Chemical Education Journal (CEJ), Vol. 15 /Registration No. 15-107/Received August 31, 2013.
URL = http://chem.sci.utsunomiya-u.ac.jp/cejrnlE.html

Learning Difference on Physical Science Concepts between High and Low Achievement Groups at Junior College Chemistry Course

Kai-Ping, Wang
Hsin Sheng Junior College of Medical Care and Management, Taiwan
e-chem@yahoo.com.tw

Abstract

The purpose of this study was to identify the difference of learning performance on physical science concepts from high and low achievement students after traditional instruction. The subjects of this study were 100 nursing students coming from two classes of a medical care junior college in north Taiwan. This study was conducted in the first term of academic year 2011. One-group pretest-posttest design was adopted. All students were assigned to high and low achievement groups by item analysis of pretest scores, and research tool is physical science test. The result found that high achievement students performed better than low achievement students among pretest, midterm, and posttest. During the learning process, high achievement students' midterm scores performed lower than pretest; in addition, posttest scores performed better than pretest and midterm. Instead, low achievement students' scores gradually improved during learning period. No significant difference was found on both groups' midterm and posttest scores. High achievement students' pretest scores were significantly better than midterm, and posttest scores were significantly better than pretest. In contrast, low achievement students' posttest scores were significantly better than pretest. There were significant differences in scores on "electronic configuration (item 3)", "electronic energy levels (item 6)", " the comparison of gravitational force and electromagnetic force (item 10)", and "whether magnetic and electrics forces are related? (item 11)" concepts. However, low achievement group has significant improvement in physical science concepts. We suggest that teachers could infuse films or animation and increase students' active learning activities in chemistry class to enhance students' understanding of these abstract concepts. Results of this study can be the ground of improving chemistry teaching, and ultimately achieving the goal of citizen scientific literacy.

Keywords: comparison of high and low achievement groups, learning performance, physical science concept of junior college students, comparison of pretest midtest and posttest achievements

Motivation

Chemical and physical sciences is closely bound up, and they are the most important basic knowledge regarding to science education. Because students' extent of physical science concept will affect their learning performance, consequently recognizing students' concept understanding of physical sciences become one of the most important topics to chemistry education.

Traditional teaching is often viewed as rigid and insufficient for attracting students' learning interest. Hence in recent years, many scholars have tried to improve students' science learning effect by a variety of teaching methods or assessment tools (Holbrook & Rannikmae, 2007; Lee, & Yi, 2013; Laugksch & Spargo, 1996; Spektor-Levy, Eylon , & Scherz, 2009).

However, traditional teaching method is still the main way in large classes currently. Rarely research explores different-achievement-students' learning process and the learning performance under this method. Further, in Taiwan, to implement the twelve-year public education program, multiple entrance system for junior high school students makes them easily available to acquire entry qualification. Subsequently, the gap of students' basic scientific competency gradually increased.

The base of the understanding of scientific concepts is the groundwork to foster scientific literacy, hence probe students' learning process can facilitate teachers recognizing students' learning weaknesses. The purpose of this study was to establish the basis of research declaration above, and finally proposes suggestions for teaching improvement.

Research questions

(1) Is there any performance difference between high and low achievement group students' in chemistry learning process?
(2) Is there any difference on physical science concept between high and low achievement group students?

Literature Review

Bridle and Yezierski (2011) argued that "*students in traditional college-preparatory chemistry courses become masters of mathematical equations without an understanding of the conceptual basis for the mathematical relationships"*. For this purpose, this study focuses on understanding physical science concepts, because these concepts are difficult for students, especially in the upper secondary schools or junior college stages.

Physical science concepts include forces, gravity, light, waves, energy, electronic configuration, physical change, and chemical change (Stein, Larrabee, & Barman, 2008). Mounting evidence shows that it is difficult for students to understand how this world operate by their viewpoint toward force and motion (American Association for the Advancement of Science, 1993; Watts & Zylbersztajn, 1981). For instance, children are difficult to understand lunar gravity, and the Earth gravity on different heights as well as gravity of objects at rest

(Watts & Zylbersztajn, 1981).

