misconceptions

Understanding the impact of formative assessment strategies on uncovering students' misconceptions was one of the goals of this research study. The findings suggest that formative assessment strategies used in this study were effective in uncovering students' misconceptions. We provide the details of these misconceptions and the impact that the formative assessment strategies had on correcting students' misconceptions in the following section.

Misconceptions: High-Achieving Students. The results of our analysis showed that 20.75% (n=11) of the participants in this group held misconceptions related to the polarity of molecules at the beginning of the study, this percentage went down to 7.54% (n=4), however, on the post test. Five participants believed at the onset that a molecule would be considered polar only if it was made up of atoms that had different electronegativity values, ignoring the molecular geometry. The number of participants who held this misconception went down to one after the intervention. Only one student believed that any atom that is part of a polar molecule must be polar prior to the intervention. This student held the same view even after the intervention. While five students in this group considered molecules that have one pair of nonbonding electrons as polar prior to intervention, only 2 students held this misconception after the intervention.

Similarly, while 56.60% (n=30) of the participants held misconceptions related to the phase changes at the beginning of the study, this percentage went down to 24.52 (n=13) at the end of the study. Finally, while 43% (n=23) of participants, believed that the physical changes in a molecule are caused by intramolecular forces in a molecule rather than by intermolecular forces between molecules at the beginning of the study this number went down to 20.75% (n=11) at the end of the study. These statistics are summarized in Figure 2.

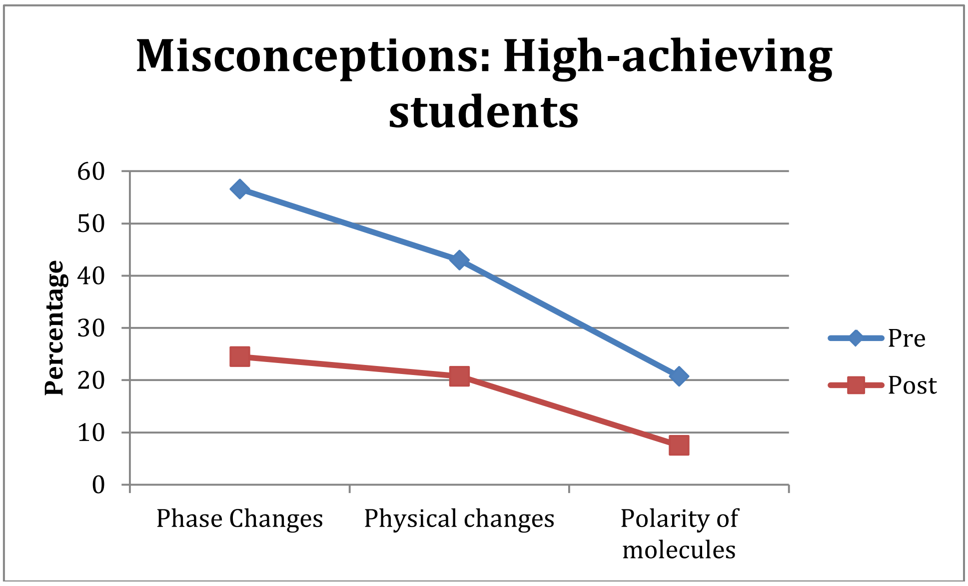


Figure 2. Change in High Achieving Students' Misconceptions over time.

As it can be seen from Figure 2, although the frequency of students' misconceptions went down some students still held misconception related to the topics covered during the intervention at the end of the study.

Misconceptions: Low-Achieving Students. When we analyzed low achieving students' responses, we observed similar misconceptions among low achieving students. For instance, while 27.91% (n=12) of the participants in this group held misconceptions related to electronegativity, only 4.65% (n=2) of the participants held this misconception at the end of the study. Similarly, while 32.55% (n=14) of the participants held misconceptions related to the polarity of molecules, only 5.66% (n=3) of the participants held the same misconception by the end of the study. The specific misconceptions held by students in this domain include; all molecules that include covalent bonds must be polar (n=3), any molecule that includes an unshared pair of electrons are considered polar (n=6), any molecule that consists of atoms of different electronegativity values must be polar (n=5). Finally, while 48.83% (n=21) of this group of students thought phase changes took place because of the weakening of the intramolecular forces, only 13.95% (n=6) of the students in this group held the same misconception at the end of the study. These statistics are summarized in Figure 3.

