Determination of seventh grade students’ understanding of certain chemistry concepts

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Abstract

In this study, it was aimed to determine 7th grade students’ understanding of some chemistry concepts. For this reason, according to Turkish Science and Technology Curriculum, a valid and reliable concept test was developed related to the concepts of “measurable properties of substance, heat and temperature, pure substance and mixture, particulate nature of substance, elements and compounds, elements and symbols, and structure of atom”. During development of the test, literature was reviewed and then item pool consists of multiple-choice items was formed in accordance with the learning objectives determined by Ministry of National Education. After the test was validated by a group of chemistry educators, it was applied to 217 seventh grade students. The coefficient alpha of the last version of the test, consists of 32 items, was found as to be 0.80. The results of students’ responses indicated that they commonly had misconceptions such as atoms can be seen under microscope, different elements consist of the same atoms, there is no space between particles in atoms, atoms only include nucleus. It was also found that students confused mixture and element, compound and molecule, melting and solubility, and they could not distinguish the substance that include molecules.

Keywords: chemistry concepts; science and technology curriculum; misconceptions

1. Introduction

In this age when the development of science and technology has dramatically speeded up, the importance put on chemistry teaching has been increasing more day by day. For an adequate chemistry teaching, basic chemistry
notions should be given properly and adequately at primary and secondary levels. The aim of chemistry teaching is not only providing students with the necessary information but also giving them the skills which are useful to make connections between scientific concepts. For an effective learning, concepts which are the basic units of information need to be constructed in the student’s mind properly (Tatar, 2005).

As Bodner (1986) also stated, the most important factor which affects individuals’ constructing new concepts in their minds is their previous knowledge. That’s why, the quality of the previous knowledge is of much importance during conceptual learning process. It becomes difficult to make connections between the previous knowledge and the new ones and construct new knowledge, if previous knowledge is deficient or wrong. This situation may lead the student to refuse new knowledge and to construct the new knowledge inaccurately, which might consequently cause misconceptions which are quite difficult to correct. For this reason, before teaching a new subject or concept, it is essential to diagnose students’ cognitive readiness level which includes mental structures related to the subjects and concepts which form the basis for learning a new subject. A number of techniques can be applied so as to diagnose the students’ cognitive readiness level. Techniques which are mostly applied are open-ended questions (Glazar & Vrtacnik, 1992; Bowen & Bunce, 1997), mind maps (Ross & Munby, 1991; Hazel & Prosser, 1994), interviews (Osborne & Gilbert, 1980; Osborne & Cosgrove, 1983; Coll & Taylor, 2001), drawings (Smith & Metz, 1996), word association (Maskill & Cachapuz, 1989), predict-observe-explain (Liew & Treagust, 1995; Liew, 2004), and multiple choice tests (Nakiboglu & Tekin, 2006; Ince, Acar Sesen, & Kirbaşlar, 2012). Multiple choice tests, which are well structured with a concern for students’ learning objectives and whose validity and reliability have been proved, are commonly applied techniques as they are effective for diagnosing the students’ understanding level. (Ayatar, 1965; Grondlund & Linn, 1990). Researches show that in studies which are used to test the students’ level of understanding of a subject or concept, multiple choice tests are the second mostly applied technique after interviews (Palmer, 1998).

Chemistry, which has much of an importance among other science subjects, is described as abstract and difficult by a good number of students. (Yang, Andre, Greenbowe & Tibell, 2003; Gilbert, Justi, van Driel, de Jong & Treagust, 2004; Çakmak, 2009). For this reason, it is highly important for students’ active participation in the learning process to develop and apply methods and techniques accordingly. In this way, students can have the chance to interpret and reconstruct the knowledge in their minds. According to constructivism, students construct new knowledge by relating it to the previous one. That’s why, students’ level of understanding new concepts should be revealed and teaching process should be designed accordingly (Hewson & Hewson, 1984).

In this study, it was aimed to determine 7th grade students’ understanding of “measurable properties of substance, heat and temperature, pure substance and mixture, particulate nature of substance, elements and compounds, elements and symbols, and structure of atom” which are the basic concepts of chemistry.

1. Method

In this research, a concept test which is suitable for the objective of this study was developed and the students’ understanding of chemistry concepts and their misconceptions were investigated.

1.1. Participants

The research was carried out with 217 seventh grade students from two secondary schools in the city centre of Istanbul in the academic year 2012-2013.

1.2. Instrument

Within the extend of the study, a concept test was developed and applied to determine 7th grade students’ understanding of measurable properties of substance, heat and temperature, pure substance and mixture, particulate nature of substance, elements and compounds, elements and symbols, and structure of atom which are the basic concepts of chemistry. During the process of developing the test, learning objectives determined by Ministry of National Education were analyzed, revised and classified according to Bloom’s Taxonomy (Krathwohl, 2002). An item pool with 53 multiple choice items was created in accordance with these objectives. Test items consist of 4
options with 3 distracters which include students’ misconceptions and one correct answer. In order to test content validity, the test was reviewed by a group of academicians and reduced to 35 items in accordance with the feedbacks. The test was applied to 217 7th grade students so as to determine its reliability. The students were given 50-minute period for the application. Item analysis of the test was made using LERTAP 5 Statistics program.