Halloun and Hestenes (1985) indicated that college students are not only in short of basic physical concepts, but also are firmly in misconceptions in place. Also Zeilik, Schau & Mattern (1998) asserted that college students are more difficult to change their physical science concepts than to do in astronomy.

Johnstone (1982) proposed that chemical knowledge can be represented in three main ways, such as macro, sub-micro and representational knowledge. Macro indicates the level of entity, which can be touched, seen, and can be used. Micro means the level of molecular, structure and bonding. Representations are referred to as the level of symbols, equations and calculation. Atomic structure and its related concepts are microscope of natural phenomena, especially the particle nature of matter is very important in the chemical learning (Yezierski & Birk, 2006), they deeply affect science and technology development (Nicoll, 2001; Özmen, 2004; Tan & Treagust, 1999; Ünal, Coştu, Ayas, 2010).

Similarly, a particulate understanding of atoms and their properties is central to explaining any chemistry concepts (Gabel, 1999). But Novick and Nussbaum (1978) concluded that Grade 7 students are difficult to assimilate particle model; moreover, most of them with their sensory perception of matter are inconsistent.

In the past 30 years, there have been a large number of results in physical science research; however, the broader use of assessment tools are not much, some of them focus on one topic such as physical or chemical changes, while others are large-scale investigated by scientific literacy test. As "The Science Belief Test" developed by Stein, Barman and Larrabee, an online assessment tool which contains 47 true false declarative items, each question accompany writing explaining to confirm the common beliefs and alternative conceptions of students (Stein, et al., 2008). Additionally, Laugksch and Spargo (1996) also developed a 110 items assessment tool -Test of Basic Scientific Literacy (TBSL). The tool contains physical science section, and the assessment subject from high school students to citizens. The scope of the study pervades United States, Africa, Hong Kong, China and Taiwan.

Science literacy is the important goals in contemporary science education (Brown, Reveles, & Kelly, 2005; Holbrook & Rannikmae, 2007), because the science is one of the greatest achievements in human cultures until now, moreover affects our lives. This study employed physical science test which was extracted from TBSL as target tool. Since the physical science is the basis for chemistry learning, this study was to analyze academic performance of different achievement students in the physical scientific concepts.

Methodology

Participants and procedure

Purposive sampling was employed in this study and the sample consists of 100 freshmen enrolled department of nursing; the students are from the junior college that is located in northern Taiwan. This study was implemented in the first term of academic year 2011.

This study adopted one-group pretest-posttest experimental method, chemistry course was scheduled as two hours per week and the total contact hours were 24. There are four control variables as follows.

(1) Materials: all students accepted the same materials (introduction, material science, atomic structure and periodic table, chemical bonding and other four chapters).

(2) Background factors: all students were freshmen nursing students, most of whom were female.

(3) Teaching period and examinations: 13 weeks, including pretest (first week), midterm (ninth week) and posttest (thirteenth week).

(4) Instructor: the same person (researcher).

Participant's pretest score and item analysis was conducted to distinguish students' achievement level. Top 27% of pretest scores were classified as high achievement group, the last 27% of pretest scores was classified as low achievement group.

Tools-Physical Science Test (PST)

PST was from physical science of science content category in TBSL (Laugksch & Spargo, 1996) and was revised by 2 different chemistry teachers. The goal of TBSL is to examine the success of scientific literacy for school; the results can provide teachers to reflect on how to improve science teaching. Most of the questions were learned in junior high school, and the test level is coping with students' ability. The concept includes forces, gravity, light, wave energy, electron configuration, Physical change, and chemical changes. There are 14 original items; further 3 items were deleted by using the value of the calculated critical ratio. Final test contains 11 true false items (Appendix 1).

70 freshmen were randomly select from other classes and agreed to examine PST. The reliability of PST was calculated .624 by KR-20 method.

Data collection and analysis

Three paper-and-pencil tests, such as pretest, midterm, and posttest were administered to both high and low groups at three stages of the study to assess students' understanding of physical science concepts during the learning process. The maximum scores for three tests were of 11 marks.

Data obtained were analyzed by using quantitative data analysis techniques. The statistic methods include descriptive statistics, pair *t*-test and covariance analyses.