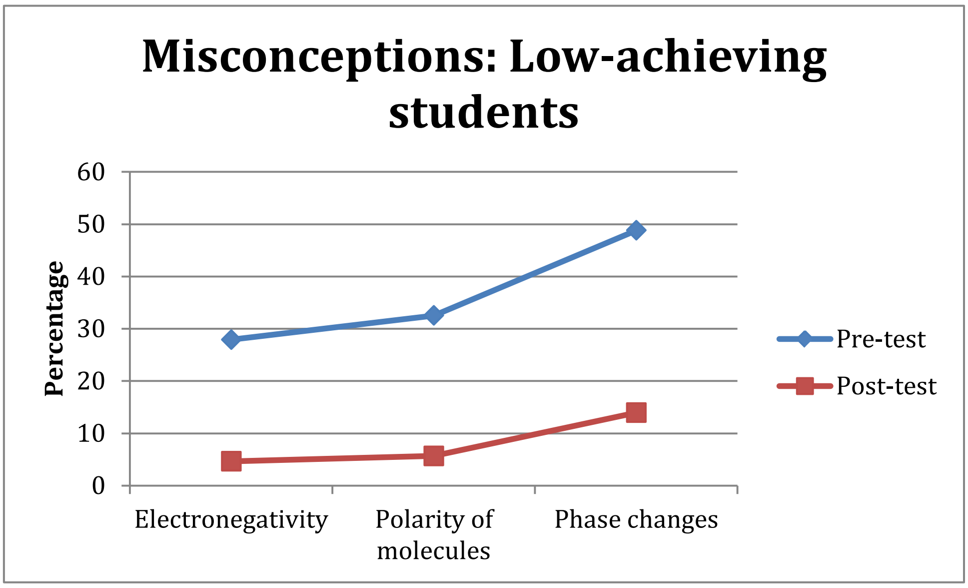


Figure 3. Change in Low-Achieving Students' Misconceptions over time.

As it can be seen from Figure 3, students held fewer misconceptions at the end of the study than they did at the onset.

Students' Engagement and their Perception of the Activities on their Learning

Although the differences between students' performance on the pre and post test show that formative assessment strategies had a positive impact on students' conceptual understanding of targeted chemistry concepts, we also wanted to understand students' perceptions of the effects of the formative assessments strategies used during the intervention on their learning. The analyses of students' responses to the open-ended questions indicate that students reported the benefits of the activities on their learning in various ways. Only 83 out of 96 participants provided comments about the impact of the activities on their learning. The majority of the participants (n=76) acknowledged the positive influence of formative assessment on their understanding of the concepts underlying the problems they missed on the midterm exam. Only seven students who scored low on the first midterm exam did not think the activities helped them to understand the concepts underlying the test problems. However, those who did not find the activities beneficial complained that they needed more time to process all the information.

The students who reported the positive influence of formative assessment provided diverse reasons. These reasons include: ability to ask questions and receive feedback from multiple peers, the freedom they needed to ask questions without experiencing the feeling of embarrassment. One student said, "it was very beneficial because I was not understanding some concepts fully. This experience gave me the chance to check my understanding with my peers and gain confidence in my knowledge.” Of 86 participants who responded, 35 participants reported that they assumed dual role of the listener and the explainer, 19 participants reported that they assumed only the listener role and 31 reported only assuming the explainer role during group-based activities. In spite of the role they assumed, the majority of the participants (n=76) reported the positive influence of formative assessment strategies on their learning.

Discussion

The results from this study confirm the results of previous studies and show that formative assessment strategies resulted in significant learning gains for students as measured by the performance of students on the pre and post tests (Black & Wiliam, 1998; Brown, Bull & Pendlebury, 1997). These results came about for several reasons. First, formative assessment strategies used in this study created a context for students’ misconceptions to come fore. After the misconceptions were identified, we created a context for the participants to become aware of their misconceptions. The students were placed in a group setting with their completed and graded pre-tests a week after we administered the test. The students were challenged both verbally and in a written form to reevaluate their knowledge of the concepts measured on the test, reflect on the mistakes they had made on the pre test, discuss the source of their mistakes with their peers who had a better understanding of the concepts covered on the test. These learning activities led to a rich discourse in which the students focused on meaning making rather than memorization of established facts of science. In spite of significant learning gains achieved, few students still held onto their existing misconceptions. This is expected because research shows that the process of reconstructing one’s “central, organizing concepts” can be quite difficult (Posner, Strike, Hewson, & Gertzog, 1982, p. 211). While formative assessment strategies may be effective for some students to achieve reconstruction, it may take others exposure to alternative experiences before they can reconstruct their existing understanding of scientific phenomena.

