Eğitim ve Bilim
2009, Cilt 34, Sayı 154

Education and Science
2009, Vol. 34, No 154

The Relation between Science Student Teachers' Misconceptions about Solution, Dissolution, Diffusion and their Attitudes toward Science with their Achievement

Fen Öğretmen Adaylarının Çözelti, Çözünme ve Difüzyon Konusundaki Kavram Yanılgıları ve Fen Tutumları ile Başarıları Arasındaki İlişki

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Abstract

The aims of this study were considered under three headings. The first was to elicit misconceptions that science student teachers had about the "solution", "dissolution" and "diffusion" concepts. The second was to understand the effect of prior knowledge on their misconceptions. The third was to determine the relationships among science student teachers' achievements, logical thinking levels and their attitudes toward science teaching and learning. It was found that science student teachers had some misconceptions about the dissolution, solubility and diffusion concepts. The results also revealed that student teachers had positive attitudes toward science and their logical thinking levels were intermediate. In addition, no statistically significant relationship among student's teacher achievements, logical thinking levels and attitudes was found.

Keywords: Solubility, Dissolution, Logical thinking, Science education, Misconceptions.

Öz

Bu çalışma başlıca üç amaçla yapıldı. Bu amaçlardan birincisi, fen öğretmen adaylarının çözelti, çözünme ve difüzyon konularındaki kavram yanılgılarını belirlemek, ikincisi kavram yanılgılarının önceki öğrenmelerinden nasıl etkilendiğini anlamak, üçüncüsü ise fen bilimlerine yönelik tutumları, mantıksal düşünme yetenekleri ile başarıları arasındaki ilişkileri belirlemektir. Sonuçların analizi, fen bilgisi öğretmen adaylarının çözünme, çözünürlük ve difüzyon kavramlarında bazı kavram yanılgılarına sahip olduklarını göstermiştir. Araştırma sonuçları, fen bilgisi öğretmen adaylarının fen bilgisine olan tutumlarının olumlu olduğunu göstermenin yanı sıra mantıksal düşünme seviyelerinin orta derecede olduğunu ortaya koymuştur. Fen bilgisi öğretmen adaylarının başarı düzeyleri, mantıksal düşünme seviyeleri ve tutumları arasında istatistiksel olarak bir ilişki olmadığı da sonuçların analizinde bulunmuştur.

Anahtar sözcükler: Çözünme, çözünürlük, mantıksal düşünme, fen eğitimi, kavram yanılgıları.

Introduction

The assessment of students' understanding of scientific concepts has been of interest to researchers and teachers in science education community recently. Various terminologies have evolved to describe students' understandings, which are different from or inconsistent within the consensus of the scientific community. The commonly used terminologies include preconceptions