Table 1. Description statistics about high and low achievement groups' scores

		Pretest		Midterm		Posttest	
Item	Group*	M	SD	M	SD	M	SD
1	H	0.88	0.33	0.77	0.43	0.92	0.28
	L	0.58	0.50	0.77	0.43	0.92	0.28
2	H	1.00	0.00	0.88	0.33	1.00	0.00
	L	0.77	0.43	0.85	0.37	0.88	0.34
3	H	0.77	0.43	0.42	0.50	0.88	0.34
	L	0.35	0.49	0.19	0.40	0.71	0.46
4	H	0.73	0.45	0.77	0.43	0.88	0.34
	L	0.38	0.50	0.58	0.50	0.75	0.44
5	H	0.88	0.33	0.69	0.47	0.83	0.38
	L	0.54	0.51	0.54	0.51	0.63	0.49
6	H	0.65	0.49	0.38	0.50	0.88	0.34
	L	0.27	0.45	0.19	0.40	0.92	0.28
7	H	0.92	0.27	0.77	0.43	0.96	0.20
	L	0.58	0.50	0.38	0.50	0.88	0.34
8	H	0.92	0.27	0.73	0.45	1.00	0.00
	L	0.35	0.49	0.54	0.51	0.79	0.41
9	H	0.85	0.37	0.77	0.43	0.92	0.28
	L	0.58	0.50	0.54	0.51	0.83	0.38
10	H	0.69	0.47	0.38	0.50	0.75	0.44
	L	0.27	0.45	0.15	0.37	0.67	0.48
11	H	0.96	0.20	0.73	0.45	0.88	0.34
	L	0.73	0.45	0.73	0.45	0.83	0.38
Total	H	9.27	0.92	7.31	2.51	9.88	1.36
	L	5.38	0.80	5.46	2.76	8.79	1.69

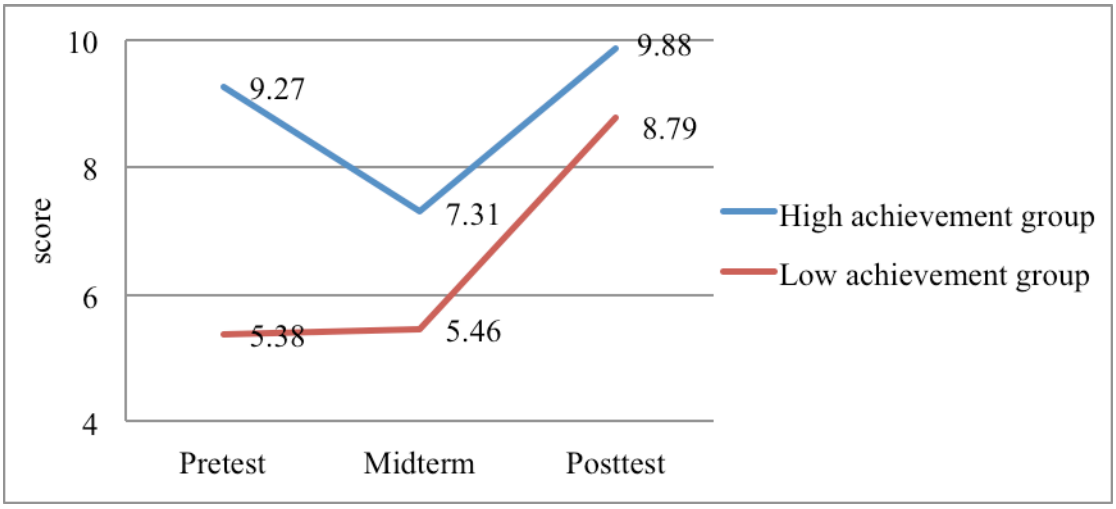
*H represents the high achievement group； L represents the low achievement group

Result

1. Descriptive statistic

There are 26 participants from high and low achievement group, respectively. High achievement group's midterm scores were lower than pretest, and posttest scores were higher than pretest. Low achievement group has gradually improved their scores during learning process. Descriptive statistics about both groups' performance is shown in Table 1. The performance of both groups is shown in Figure 1.