Nevertheless, the results of this study encourage us further to use formative assessment strategies in university chemistry classrooms. However, university professors’ implementation of formative assessment strategies may not be as easy as it seems. In order for university professors to use formative assessments strategies in college science classrooms, professors need to develop beliefs that are consistent with the epistemologies underlying the formative assessment theory, and develop pedagogical knowledge of formative assessment strategies (Tomanek, Talanquer, & Novodvorsky, 2008). Obviously, if a professor's understanding of the role of assessment is limited to measuring the learning of their students at the end of semester tests or midterm tests, formative assessment will not become prevalent in college science classrooms.

Second, formative assessment challenges the authority of the teacher that many college professors are not willing to abandon (Abbas, Goldsby, & Gilmer, 2002; Balinsky, 2007). Third, in order for formative assessment to become effective and bring about improvements in students' learning, professors need to have a sophisticated understanding about the purposes of formative assessment and a solid knowledge of formative assessment strategies.

Black and William (1998) state that when the teachers hold naïve views and limited knowledge of formative assessment strategies the effects of formative assessment on students' learning outcomes is minimal. It has been discussed in science education literature that in order for college science professors to use reform-based teaching strategies, we need to pay an increasing emphasis on the professional needs of college science professors. These needs include: developing reform-based beliefs about teaching and learning, developing pedagogical content knowledge and acquiring knowledge of different purposes and forms of assessments. However, we argue that even when such professional development programs are provided, the current culture of college science teaching makes it harder for such reform-based pedagogies to prevail in college science courses (Author, 2010; Balinsky, 2007; Taylor et al. 2002).

First, many university professors have limited knowledge of reform-based pedagogies (French, 2006; Taylor et al., 2002). Second, even in the presence of such knowledge there is limited accountability for college professors to use reform-based pedagogies such as formative assessment (Author, 2010; Balinsky, 2007). The challenge facing the science education community at large is to find new ways to engage the university professors in understanding and implementing reform-based pedagogies such as formative assessment strategies in their classrooms. However, this challenge cannot be overcome very easily. It requires institutional commitment to bring about changes in the culture of teaching in science classrooms (Aydeniz, 2010; Balinsky, 2007; French, 2006; Lord, 2008). For instance, in an effort to motivate college professors to seek out innovative teaching ideas and use them effectively in their classrooms, the tenure process should reward good teaching as well as well as productivity in publication and grant acquisition.

Limitations

There are several limitations to this study that we would like our readers to keep in mind as they consider the implications of the results of this study for their particular context. First,this research study only involved the participation of 96 students. This is a relatively small number of students through which we can establish the effectiveness of formative assessment strategies. Without more data and additional participants, it is difficult to claim that differences in student performance between pre and post-test are results of the formative assessment strategies implemented.

Second, it would be naïve to argue that formative assessments alone contributed to the significant learning gains achieved by the students. For instance, we do not know if some students spent extra time outside of the classroom studying for the post-test. If students spent a significant study time outside of the classroom, we were not able to measure their study time outside of school. We want our readers to keep these limitations in mind as they consider its implications for similar contexts.

References

Abbas, A. O., Goldsby, K. A., & Gilmer, P. J. (2002). Promoting active learning in a university chemistry class: Metaphors as referents for teachers' roles and actions, In P. C. Taylor, P. J. Gilmer, & K. Tobin (Eds.), *Transforming undergraduate science teaching: Social constructivist perspectives* (pp. 183-210), New York: Peter Lang Publishing, Inc.

Balinsky, M. G. (2007). *Forging an identity: Four science doctoral students in a collaborative partnership with K-12 science teachers.* Unpublished Dissertation, Florida State University, Tallahassee, FL.

Beeth, M.E. (1998). Teaching for conceptual change: Using status as a metacognitive tool. *Science Education, 82*, 343-356.

Black, P., Harrison, C., Lee, C., Marshall, B., & Wiliam, D. (2002). *Working inside the black box: Assessment for learning in the classroom*. London, UK: King's College London Department of Education and Professional Studies.

Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education: Principles, Policy & Practice, 5*(1), 7-71.

Bodner, G.M., & Herron, J.D. (2002). Problem solving in chemistry. In: J. Gilbert (Ed.), *Chemical education*: *Research-based practice* (pp. 105-133). Dordrecht: Kluwer Academic Publishers.

Boud, D. (1995). *Enhancing learning through self-assessment*. London: Kogan Page.

Boo, H.K. (1998). Students' understandings of chemical bonds and the energetics of chemical reactions. *Journal of Research in Science Teaching, 35*(5), 569-581.