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(Driver and Easley, 1978; Novak, 1977), misconceptions (Driver and Easley, 1978; Garnett and Treagust, 1990) and children's science (Gilbert, Osborne and Fensham, 1982). In this study, the term "misconception" was used because of its frequent appearance in research studies. As one of the main branches of physical science, chemistry is a world filled with interesting phenomena appealing to experimental activities, and fruitful knowledge for understanding the natural and manufactured worlds. Students do not need to transform instructional language or materials that teachers use in the chemistry classroom into meaningful representations. Some studies have been conducted in the area of misconceptions in solutions chemistry (Abraham, Gryzyowski, Renner and Marek, 1992; Çalık and Ayas, 2005a). In addition, some other studies have shown that students develop their scientific conceptions from many sources including personal experiences, gender, peer interaction, language, textbook, laboratory procedures, etc. Similarly, some teachers serve as another major source of misconceptions (Wandersee, Mintzes and Novak, 1994). It is clear that teachers with misconceptions about science are not likely to be able to make their students develop scientifically accurate concepts. Therefore, teacher education plays an important role in the development of future generation. The main purpose of a teacher education program is to provide science teachers with a good self-image, an outgoing personality, and an interest in helping their students to understand science in a meaningful way. Studies have shown that students have a considerable number of misconceptions about various chemistry topics some of which are mass, volume and density (Hewson and Hewson, 1983), dissolution concept (Abraham, Gryzybowski, Renner and Marek, 1992; Abraham, Williamson and Westbrook, 1994; Çalık and Ayas, 2005a; Ebenezer and Erickson, 1996; Cosgrove and Osborne, 1981), the nature of solution (Prieto, Blanco and Rodriguez, 1989); solubility (Ebenezer and Erickson, 1996; Gennaro, 1981), the role of energy in the solution process (Ebenezer and Fraser, 2001; Liu, Ebenezer and Fraser, 2002), the effect of temperature and stirring on the dissolution of solids (Blance and Prieto, 1997), the conservation of mass during the dissolution process (Driver and Russel, 1982; Holding, 1987; Piaget and Inhelder, 1974) types of solution (Çalık and Ayas, 2005b; Pınarbaşı and Canpolat, 2003), relationship between surface area and rate of solution (Çalık and Ayas, 2005b), strategies to overcome misconceptions (Akgün and Gönen, 2005; Ebezener, 2001; Ebezener and Gaskell, 1995; Griffiths, 1994; Kaartinen and Kumpulainen, 2002; Kabapınar, Leach and Scott, 2004; Taylor and Coll, 1997;).

The aforementioned studies have tried to answer several questions such as; (1) what kinds of misconception do students have, (2) how common are these misconceptions; appear (3) how these misconceptions may be replaced with correct idea and (4) suggestions on what teachers can do in order to improve teaching-learning environment that would reduce students' misconceptions. These studies have used a number of terms such as preconceptions, misconceptions alternative conceptions that and students have and these terms also reflect some researchers view of knowledge. That is, alternative conceptions fit ideas associated with a positive tendency (Taber, 2000). In this study, the term misconception is used to describe any conceptual misperception and misunderstanding which are inconsistent with those accepted by scientific community.

In studies on solution chemistry, only Prieto et al. (1989) reported that examples given by some students were limited to particular solids that dissolved in liquids. They emphasized that for students, the solute was the most important component in the dissolution process and they described the solute as a passive component. Also, authors pointed out that only grade 8 students mentioned the interaction between a solute and solvent, however, here the meaning seem to imply a chemical transformation.

As can be seen from the related literature although the cited studies on solution chemistry have concentrated on different perspectives, there appears to be an absence of what students understand about the terms 'solution', 'solute' and 'solvent', whether they are able to apply theoretical knowledge to novel situations, whether students able to make connection between school and life experiences and how the instruction that students receive influences their ideas. According to Leach and Scott (2003), learning science as learning to use science language could be understood as a process of internalization since the learner must interpret, reorganize, and reconstruct his or her experiences by making interactions with others. In fact, it has been demonstrated that students generally learn more from teachers with high self-efficacy than from those whose self-efficacy is low (Ashton and Webb, 1986). Besides, teachers' beliefs in their instructional efficacy are a very strong prediction of academic attainment in young children (Saklofske, Michayluk and Randhawa, 1988). Many studies have also addressed the construct of techers' attitudes toward science and how the construct can affect teaching (Stevens and Wenner, 1996; Wenner, 1993). Koballa and Crawley (1985) have stated that there is an interrelationship between beliefs, attitude and behavior. They illustrated this relationship with a scenario in which elementary school teachers judged their ability to teach science as low (belief), resulting in a dislike for science teaching (attitude) that ultimately translated into teachers who avoided teaching science (behavior). It is possible to state that science teachers' logical thinking abilities and attitudes towards science and science teaching are important factors affecting the quality of science taught to students. Therefore, education of pre-service science teachers is very important. Hence, in this study; (a) science student teachers' beliefs about the factors that influenced dissolution, (b) their ability levels, (c) their attitudes toward science teaching and learning were determined. In addition, relationships among student attitudes, achievements and logical thinking levels were examined.