Figure 1. Diagram of physical science scores in learning process



2. Compare both groups' performance in learning process

Analysis of covariance was employed to examine both group's performance difference in learning process. Result showed that when pretest total scores were controlled, the difference between groups was not significant with respect to midterm adjusted mean scores [F(1-49) = 2.60, p>.05]. Although a significant difference did not exist between the midterm mean scores of the groups, the mean of the high achievement group (X = 7.31) was higher than that of the low achievement group (X = 5.46).

Table 2. ANCOVA results of midterm scores adjusted according to pretest in both groups

Source	Type Ⅲ Sum of Squares	df	Mean Square	F	p
Pretest	3.112	1	3.112	.442	.509
Group	18.291	1	18.291	2.599	.113
Eror	344.888	49	7.039		
Corrected Total	392.308	51			

R Squared = .121 (Adjusted R squared = .085)

Table 3. ANCOVA results of posttest scores adjusted according to pretest in both groups

Source	Type Ⅲ Sum of Squares	df	Mean Square	F	p
Pretest	3.732	1	3.732	1.602	.212
Group	.101	1	.101	.043	.836
Eror	104.851	45	2.330		
Corrected Total	4304.000	48			

R Squared = .134 (Adjusted R squared = .099)

Result showed that when pretest total scores were controlled, it was not significant with respect to posttest adjusted mean scores [F(1-45) = .04, p>.05]. Although a significant difference did not exist between the posttest mean scores of the groups, the mean of the high achievement group (X = 9.88) was higher than that of the low achievement group (X = 8.79).

3. Performance of high achievement group in learning process

Pair-*t* test was employed to examine high achievement group's performance in learning process. The results shows that item 3, 6, 10, 11 and total scores presented significant differences in pretest and midterm (Table 4), and pretest score is higher than midterm score. In the aspect of pretest-posttest, only total score presented significant differences and posttest scores is higher than pretest (Table 5).

Table 4. The pretest-midterm scores of the high achievement group (n = 26)

Item	Mean	SD	t	df	p
1	0.12	0.59	1.00	25	0.33
2	0.12	0.33	1.81	25	0.08
3	0.35	0.49	3.64	25	0.00**
4	-0.04	0.53	-0.37	25	0.71
5	0.19	0.49	2.00	25	0.06
6	0.27	0.60	2.27	25	0.03*
7	0.15	0.54	1.44	25	0.16
8	0.19	0.57	1.73	25	0.10
9	0.08	0.56	0.70	25	0.49
10	0.31	0.62	2.54	25	0.02*
11	0.23	0.51	2.29	25	0.03*
Total	1.96	2.99	3.35	25	0.00**

*represented $p < .05$；** represented $p < .00$

Table 5. The pretest-posttest scores of the high achievement group (n = 26)

Item	Mean	SD	t	df	p
1	-0.04	0.46	-0.44	23	0.66
2	1.00	0.00	0.00	23	1.00
3	-0.08	0.41	-1.00	23	0.33
4	-0.17	0.56	-1.45	23	0.16
5	0.08	0.50	0.81	23	0.43
6	-0.21	0.59	-1.74	23	0.10
7	-0.04	0.36	-0.57	23	0.58
8	-0.08	0.28	-1.45	23	0.16
9	-0.08	0.41	-1.00	23	0.33
10	-0.08	0.58	-0.70	23	0.49
11	0.08	0.41	1.00	23	0.33
Total	-0.63	1.31	-2.33	23	0.03*

*represented $p < .05$； ** represented $p < .00$

4. Performance of low achievement group in learning process

Pair-*t* test was employed to examine low achievement group's performance in learning process. The results show that no significant difference was found in pretest and midterm (Table 6). In the aspect of pretest-posttest, items 1, 3, 4, 6, 7, 8, 10 and total scores presented significant differences, and posttest score is higher than pretest (Table 7).