Brown, G., J. Bull., & Pendlebury, M. (1997). *Assessing student learning in higher education*. London: Routledge.

Butler, D. L. & Winne, P.H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research, 65*, 245-281.

Clark, C.M., & Rust, F.O. (2006). Learning-centered assessment in teacher education. *Studies in Educational Evaluation* 32,73-82.

Chiu, M-H. (2005). A national survey of students' conceptions in chemistry in Taiwan. *Chemical Education International, 6*(1), 1-8.

Chin, C., Brown, D. E., & Bruce, B. C. (2002). Student-generated questions: a meaningful aspect of learning in science. *International Journal of Science Education, 24,*(5), 521-549.

Coll, R., France, B., & Taylor, I. (2005). The role of models/and analogies in science education: Implications from research. *International Journal of Science Education, 27*(2), 183-198.

Donovan, M. J., & Bransford, J. D. (2005). *How students learn: Science in the classroom*. Washington, DC: National Academy Press.

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 et al. (Ed.), *International handbook of research on conceptual change* (pp. 629-646). New York: Routledge.

French, D. P. (2006). Don't confuse inquiry *and* discovery. *Journal of College Science Teaching, 35*(6),58-59.

Furtak, E. M., Ruiz-Primo, M.A. (2008). Making students' thinking explicit in writing and discussion: an analysis of formative assessment prompts. *Science Education. 92*(5), 799-824.

Furtak, E. M. (2009). *Formative assessment for secondary science teachers.* Thousand Oaks, CA: Corwin Press.

Gallagher, J. (2007). *Teaching science for understanding: A practical guide for middle and high school teachers.* New Jersey: Prentice Hall.

Gallagher, J. J. (2000). Teaching for understanding and application of science knowledge. *School Science and Mathematics, 100*(6), 310-318.

Gilbert, J. G., De Jong, O., Justi, R. Treagust, D. F. & van Driel, J. H. (Eds.). (2002). *Chemical education: Towards research based practice*. Dordrecht, The Netherlands: Kluwer

Harrison, A. G., & Treagust, D. F. (2000). Learning about atoms, molecules and chemical bonds: A case-study of multiple model use in grade-11 chemistry. *Science Education, 84*, 352-381

Justi, R., & Gilbert, J. (2002). Models and modeling in chemical education. In J. K. Gilbert, O. DeJong, R. Justi, D. F. Treagust & J. H. Van Driel (Eds.), *Chemical education: Towards research-based practice* (pp. 47-68). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Leach, J., & Scott, P. (2000). The concept of learning demand as a tool for designing teaching sequences. Paper prepared for the meeting *Research-based teaching sequences,* Université Paris VII, France, November 2000.

Lord, T. (2008). We know how to improve science understanding in students, so why aren't college professors embracing it? *Journal of College Science Teaching 38*(1), 66-8.

Lyons, T. (2006). Different Countries, same science classes: Students’ experience of school science classes in their own words. *International Journal of Science Education, 28*(6), 591-613.

National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academy Press.

National Research Council [NRC]. (2001). *Knowing what* students know*: The science and design of educational* assessment. Washington, DC: National Academy Press.

Nakhleh, M. B., Samarapungavan, A., & Saglam, Y. (2005). Middle school students' beliefs about matter. *Journal of Research in Science Teaching, 42*(5), 581-612.

Nicol, D. J. & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education, 31*(2), 199-218

Nicoll, G. (2001). A report of undergraduates’ bonding misconceptions. *International Journal of Science Education, 23*(7), 707-730.

Ozmen, H. (2008). The influence of computer-aided instruction on students’ conceptual understanding of chemical bonding and attitude toward chemistry: A case for Turkey. *Computers and Education, 51*, 423-438.

Pabuccu, A., & Geban, O. (2006). Remediating misconceptions concerning chemical bonding through conceptual change text. *Hacettepe Üniversitesi Egitim Fakültesi Dergisi, 30*, 184-192.

Peterson, R. F., Treagust, D. F., & Garnett, P. (1989). Development and application of a diagnostic instrument to evaluate grade-11 and-12 students’ concepts of covalent bonding and structure following a course of instruction. *Journal of Research in Science Teaching, 26* (4), 301-314.

Pfundt, H., & Duit, R. (1998). *Bibliography: Students' Alternative Frameworks and Science Education.* Kiel, Alemania: IPN.