Methods

Pilot Study

Chemistry Concept Test was administered to 20 pre-service science teachers who were not involved in the main study. 120 minutes were given to students in order them to anwer all the questions and do activities. The pilot study revealed that questions and activity items in Chemistry Concept Test were quite understandable and clear for all students.

The Sample

The sample under investigation comprised of 40 pre-service science teachers from science education departments. The sample was selected at the Dicle University Ziya Gökalp Education Faculty in the province of Diyarbakır in Turkey. The students in the sample had studied the topics at different levels from elementary school to University.

The students were given 120 minutes to make activities and answer questions in Chemistry Concept Test. In addition, Logical Thinking Ability Test and Science Attitude Scale were administered to these students. The students were given 40 minutes to complete these tests and were encouraged to answer all questions in both tests.

Instruments and Data Collection Procedure

In this study three test were used.

1) Chemistry Concept Test (CCT) that related to dissolution and dissolutivity,

2) Logical Thinking Ability Test (LTAT),

3) Science Attitude Scale (SAS).

During the instructions following experiments were performed:

1) To take into consideration two beaker glasses included equal amount of water and sugar. Granulated sugar was put into one beaker glass and cube sugar was put in to other beaker glass. What did you observe for five minutes? Which evidents came into existence?

2) Take two beaker glasses containing equal amount of water, one is at 20^0C the other is at 80^0C. After you throw equal amount of sugar cubes in each beaker glasses, which changes do you observe?

3) Put equal number of sugar cubes in two beaker glasses in different sizes, each containing equal amount of water. Then write your observations.

Following these activities, four questions related to these activities were administered to students under this investigation. Furthermore; a group of chemistry educators and teachers checked the test for validity and reliability of instrument. The chemistry concept test (CCT) items related to dissolution concept considered in this study are shown below:

1) Explain the dissolution phenomenon considering the interaction forces between solid and liquid molecules.

2) Is dissolution a physical phenomenon? Write your reason.

3) What are the factors affecting dissolution rate? Write your answer.

4) What happens when some amount of ink is dropped into water?

One of the tests used in this study was logical thinking ability test. This test was developed by Tobin and Capie (1981). The psychometric characteristics of LTAT have been well-documented by the developers. The test consists of 10 items designed to measure controlling variables (items 1 and 2), proportional (items 3 and 4), probabilistic (items 5 and 6), correlations (items 7 and 8) and combinational reasoning (items 9 and 10). The reliability of test was found 0.81. The Likert type scale (fully agree, agree, undecided, disagree and fully disagree) with 15 items was developed by Geban, Ertepınar, Yılmaz, Altan and Şahbaz (1994) and was used to determine science student teachers' attitudes toward science. The reliability of the scale was found to be 0.78.

Data Analysis

The open-ended questions listed above were analyzed under the following categories and headings, which were suggested by Abraham et al. (1994).

- Sound Understanding: Responses that included all components of the validated response.
- Partial Understanding: Responses that included at least one of the components of validated response but not all the components.
- Specific Misconceptions: Responses that included illogical or incorrect information.
- No Understanding: Repeated the question; contained irrelevant information or unclear response.

The following method was used in order to determine students' achievement scores.

Sound understanding responses were scored with 2 points, partial understanding responses were scored with 1 point, specific misconception and no understanding responses were scored with zero point.

Logical Thinking Ability Test questions have two stages. When students gave correct responses for both the first and the second stage, questions were scored with "1" point in other cases question was scored with zero point. For items 1, 2, 3, 4, 5, 6, 7 and 8, the students select a response from among five possibilities, and then they are provided with five justifications among which they choose from. The correct answer is the correct choice plus the correct justification. The test score of students for each item equals 1 if they choose correct choice plus the correct justification, and equals 0 if they mark correct choice but wrong justification or wrong choice with wrong justification. Thus, score gained by each student in this test was determined in this way.