Table 6. The pretest-midterm scores of the low achievement group (n = 26)

Item	Mean	SD	t	df	p
1	-0.19	0.63	-1.55	25	0.13
2	-0.08	0.56	-0.70	25	0.49
3	0.15	0.61	1.28	25	0.21
4	-0.19	0.69	-1.41	25	0.17
5	0.00	0.63	0.00	25	1.00
6	0.08	0.56	0.70	25	0.49
7	0.19	0.69	1.41	25	0.17
8	-0.19	0.49	-2.00	25	0.06
9	0.04	0.60	0.33	25	0.75
10	0.12	0.65	0.90	25	0.38
11	0.00	0.49	0.00	25	1.00
Total	-0.08	2.71	-0.15	25	0.89

Table 7. The pretest-posttest scores of the low achievement group (n = 26)

Item	Mean	SD	t	df	p
1	-0.33	0.56	-2.89	23	0.01*
2	-0.08	0.58	-0.70	23	0.49
3	-0.38	0.65	-2.84	23	0.01*
4	-0.38	0.65	-2.84	23	0.01*
5	-0.08	0.78	-0.53	23	0.60
6	-0.71	0.46	-7.47	23	0.00**
7	-0.29	0.55	-2.60	23	0.02*
8	-0.42	0.50	-4.05	23	0.00**
9	-0.25	0.74	-1.66	23	0.11
10	-0.38	0.65	-2.84	23	0.01*
11	-0.08	0.50	-0.81	23	0.43
Total	-3.38	1.86	-8.89	23	0.00**

*represented $p < .05$; ** represented $p < .00$

Discussion

Learning performance of physical science concepts between high and low achievement students

This study reveals that midterm scores (at ninth week) of high achievement students' physical science concepts have significantly lower than pretest scores at "electron configuration" (item 3), "electronic energy levels" (item 6), "the comparison of gravitational force and electromagnetic force " (item 10), "whether magnetic and electrics forces are related?" (item 11) and total score (Table 4, 5). In the thirteenth weeks, posttest scores of high achievement group were significantly better than pretest scores. Results shows that high achievement students' errors concepts aroused at ninth week and it will be significantly improved until the thirteenth week.

Based on the book of "Benchmarks for Science Literacy" (AAAS, 1993), high achievement students' error concepts can be classified to science content as follows: (1) force of nature (item 10, 11), (2) structure of matter (item 3), and (3) energy transformations (item 6).

In the aspect of force of nature, gravitational force is an attraction between mass. Hence, the gravitational forces between atoms are quite weak because of their masses are completely in light weight. Besides, the strength of the forces is affected by their distance. The longer the distance, the weaker the force is. These are the nature of microscopic phenomenon.

Electromagnetic forces acting within and between atoms are vastly stronger than the gravitational forces acting between the atoms (AAAS, 1993). The positive and negative charge atoms make the molecule as a whole electrically neutral.

High achievement students had difficulty in distincting the gravitational force and electromagnetic force. Our findings are similar to the statement of Watts and Zylbersztajn (1981), who presented that students confused the earth gravity on different heights. It implies that teachers could list their difference and explicitly express the definition of these two science concepts to eliminate errors in students' ideas.

In addition, magnetic forces are very closely related to electric forces and can be thought of as different aspects of a single electromagnetic force (AAAS, 1993). This is because moving electric charges produce magnetic forces and moving magnets produce electric forces. Most of modern technologies work by interaction with electric and magnetic forces, and produce the electromagnetic waves.

A paradoxical idea for students is how weak gravity is compared to electric and magnetic forces (AAAS, 1993). For students, gravitational forces seem stronger than trivial electric forces, *e.g.* combing the dry hair. However, it seems that students could hardly recognize that small amount of charge could force the dry hair up against gravity.

Study of the nature of electric and magnetic forces should be joined to the study of the atoms (AAAS, 1993). The atomic theory can powerfully explain many phenomena, but it demands imagination and evidence inference, as the results of electric forces and magnetic forces are invisible. The priority should be put on what conditions produce a magnetic field and what conditions induce an electric current.

In the aspect of structure of matter and energy transformations, energy levels are associated with different configuration of atoms and molecules (AAAS, 1993). Besides, it is difficult to understand which other features of the reactions between iron and chlorine, or hydrogen and oxygen, for students are expected to deduce from atomic electronic arrangements (Taber, 2003). Therefore, teacher should emphasize the importance of electronic configuration and energy levels of atoms in chemical reaction.