Pintrich, P. R., & Zusho, A. (2002) Student motivation and self-regulated learning in the college classroom. In: Smart. J.C. & Tierney, W.G. (Eds), *Higher education: handbook of Theory and Research,* Volume XVII(pp. 55-128), New York: Agathon Press.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Towards a theory of conceptual change. *Science Education, 66* (2), 211-227.

Scott, P., Mortimer, E., & Aguiar, O. (2006). The tension between authoritative and dialogic discourse: a fundamental characteristic of meaning making interactions in high school science lessons. *Science Education, 90*, 605-631.

Taber, K. S., & Coll, R**.** (2002) Chemical bonding, in Gilbert, J. K. et al., (editors) *Chemical Education: Research-based Practice* (pp.213-234), Dordrecht: Kluwer Academic Publishers.

Taber, K. S. & Watts, M. (2000) Learners' explanations for chemical phenomena, *Chemistry Education: Research and Practice in Europe, 1*(3), 329-353.

Taylor, P., Gilmer, P., & Tobin, K. (Eds) (2002). *Transforming undergraduate science teaching: Social constructivist perspectives.* New York, NY: Peter Lang Publishing, Inc..

Tomanek, D., Talanquer, V., Novodvorsky, I. (2008). What do science teachers consider when selecting formative assessment tasks? *Journal of Research in Science Teaching, 45(*10), 1113-1130.

Wandersee, J. H. , Mintzes, J. J. & Novak, J.D. (1994). Research on alternative conceptions in science. In D.L. Gabel (Ed) *Handbook of Research on Science Teaching and Learning.*

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

Yin, Y., R. Shavelson, C. Ayala, M. Ruiz-Primo, P. Brandon, & E. Furtak. (2008). On the impact of formative assessment on student motivation, achievement, and conceptual change. *Applied Measurement in Education*, *21*(4), 1–42.

Zurowski, R.M (1998). Making the most out of exams. Procedures for item analysis. *Forum*, *7*(6), 1-4.

Appendix A. TESTLER

FIRST SEMESTER PRE-TEST 135 GENEL KİMYA I

1) Boşlukları doğru kavramlarla doldurunuz.

* Bir redoks tepkimesinde başka bir bileşiği ……………….bileşiğe yükseltgen denir.
* 0,070830. 10^2 ’ de ……....tane anlamlı rakam vardır.
* LiH bileşiği için hidrojen’in yükseltgenme basamağı… ….Lityum’un ki ise …… …dır/dir.
* 6 ^{0}C deki suyun yoğunluğu 4 ^{0}C de suyun yoğunluğundan daha……….olur.
*................atom modelinde, bir elementin bütün atomlarının kütlesi ve diğer özelliklerinin aynı olduğunu savunulur.
* Pozitif yüklü kutuba………denir
* 1 tane C-12 atomunun ağırlığı................ (12akb/12g) dır/dir.
* 6,022 .10^{23} tane Hidrojen <u>molekülünün</u> ağırlığı.................... (1akb/1g/2akb/2g)dır/dir.
* Katot ışınları ……...yüklü parçacık gibi davranır.

2) Aşağıdakiler ne çeşit organik bileşiklerdir?
$CH_3CHCHCH_2CH_3$……………..$CH_3CH_2CO_2H$……………… …ve CH_3CH_2 CH(OH) CH_2CH_3………………

3) Laboratuarda 5 L, 4 M asit çözeltisi bulunmaktadır. Deney yapabilmek için 800 mL, 3 M asit çözeltisine gerek duyulmaktadır.

- 5 L, 4 M asit çözeltisinden kaç mL kullanılmalıdır?
- Kaç mL saf su kullanılmalıdır?

4) Nitrik Asit, aşağıda verilen ardışık tepkimelere göre amonyak ve oksijenden üretilir.

$$4NH_{3(g)} + 5O_{2(g)} \rightarrow 4NO_{(g)} + 6H_2O_{(g)}$$
$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$$
$$3NO_{2(g)} + H_2O_{(s)} \rightarrow 2HNO_{3(aq)} + NO_{(g)}$$

Üçüncü basamakta oluşan $NO_{(g)}$’ ın tekrar tepkimeye girmediğini düşünürsek, kütlece %50 lik 5,10 kg amonyak çözeltisinden % 80 verimle kaç kilogram nitrik asit elde edilir, çözüm yolunuzu ayrıntılı olarak göstererek hesaplayınız. (NH_3: 17 g/mol; HNO_3: 63 g/mol)