Items in the SAS were scored with 5 points if marked "fully agree", 4 points if marked "agree", 3 points if marked "undecided", 2 points if marked "disagree", 1 point if marked "fully disagree".

Inductive analysis (Abraham et al., 1994) was used to evaluate the results of the open-ended written test and the information transcribed from the test. First, researchers examined the information piece by piece, read the information repeatedly, and then wrote out the different kinds of conceptions that students reported. The analysis guidelines, especially the conceptualizations of the data, the coding of data, and development of, categories-were determined in terms of students' responses. The researchers then came together in order to discuss and label each sentence. Throughout the labeling process, codes were revised and redefined. Classifications and their definitions are summarized in Table 2 through 5.

The results obtained from the three tests used in this study were analyzed by using the program called SPSS.

Results

The results obtained from the chemistry test are presented below by taking each item into consideration. Percentages of the obtained responses for each item are indicated in Table 1.

Table1.

Percentages of Responses Given to Questions by Science Teacher Students

UL	Items	1 (%)	2 (%)	3 (%)	4 (%)
SU		8	60	50	20
PU		57	33	40	50
SM		28	7	8	8
NU		7	-	2	22

UL: Understanding Level

SU: Sound Understanding SM: Specific Misconceptions

PU: Partial Understanding NU: No Understanding

For Item 1, sound understanding included knowledge "if solid and liquid molecules have similar structures their dissolution becomes easy and rapidly". As can be seen in Table 1, 8% of the students showed sound understanding, the proportion of students' responses categorized under the partial understanding category was 57 percent, proportion of students responses classified under specific misconception category was 28 percent and no understanding category was seven percent. Some examples from the given answers for Item1 are presented in Table 2.

Table2.

Some Examples from the Responses Given for Item 1

UL	Examples
SU	● If solid and liquid molecules have similar structure their dissolution becomes easily and rapidly. For example, polar substance in polar solvents and apolar substances in apolar solvents ionic structured compound in polar solvents were expected to dissolve better. Generally, molecules that rapidly dissolve each other have similar kind and magnitude forces.
PU	● Liquid molecules had been dissolved in the solid molecules. Physical shape of solid was changed.
SM	● Gap among liquid molecules more than solid molecules, so liquid substance in order to filled these gap dissolve solid substances.
NU	● A solid substance dissolves easily in liquid substance.

In Item2, sound understanding is as follows: dissolution phenomenon is generally physical phenomenon. However, some dissolves performs as chemical. For example, CO_2 dissolve in H_2O. As can be seen from Table 1, 60% of students showed sound understanding, the proportion of students responses categorized under the partial understanding category was 33%. Proportion of students responses classified under specific misconception category was seven percent and no understanding category was zero percent. For Item 2, nobody entered having "no understanding" category. Some examples from the given answers for Item 2 are presented in Table 3.

Table 3.

Some Examples from the Responses Given for Item 2

UL	Example
SU	• Dissolution phenomenon is generally physical phenomenon. However, some dissolves also performes as chemical. For example, reaction that come into being between H_2O and CO_2.
PU	• Dissolution phenomenon is physical.
SM	• In dissolve phenomenon can not be observed gas way-out and falling in any substance.

For Item 3, sound understanding included knowledge of "kind of solute and solvent, pressure, temperature contact surface and stirring factors effect dissolution rate". As can be seen from Table1, 50% of students showed sound understanding, the proportion of students' responses categorized under the partial understanding category was 40% of students responses classified under specific misconceptions category was eight per cent and no understanding category was two percent. Some examples from the given answers for Item 3 are presented in Table 3.

Table 4.

Some Examples from the Responses Given for Item 3

UL	Examples
SU	• Factors that effect dissolution rate are sort of solute and solvent, pressure, temperature, contact surface and stirring.
PU	•As a results of stirring, kinetic energy increases.
SM	• Temperature causes breaking bonds among the molecules.
NU	• Liquids can not dissolve every solid.