As mentioned above, error concepts may be due to mutual influence of new knowledge and old experiences, resulting in midterm scores lower than pretest scores. However, with the increase of teaching content, student's physical science concepts will gradually meet the scientific view.

In the thirteenth week, more than half of the questions (items 3, 4, 6, 7, 8, and 10) and the total score of low achievement students' performance were significantly better than pretest scores (Tables 6 and 7). These results show that their physical science concepts will be significantly improved at least last 13 weeks learning. The main cause might be their incomplete or insufficient prior knowledge or proficiency of information process.

According to the cognitive development theory, Piaget (1964) believed that students have been formal operational stage between the ages of 14-15 year-old, and they should be able to understand abstract concepts. However, the results of this study show that, regardless of the level of students (high or low achievement), they must undergo 13 weeks of learning to achieve significant improvement; in other words, after a period of time, traditional teaching may facilitate students' conceptual understanding about abstract concepts in chemistry.

Limitations of the study

Due to the gender unequality (most of participants are female in nursing classes), this study's findings may not infer to other learning set. Besides, as the sample size of the study was small, it needs to be supported by larger-scale studies to reveal the effects of traditional instruction. The average of students' entrance PR values was 30, where the PR value indicates the student's academic achievement surpassing other students' in number, and ranging from 0 to 100 (the higher the value of a student, the better his/her academic achievement is). Thus, their academic achievement levels were below 50% of the same grade in Taiwan. At least under these conditions, students' learning performance may be different from other students with different PR values.

Conclusion

Citizens' scientific literacy has become one of the most important goals toward science education in many countries. Understanding the difference in physical science concepts learning acquired between high and low achievement students is helpful for further enhancement of citizens' scientific literacy. This study provides an empirical research example and results, and the conclusions are as follows:

(1) There was no significant difference on learning performance between high and low achievement groups.

(2) Pretest scores of the high achievement group were significantly better than midterm, and posttest scores were significantly better than the pretest; the posttest scores of low achievement group were significantly better than the pretest.

(3) In the ninth week, high achievement group students have significant errors in concepts on "electronic configuration", "electronic energy levels", " the comparison of gravitational force and electromagnetic force ", and "whether magnetic and electrics forces are related?". But posttest scores (thirteenth week) of both the high and low achievement groups were significantly better than pretest.

Suggestion

(1) Different energy levels are associated with different configurations of atoms and

molecules (AAAS, 1993). High achievement group students have errors in the concept of energy levels and electronics configuration in the midterm. Results might be due to poor visualization capacity (Gabel, Samuel, & Hunn, 1987). This study suggests that teachers may infuse films or animation in chemistry class to enhance students' understanding of these abstract concepts.

(2) According to the opinions of cognitive learning theory, Novak and Gowin (1984) argued that teachers' task is to try to find ways to increase meaningful learning, possibly by actively involving students in the process of knowledge construction. Consequently, it is recommended that teachers could increase students' active learning activities, such as ask questions, discuss, or conceptual understanding strategies to strengthen students' meaningful learning, ultimately to enhance students' understanding of physical science concepts, and even shorten the learning time.

Reference

American Association for the Advancement of Science (1993). "Benchmarks for Science Literacy". Oxford University Press, New York.

Bridle, C. A., & Yezierski, E. J. (2011). "Evidence for the effectiveness of inquiry-based, particulate-level instruction on conceptions of the particulate nature of matter", *Journal of Chemical Education*, **89** (2), 192-198.

Brown, B. A.; Reveles, J. M. & Kelly, G. J. (2005). "Scientific literacy and discursive identity: A theoretical framework for understanding science learning", *Science Education,* **89***,* 779–802.

Gabel, D. L.; Samuel, K. V. & Hunn, D. (1987). "Understanding the particulate nature of matter", *Journal of Chemical Education,* **64** (8), 695-697.

Gabel. D. (1999). "Improving Teaching and Learning through Chemistry Education Research: A Look to the Future", *Journal of Chemical Education,* **76** (4), 548-554.

Halloun, I. A. & Hestenes, D. (1985). "The initial knowledge state of college physics students", *American journal of Physics*, **53** (11), 1043-1055.