5) Kükürt trioksit kütlece %40 kükürt içerir. 24 g kükürt ile 24 g oksijen tepkimeye sokuluyor. Hangi maddeden kaç gram artar? En çok kaç gram kükürt trioksit elde edilir? (S:32 g/mol; O: 16g/mol)

6) Bir C,H ve N bileşiğinin 48,6 gramı, 4,2 g H; 3 mol C ve 3,6. 10^{23} tane azot atomu içeriyor. Bileşiğin molekül kütlesi 162 akb olduğuna göre, bileşiğin basit ve molekül formülleri nelerdir? (C: 12,0 g/mol; H:1,0 g/mol; N:14 g/mol; Avagadro sayısı: 6,00.10^{23})

7) Aşağıdaki yarılma (disproporsiyon) tepkimesini a) yükseltgenme ve indirgenme yarı reaksiyonlarını; b) net eşitliği yazarak ve açıklayarak denkleştiriniz.

$Cl_{2(s)} \rightarrow Cl^- + ClO_3^-$ (Bazik çözelti)

8) Aşağıdaki adları verilen bileşiklerin formüllerini ve formülleri verilen bileşiklerinde adlarını uygun boşluklara yazınız.

Cl_2O_7.. ….$HCl_{(k)}$................................. ……..Periyodik asit ....
Sodyum karbonat..............................Sodyum perklorat............................Cr_2O_3 ....
$CuSO_4$ $5H_2O$…………..…………….$H_2S_{(aq)}$…………………………… Magnezyum Dihidrojenfosfat………

9) Aşağıda verilen durumlarda bir tepkime olup olmayacağını öngörünüz. Oluyorsa net iyonik eşitliği yazınız.

a) $CuSO_{4\,(aq)} + Na_2CO_{3(aq)} \rightarrow$

b) $AgNO_{3\,(aq)} + KOH_{(aq)} \rightarrow$

c) Demir (III) Klorür + Sezyum Fosfat →

10) Hidrojen peroksit çözeltisi, $H_2O_{2(aq)}$, $KMO_{4(aq)}$ çözeltisi ile titre ediliyor. Reaksiyon;

$5\,H_2O_{2\ (aq)} + KMnO_{4(aq)} + H_2SO_{4(aq)} \rightarrow O_{2(g)} + MnSO_{4(aq)} + K_2SO_{4(aq)} + H_2O_{(s)}$ (DENKLEŞMEMİŞ)

Bu reaksiyona göre, 100,0 mL 0,10 M $KMnO_4$ çözeltisini titre etmek için 20,0 g H_2O_2 çözeltisi gerekiyorsa, H_2O_2 çözeltisi kütlece yüzde kaçlık bir çözeltidir? (H:1; O:16)

11) Yükseltgenme – indirgenme (redox) reaksiyonları ne demektir? Redox reaksiyonu olmayan bir tepkime yazıp nedenlerini yazınız.

FIRST SEMESTER POST TEST 135 GENEL KİMYA I

1) Boşlukları doğru olacak şekilde doldurunuz. (10 puan)
* 97,0010’ da ……tane anlamlı rakam vardır.
* KO_2 bileşiği için Potasyumun yükseltgenme basamağı………iken oksijeninki ise … …dır/dir.
* $2NO_{2(g)} + 7H_{2(g)} \rightarrow 2NH_{3(g)} + 4H_2O_{(g)}$ redox reaksiyonunda $H_{2(g)}$ ………………………(yükseltgen/indirgen) maddedir.
* 0 ^{0}C deki suyun yoğunluğu 4 ^{0}C de suyun yoğunluğundan daha………olur.
* Pozitif yüklü iyona………..…denir.
* …………parçacıkları, He^{+2} iyonu ile aynı özelliklere sahiptir.
* 6,022 .10^{23} tane C-12 atomu...................(12akb/ 12g) dır/dir.
* 1 tane Flor <u>molekülünün</u> ağırlığı................... (F:19 akb/19 g/38g/38akb)dır/dir.
* Atom maddenin en küçük yapı taşı ise, ……………de bileşiklerin en küçük birimidir.

2) Aşağıdakiler ne çeşit organik bileşiklerdir? (3 puan)
$CH_3CH_2CH_2CH_3$………………;CH_3COOH…..……………… …ve CH_3CH_2 CH(Cl) CH_2CH_3……………………………..

3) Laboratuarda 3 L, 2 M baz çözeltisi bulunmaktadır. Deney yapabilmek için 600 mL, 1,5 M baz çözeltisine gerek duyulmaktadır. (7 puan)

- 3 L, 2 M baz çözeltisinden kaç mL kullanılmalıdır?