For Item 4, sound understanding included knowledge of "kind of ink to be diffused in to water molecules and spreads out all over the water homogeneously". As can be seen in Table 5, 20% of students showed sound understanding the proportion of students' responses categorized under the partial understanding category was 50%. Proportion of students responses classified under specific misconception category was eight percent and no understanding category was 22%. Some examples from the given answer for Item4 are presented in Table 5.

Table 5.

Some Examples from the Responses Given for Item 4

UL	Examples
SU	• Ink with water mixture as a homogeneous mixture such mixtures make up diffusion. Ink will be diffused among water molecules and spreads out all over the water homogeneously.
PU	• Ink will be diffused among water molecules.
SM	• Color of the water changes because ink dissolves in water.
NU	• Ink spreads out heterogeneously among water molecules, and water is become colored.

As can be seen from Table 1, only 8% of science student teachers could explain the concept of dissolution with reasons, while 40% of them had misconceptions and lack of knowledge that dissolution was physical change and 30% of science student teachers had some misconceptions about diffusion of ink in water.

Discussion

The results obtained in this study show that pre-service science teachers have some difficulties describing the terms solution, dissolution rate and diffusion. Successfully learning often depends on the ability to recognize and identify the most relevant bodies of knowledge that already exist in the learner's long-term memory, which may be used for making sense of new knowledge and for reasoning about situations. Stanovich (1999) emphasized the human tendency to contextualize problems with as much prior knowledge concerning the particular context as one retrieve. This prior knowledge, its organization, and individuals' relevant beliefs are related to the specific mechanisms of attention and recognition which capture the problems features and stimulate their retrieval. Thus, this study's findings indicate that even though some pre-service science teachers in the sample have an accurate understanding of physical and chemical processes, some of these students have misconceptions about the dissolution rate and their knowledge about this process was insufficient. In fact, the present study revealed that science student teachers' misconceptions and misunderstandings about solubility concepts are more than their knowledge about the solution concept. Therefore, this study is in agreement with earlier studies in some respects (Stavy, 1990; Çalık ve Ayas, 2005a). According to Çalık and Ayas (2005a) some of misconceptions and confusions stem from their teachers. Since, teachers are the prime source of instruction in the educational context. Therefore, first, misconceptions of pre-service teachers should be remedied. 28 percent of students under investigation on claim that gap among liquid molecules greater, so liquid substances in order to filled these gasp dissolve solid substances. This result is in agreement with previous studies results (Abraham, Gryzybowski, Renner and Marek, 1992; Abraham, Wiliamson and Westbrook; 1994; Cosgrove and Osborne, 1981; Ebezener and Erickson, 1996; Çalık and Ayas; 2005a). These researchers reported that many students have misconceptions and confusions about the dissolution concept in different education levels.

For Item 2, seven percent of students under investigation stated that gas way-out (release) and falling in any substance connot be observed in dissolve phenomenon. These responses indicated that these students have some misconceptions about the dissolution concept. Prieto et al. (1989) reported that students saw the solute as the most crucial component of dissolution process, and even though some of them used word solvent, they tended to regard it as a passive component. In this study was seen some student teachers' believed that the solvent had an active role and the solute has a passive role during dissolution process. Finding in this study are in agreement with Çalık and Ayas's (2005a) result. Their study had been performed on 7, 8, 9 and 10 grades students.

These similarities between findings supported the same research findings about the source of misconceptions. Namely, students misconceptions may be stem from teachers. Because, some times teachers serve as another major source of misconceptions (Wandersee, Mintzes and Novak, 1994). It is clear that teachers with misconceptions about science are not likely to be able to make their students develop scientifically accurate concepts.