Holbrook, J. & Rannikmae, M. (2007). "The Nature of Science Education for Enhancing Scientific Literacy", *International Journal of Science Education,* **29** (11), 1347–1362.

Johnstone, A. H. (1982). "Macro - and micro – chemistry", *School Science Review,* **64**, 377-379.

Korpan, C. A.; Bisanz, G. L.; Bisanz, J. & Henderson, J. M. (1997). "Assessing Literacy in Science: Evaluation of Scientific News Briefs", *Science Education,* **81**, 515–532.

Laugksch, R. C. & Spargo, P. E. (1996). "Construction of a paper-and-pencil test of basic scientific literacy based on selected literacy goals recommended by the American Association for the Advancement of Science", *Public Understanding of Science,* **5**, 331-359.

Laugksch, R. C. (2000). "Scientific literacy: A conceptual overview", *Science Education*, **84** (1), 71-94.

Lee, G. & Yi, J. (2013). "Where Cognitive Conflict Arises From?: the Structure of Creating Cognitive Conflict", *International Journal of Science and Mathematics Education*, **11** (3),601-603.

Nicoll, G. (2001). "A report of undergraduates' bonding misconceptions", *International Journal of Science Education,* **23**, 707–730.

Novak, J. D. & Gowin, D. B. (1984). "Learning How to Learn", Cambridge University Press, Cambridge.

Novick, S. & Nussbaum, J. (1978). "Junior high school pupils' understanding of the particulate nature of matter: An interview study", *Science Education,* **62** (3), 273-281.

Özmen, H. (2004). "Some Student Misconceptions in Chemistry: A Literature Review of Chemical Bonding", *Journal of Science Education and Technology,* **13** (2), 147-159.

Piaget, J. (1964). "Part I: Cognitive development in children: Piaget development and learning", *Journal of research in science teaching*, **2** (3), 176-186.

Spektor-Levy, O.; Eylon, B-S. & Scherz, Z. (2009). "Teaching Scientific Communication Skills In Science Studies: Does It Make A Difference?", *International Journal of Science and Mathematics Education,* **7**, 875-903.

Stein, M., Larrabee, T. G., & Barman, C. R. (2008). "A Study of Common Beliefs and Misconceptions in Physical Science", *Journal of Elementary Science Educati*on, **20** (2), 1-11.

Taber, K. S. (2003). "The atom in the chemistry curriculum: Fundamental concept, teaching model or epistemological obstacle?", *Foundations of Chemistry*, **5** (1), 43-84.

Tan, K. C. & Treagust, D. (1999). "Evaluating students' understanding of chemical bonding", *School Science Review,* **81**, 75–84.

Ünal, S.; Coştu, B. & Ayas, A. (2010). "Secondary School Students' Misconceptions of Covalent Bonding", *Journal of Turkish Science Education,* **7** (2), 3-29.

Watts, D. M. & Zylbersztajn, A. (1981). "A survey of some children's ideas about force", *Physics Education,* **16** (6)*,* 360-365.

Yezierski, E. J. & Birk, J. P. (2006). "Misconceptions about the Particulate Nature of Matter Using Animations to Close the Gender Gap", *Journal of Chemical Education,* **83***,* 954-960.

Zeilik, M.; Schau, C. & Mattern, N. (1998). "Misconceptions and their change in university-level astronomy courses", *The Physics Teacher,* **36***,* 104-107.

Appendix 1: Physical Science Test

1. Everything is made of over one hundred chemical elements and formed by different combinations in the material world.
2. Each material may exist in different states (e.g., solid, liquid or gaseous) by different temperature and pressure.
3. Atomic bonding between atoms is determined by outer layer electron arrangement of each atom.
4. When a certain state of energy (for example heat) or some places of energy reduce, another state or place of energy will equally increase.

*5. Atomic arrangement in the molecules has nothing to do with the energy of molecules.

6. Electron energy levels are not continuous.
7. Nothing is stable among atoms, organisms and planets, and all of them are always activated.
8. Motion is caused by imbalance forces.
9. Every object will create gravitational force on other objects in the universe.
10. Electromagnetic force is larger than gravitational force when it acts on the atoms.

*11. Magnetism and electricity force are unrelated to each other.

(* indicates wrong answer)