Three items whose difficulty index of item discrimination was not at a desired level were specified and they were not included in the test which was ready to use with 32 multiple choice items. It was found that the level of difficulty of other items was medium, and item discrimination index was above 0.30. As removing the items whose discrimination index was between 0.20 and 0.30 does not affect the reliability coefficient values, they were also decided to be included in the test. Consequently, the test was reduced to 32 items with the removal of 3 items in total. Item analysis showed that average difficulty value of the test was 0.55. According to Çepni et al. (2008), average difficulty value of the test should be around 0.50. When item discrimination index was checked, average discrimination value of the test was identified as 0.34. If the average discrimination index of a test is above 0.30, it is a feature which is looked for in a test (Turgut, 1995). An assessment tool’s reliability coefficient’s being above 0.70 is generally considered to be enough for the reliability of the test results (Büyüköztürk et al. 2013). In this respect, as the reliability coefficient of the test has been found to be 0.80 after the test analysis, it is proved to be consistent and reliable.

2. Findings

The students’ answers to the multiple choice items in the concept test which was created for this study were analyzed. It was found that students successfully answered the items related to Measurable Properties of Substance Subject (items which require mathematical operation) and Heat and Temperature (items which require data reading) in a high percentages. On the other hand, it was found that students have such misconceptions that “Adding oil in the water while cooking pasta is not a mixture”, “A new substance is formed when we mix chalk powder and iron powder”, “Ayran, coins and sea water is not a mixture” at Pure Substance-Mixture Subject (not being able to distinguish pure substance from a mixture); “Sugar melts in tea”, “Sugar forms a new substance together with tea”, “Sugar melts in water”, “State of sugar is changed” at Dissolution-Melting Subject (not being able to distinguish dissolution from melting); “Rain and sea water combine and form a compound of salty water” at Compounds-Mixtures Subject (not being able to distinguish compounds from mixtures); “Atoms forming the iron and those forming the copper are the same”, “There is no space between the particles of atom”, “Atom can be examined under the microscope”, “Atom is made up of a core”, “Atom’s being neutral means that its negative charges are less than its positive ones”, “There is an electron and a neutron in the nucleus and a proton on its layer”, “There is a proton and an electron in the nucleus and a neutron on its layer”, “Both proton and electron are of the same mass”, “Both electron and neutron are of the same mass” at Structure of Atom Subject (misconceptions about the structure of atom and the particles forming it); “Atoms which form the copper differ from one another”, “Both iron and copper are made up of similar kinds of atoms”, “While forming a compound, substances which form it do not lose their qualities” at Elements-Compounds Subject (not being able to distinguish elements and compounds); and at Elements-Compounds-Molecules Subject (not being able to distinguish elements, compounds and molecules).

4. Discussion

A valid and reliable concept test was developed for the subjects of measurable properties of substance, heat and temperature, pure substance and mixture, particulate nature of substance, elements and compounds, elements and symbols, and structure of atom which are in the schedule of Turkish Primary School Science and Technology lessons and the basic concepts of chemistry. During the process of developing the test, related literature review was made, subject-related learning objectives defined by TTKB were taken into account, and an item pool which consists of multiple choice questions was created. After specialists’ views were gathered, it was applied to 217 7th grade students and reliability coefficient of this test having 32 items with its final draft was defined as 0.80.

Basic qualities which are looked for in a good measuring tool are validity and reliability (Uysal, 1975; Tekin, 1993). Validity is the degree to which a measurement tool can measure the intended variable without any others (Kline, 1986; Turgut, 1995; Baykul, 2000). Asking for teachers’ and lecturers’ opinions about the validity of the test...
can be frequently seen in literature (Peterson & Treagust, 1989; Ayas & Demirbaş, 1997). For this purpose, the test which included 53 items at first, was reviewed by a group of academician and reduced to 35 items in accordance with the feedbacks provided that it sticks to the objectives determined by TTKB. In this way, it was determined that this test was appropriate for the 7th grade students’ readiness level and pre-decided objectives; therefore, it had face and content validity. The second important criterion is the reliability of the test. Reliability is a sign that shows the consistency between the answers of the individuals to the items and to what extent the test measures intended variable (Büyüköztürk, 2006). Reliability is referred as reliability coefficient. The test was applied to a group of 217 7th grade students in order to determine the reliability of the test which was developed for this study. The reliability coefficient of the test which included 32 items has been calculated to be 0.80 after the test analysis; which proves the test to be consistent and reliable.

It is highly important to determine students’ cognitive readiness level for related subjects and concepts before presenting a new subject so that new information is constructed correctly and consequently, information is acquired in a meaningful way. In this sense, students’ answers to the multiple questions in the concept test which was created to determine their understanding level of measurable properties of substance, heat and temperature, pure substance and mixture, particulate nature of substance, elements and compounds, elements and symbols, and structure of atom were analyzed. As a result, it is found that students have such misconceptions that atom can be seen under a microscope, different types of elements are made up of similar types of atoms, there is no space between the particles of atom, atom is made up of a core; not being able to distinguish the differences between mixture-element, compound-molecule, melting-dissolution; not being able to distinguish the substances which include molecules on the model from those which do not.

Misconceptions which are found in this study were also determined by a number of researchers, some of them are: All solutions are liquid; Compounds are not pure substances; As sugar is a mixture, it is not a pure substance; Sugar is melted in the water and spread/ dissolved; formation of mixture is a chemical change; Mixtures are heterogeneous; There is no specific ratio between the components of compounds; The smallest item which forms a compound is atom; Compounds are made up of two similar kinds of atoms; Sugar is not a pure substance as it is a mixture (Papageorgiou & Sakka 2000; Valanides, 2000; Tezcan & Bilgin, 2004; Uzuntiryaki & Geban, 2005; Coştu et al. 2005; Karaer, 2007; Konur & Ayas, 2008; Ayvacı & Çoruhlu, 2009; Kalın & Arık 2010; Say, 2011).

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