As noted in Table 4, some student teachers believe that temperature causes breaking bonds among the molecules. This is not scientific knowledge; therefore these student teachers (8%) have alternative ideas about the effect of temperature on dissolution process. These findings are in agreement with related literature in some respects. Blanco and Prieto (1997) reported that students have crucial misconceptions about the effect of temperature and stirring on the dissolution of solids. For Item 4, some of science student teachers (%22) under investigation stated that ink spreads out heterogeneously among water molecules, and water is become coloured. This state indicated that some student teachers have inaccurate beliefs about the diffusion phenomenon. The present results substantiate earlier studies reporting that students at different levels have difficulties perceiving matter structure as dynamic (Lee et al., 1993; Novick and Nussbaum, 1978, 1981). Students have often been shown to exhibit difficulties in understanding matter in terms of the kinetic theory. Therefore, students have no basis for understanding of the invisible molecular events that cause natural phenomena. The present findings call for science student teachers to diverse experiences with the dynamic characteristics of matter. Matter's dynamic structure constitutes the basis for understanding most of the simple as well as the majority of the more complex process and phenomena in the various topics (for examples; diffusion, osmosis, dynamic equilibrium, ecology) (Eliam, 2002, 2004).

In order to see the relationship between dimensions of the logical thinking ability scores, the science teaching-learning attitude scale and chemistry concepts test scores, the Pearson correlation analysis was computed. It was found that participants' logical thinking test scores are not correlated with their chemistry concepts test scores ($P>0.05$). This means that pre-service science teachers' logical thinking abilities were not influenced their achievement related to solution, dissolution and diffusion concepts. Also, correlation was not found between their logical thinking abilities and attitudes toward science teaching-learning ($P>0.05$). No, statistically significant relationship among those variables is found either ($P>0.05$).

Conclusion

The results of this study show that student teachers are not able to understand different topics like solution, solubility, dissolution and diffusion. These topics are mainly treated as dependent subject in their textbooks. Understanding is sometimes incomplete at every level and it is easy to draw inconsistent outcomes from incomplete models. Therefore, there is need to determine willful misconceptions in chemistry subjects. The main aim of this study was to determine understanding levels science student teachers' related to solution, solubility, dissolution and diffusion concepts. However, another aim of study was to investigate relationships among students' understanding levels, logical thinking ability levels and attitudes toward science. The results revealed that many participants held several misconceptions concerning fundamental chemistry concepts. The solutions, the solubility, the dissolution and diffusion were among such concepts. These concepts are basic to scientific concepts and acts as having important role to the understanding other concepts in different disciplines of natural science. The results obtained in this study add to the evidence that, regardless of student level of schooling, misconceptions are prevalent and resistant. Many participants under this investigation had different levels of difficulties in some concepts as the solution, solubility, dissolution and diffusion regarding their intelligence differences. When looked at student level of understanding by considering of percentages in "sound understanding" category, there are some discripancies for four items (Table 1). Participants' percentages related to Item 1 and Item 4 were very low but for Item 2 and Item 3 they were found to be at intermediate level. Percentages related to "partial understanding" category for all Items higher than other three categories. However, for Item1 "specific misconception" category percentages are higher than other items percentages. These results indicated that the science student teachers under investigation have some misconceptions about the dissolution and diffusion concepts. Therefore, teacher educators, first of all, should determine and remedy misconceptions of science student teachers related to their branches. The present study showed that student teachers preserved many misconceptions. Furthermore, participants' logical thinking levels and their attitudes towards science were determined. In order to see the relationship between dimensions of the logical thinking ability scores, the science teaching-learning attitude scale and chemistry concepts test scores, the Pearson correlation analysis was computed and no statistically significant relationship among those variables is found.

Science teachers have vital role in science education because they will educate our younger generation. Therefore, teacher training programs, which are not likely to be able to make students develop scientifically accurate conceptions, need to critically weigh the long term consequences of having pre-service science teachers graduate before they get the chance to explore and try to alter their misconceptions about scientific ideas. Teacher education programs, at the same, time should evaluate the efficacy levels of teacher traines and begin to find ways to enhance their efficacy beliefs, logical thinking abilities and attitudes regarding science teaching. Further research may focus on how science student teachers' misconceptions could be remedied and their attitudes increased.

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