- Kaç mL saf su kullanılmalıdır?

4) $TiO_{2(k)}$ doğada saf halde bulunmaz. Bir yöntemle safsızlık içeren $TiO_{2(k)}$, gaz halindeki $TiCl_{4(g)}$ e dönüştürülür, sonra tekrar saf katı $TiO_{2(k)}$’ e çevrilir. Bu yöntemle %60 verimle 240 gram saf $TiO_{2(k)}$ elde etmek için kütlece %50’lik bir karbon karışımından kaç gram almak gerekir? (TiO_2: 80g/mol; C: 12 g/mol) (15 puan)

$2TiO_{2(\text{saf değil})} + 3C_{(k)} + 4Cl_{2(g)} \rightarrow 2\,TiCl_{4(g)} + CO_{2(g)} + 2CO_{(g)}$

$TiCl_{4(g)} + O_{2(g)} \rightarrow TiO_{2(k)} + 2Cl_{2(g)}$

5) Suda, hidrojenin oksijene kütlece oranı 1/8 dir. Kütleleri birbirine eşit olan hidrojen ve oksijen gazları tepkimeye sokuluyor. Gazlardan biri bittiğinde oluşan su 18 g olduğuna göre
(10 puan)

a) Hidrojen ve oksijenden kaçar gram tepkimeye girmiştir.
b) Başlangıçta toplam kütle nedir?
c) Hangi gazdan kaç gram artmıştır?

6) Bir C,H ve azot bileşiğinin 48,6 gramı, 1,8. 10^{24} tane C atomu; 4,2 g hidrojen ve 0,6 mol N içeriyor. Bu bileşiğin molekül kütlesi 324 akb olduğuna göre, bileşiğin basit ve molekül formülünü bulunuz? (C: 12,0 g/mol; H:1,0 g/mol; N:14,0 g/mol; Avagadro sayısı: 6,0.10^{23})
(6 puan)

7) Aşağıdaki yarılma (disproporsiyon) tepkimesini a) yükseltgenme ve indirgenme yarı reaksiyonlarını; b) net eşitliği yazarak ve açıklayarak denkleştiriniz. (15 puan)

$Br_{2(s)} \rightarrow Br^-_{(aq)} + BrO_3^-{}_{(aq)}$ (bazik çözelti)

8) Aşağıdaki adları verilen bileşiklerin formüllerini ve formülleri verilen bileşiklerinde adlarını uygun boşluklara yazınız. (9 puan)

$Cl_2O_{7\,(k)}$.. P_4O_6......... …..…............................ .....Sodyum bikarbonat..

$HBr_{(k)}$..$Ca(HSO_3)_2$…..…………..…………Amonyum dikromat……………………………

$HBrO_{4(aq)}$………………………..…$HNO_{2(aq)}$ ……..……………………. …$MgSO_4.7H_2O$ ……………………………………

9) Aşağıda verilen durumlarda bir tepkime olup olmayacağını öngörünüz. Oluyorsa net iyonik eşitliği yazınız. (6 puan)

$NaOH_{(aq)} + MgSO_{4\ (aq)} \rightarrow$

$MgBr_{2(aq)} + Na_2CO_{3(aq)} \rightarrow$

$NaCl_{(aq)} + Fe(NO_3)_{2\ (aq)} \rightarrow$

10) Hidrojen peroksit çözeltisi, $H_2O_{2(aq)}$, $KMO_{4(aq)}$ çözeltisi ile titre ediliyor. Reaksiyon;

$H_2O_{2\ (aq)} + KMnO_{4(aq)} + H_2SO_{4(aq)} \rightarrow O_{2(g)} + MnSO_{4(aq)} + K_2SO_{4(aq)} + 8\,H_2O_{(s)}$ (DENKLEŞMEMİŞ)

Bu reaksiyona göre, 200,0 mL 0,05 M $KMnO_4$ çözeltisini titre etmek için 10,0 g H_2O_2 çözeltisi gerekiyorsa, H_2O_2 çözeltisi kütlece yüzde kaçlık bir çözeltidir? (H:1; O:16) (15 puan)

11) Yükseltgenme – indirgenme (redox) reaksiyonları ne demektir? Redox reaksiyonu olmayan bir tepkime yazıp nedenlerini yazınız.
(4 puan)

SECOND SEMESTER PRE TEST 134 GENEL KİMYA II

1- Elektron ilgisi ve Elektronegatiflik kavramlarını açıklayınız. Flor ve Lityum elementlerinin elektron ilgileri ve elektronegatifliklerini karşılaştırınız.

2- Asetik asidin, CH_3COOH, molekül geometrisini ve bağlanma düzenini bulunuz. Bağ oluşumunu şematik olarak gösteriniz.

3- $O_{2(g)}$'nın neden paramanyetik özellik gösterdiğini nasıl açıklayabilirsiniz yazınız.

4- $NH_{3(g)}$ ın oluşum entalpisini bağ enerjilerini kullanarak tahmin ediniz. (Ortalama bağ enerjileri: N-N, 163 kj/mol; N=N 418 kj/mol; N≡N 946 kj/mol; H-H 436kj/mol; H-N 389kj/mol)

5- SO_2 molekülünün; a) rezonans melezine katkıda bulunan Lewis yapılarını yazınız. b) geometrik şeklinin nasıl olmasını beklersiniz, açıklayınız.

6- SF_6, H_2O_2, C_2H_4 bileşiklerinden hangisi ya da hangilerinin polar olmasını beklersiniz, neden?

7- Aşağıdaki maddeleri kaynama noktalarının artışına göre sıralayınız. Bu maddelerden biri oda sıcaklığında sıvı, ötekiler gaz halindedir. Hangisinin sıvı olduğunu tahmin ediniz. Tahmininizi nasıl yaptığınızı açıklayınız. CH_3OH; C_3H_8;N_2;N_2O

8- Viskozite ile moleküller arası çekme kuvvetleri arasında nasıl bir ilişki olabilir, açıklayınız.

9- CF_4, CCl_4, CBr_4 ve CI_4 karbon-halojen bileşiklerinin erime noktaları sırasıyla -183,7 ^{0}C, -22,9 ^{0}C, 90,1^{0}C ve 171 ^{0}C 'dir. Erime noktalarındaki bu artışın sebebini açıklayınız.

10- NaCl molekülünü katı halde nasıl bulunur, açıklayınız.. NaCl suyun içinde çözüldüğünde, sodyum ve klor atomları arasında bulunan iyonik bağ korunur mu? Açıklayınız. Çözülme esnasında nasıl etkileşimler olur? Çizerek açıklayınız.

SECOND SEMESTER POST TEST 134 GENEL KİMYA II

1- K-F ve Br-F bağlarından hangisi daha polardır, açıklayınız. (Atomların elektronegativitelerinin büyüklüğünü periyodik tablodaki yerlerine göre tahmin ediniz).

2- N_2O molekülü için uygun bir melezleşme ve bağlanma düzenini şematik olarak gösteriniz.

3- Ne_2^+ için molekül orbital diyagramını yazınız. Ne_2^+ molekülü manyetik alandan etkilenir mi açıklayınız.

4- HCO_2^- için a) rezonans melezine katkıda bulunan Lewis yapılarını yazınız. b) C-O bağı enerjisi 360 kj/mol ve C=O bağının enerjisi ise 736 kj/mol ise ise HCO_2^- deki karbon ile oksijen arasındaki bağın kırılması sırasındaki enerji değişimi nasıl olmalıdır tahmin ediniz, sebebini açıklayınız.

5- ClF_3 molekülünün molekül geometrisi nasıl olmalıdır, çizerek açıklayınız.

6- C_2N_2 molekülünün polarlığı hakkında ne söylenebilir? Lewis yapısını ve molekül geometrisini belirterek açıklayınız.

7- Açık bir kapta bulunan su tamamen buharlaştığında; H_2O moleküllerinin hacmi; b) H-O arasındaki bağın kuvveti; c) H_2O molekülleri arasındaki bağların kuvveti değişir mi, değişirse nasıl bir değişim beklersiniz.

8- Flor ve Brom elementleri 7A grubundadır. Bu elementler doğada diatomik olarak bulunurlar ve benzer kimyasal özellikler gösterirler. Oda sıcaklığında florun (F_2) gaz, Bromun (Br_2) sıvı olmasının nedenini açıklayınız?

9- Aşağıda verilen bileşiklerden hangisi ya da hangileri H bağlarına sahip olabilir, açıklayınız.
H_2; NO; HCO_2H

10- Ayrı beherler sırasıyla saf su, ve deterjanlı su ile yarısına kadar doldurulmuştur. Bu beherlere, sırasıyla aynı büyüklükte asetat kâğıdı parçaları atılırsa asetat kâğıdının, bu sulardaki yüzme davranışı değişir mi? (saf su ya da deterjanlı sudan hangisinde yüzdüğü gözlemlenebilir) Bunu nasıl açıklarsınız?