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A DESCRIPTIVE INVESTIGATION OF TURKISH STUDENTS' MISCONCEPTIONS ON COMMON SCIENCE CONCEPTS

A MASTER'S THESIS

BY

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THE PROGRAM OF CURRICULUM AND INSTRUCTION
İHSAN DOĞRAMACI BİLKENT UNIVERSITY
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To my family with love...

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of

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Emrah Topal

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THESIS TITLE: A DESCRIPTIVE INVESTIGATION OF TURKISH STUDENTS' MISCONCEPTIONS ON COMMON SCIENCE CONCEPTS

Emrah Topal

May 2018

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction.

Assoc. Prof. Dr. Erdat Çataloğlu (Supervisor)

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction.

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ABSTRACT

A DESCRIPTIVE INVESTIGATION OF TURKISH STUDENTS' MISCONCEPTIONS ON COMMON SCIENCE CONCEPTS

Emrah Topal

M.A. in Curriculum and Instruction
Supervisor: Assoc. Prof. Dr. Erdat Çataloğlu

May 2018

The purpose of the study was to investigate Turkish students' misconceptions about general science subjects. Variables such as gender, school type, grade, age, and school level were employed in the present study. Descriptive research method was used and the sample consisted of 749 students (male=364, female=385) from two state middle schools, two state high schools, one private middle school, and one private high school located in the Çankaya district of Ankara. The instrument used was the Turkish translated version of the questionnaire "A Survey of Some Science-Related Ideas – SSSRI." SSSRI was developed by Osborne, Freyberg, & Bell (1985) for the purpose of determining students' misconceptions on general science subjects. The SSSRI contains 19 multiple-choice type and one open-ended question. The questionnaire was administered to students in the fall term of 2017-18 academic year. The analyses of data were conducted by taking into consideration students' grades of science, biology, physics, and chemistry courses, total scores of students, and their responses to each item. Descriptive statistical analyses were conducted to determine students' levels of misconceptions based on variables: gender, school type, grade, age, and school level. Independent samples t-test was used to find out if there were significant differences between mean scores within gender and school type.

One-way ANOVA was conducted to determine if there was significant difference between mean scores of grades. Additionally, Pearson correlation coefficients were computed between total scores of students and their grades of science, biology, physics and chemistry courses. Analyses demonstrated that students' misconceptions about general science subjects were independent from their gender and school type. Moreover, students still had misconceptions, especially in topics "electric current" and "change of state of water."

Key words: General science, misconception, meaningful learning, test validation.

ÖZET

TÜRK ÖĞRENCİLERİN FEN KONULARINDAKİ YAYGIN KAVRAM YANILGILARI ÜZERİNE BETİMLEYİCİ BİR ARAŞTIRMA

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Çalışmanın amacı, Türk öğrencilerinin fen konularındaki kavram yanılgılarını araştırmaktır. Bu çalışmada cinsiyet, okul türü, sınıf, yaş ve okul seviyesi gibi değişkenler kullanılmıştır. Çalışmada betimleyici araştırma yöntemi kullanılmıştır ve Ankara'nın Çankaya ilçesindeki, 2 ortaokul ve 2 lise olmak üzere 4 devlet okulundaki, 1 ortaokul ve 1 lise olmak üzere 2 özel okulundaki 749 (erkek=364, kız=385) öğrencinin katılımı ile gerçekleştirilmiştir. Veri toplama aracı olarak "Bazı Fen Kavramlarını Belirleme Anketi'nin" (BFKBA) Türkçe versiyonu kullanılırmıştır. BFKBA öğrencilerin fen konularındaki kavram yanılgılarını ortaya çıkarmak amacıyla Osborne, Freyberg, & Bell (1985) tarafından geliştirilmiştir. BFKBA 19 çoktan seçmeli ve 1 açık uçlu soru içermektedir. Öğrenciler çalışmaya 2017-18 akademik yılının sonbahar döneminde katılmışlardır. Veriler öğrencilerin fen, biyoloji, fizik ve kimya derslerindeki notlarını, anketteki toplam puanlarını ve her soru için verdikleri cevapları göz önünde bulundurarak analiz edilmiştir. Öğrencilerin cinsiyet, okul türü, sınıf, yaş ve okul seviyesi değişkenlerine göre kavram yanılgıları seviyelerini belirlemek için betimleyici istatistiksel analiz yapılmıştır. Bağımsız örneklemler t testi, cinsiyet ve okul türünün kendi içindeki gruplarının ortalama skorları arasında belirleyici bir fark olup olmadığını ortaya koymak için kullanılmıştır. Tek yönlü varyans analizi, sınıfların ortalama skorları arasında belirleyici bir fark olup olmadığını belirlemek için yapılmıştır. Ayrıca, öğrencilerin fen, biyoloji, fizik ve kimya dersleri notlarıyla anketteki toplam puanları arasındaki Pearson korelasyon katsayıları hesaplanmıştır. Çalışma sonucunda, öğrencilerin fen konularındaki kavram yanılgılarının cinsiyetlerinden ve okul türlerinden bağımsız olduğu gözlenmiştir. Buna ek olarak, öğrenciler özellikle “elektrik akımı” ve “suyun hal değişimi” konularında hala kavram yanılgılarına sahiptir.

Anahtar Kelimeler: Genel fen konuları, kavram yanılgıları, anlamlı öğrenme, test geçerliliği.

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CHAPTER 1: INTRODUCTION

Introduction

Students have many interactions with the physical world. They surely develop some understanding about the natural phenomena without the need of formal education. Students do construct their own understanding of the world, moreover, most often their understanding of the world and nature is sensible and coherent from their perspective (Osborne & Gilbert, 1980). Research in science education has shown that the views of students, that is their constructed reality of the world, might be in conflict with the accepted scientific views. In the science education literature, these wrong or contradictory students' views of understanding are commonly referred as students' misconceptions or alternative views. It should be noted that, although these misconceptions are partially or completely wrong, they are still sensible and plausible to students (Osborne, Bell, & Gilbert, 1983).

Science education research has also found out that students have simultaneous contradicting ideas. As Driver & Easley (1978) explained, one of the reason of this phenomena is that students make different connections of concepts between what is already known and experienced and what they have learned in schools. These non-scientific experiences of students have a considerable influence on what they will be able to learn in science classes (Gilbert, Osborne, & Fensham, 1982).

Meaningful learning is defined as learners' ability to explain and use knowledge in a scientific way rather than intuition or believe level (Novak, 2002). It has also been stated that students' formal understanding of contradictory concepts creates a problem in learning meaningful science. It is now well established that meaningful learning is hindered through misconceptions which form metal obstacles towards meaningful scientific understanding of concepts (Minstrell, 1984).

In this study, Turkish students' misconceptions on general science subjects as defined by Osborne, Freyberg, & Bell (1985) was investigated.

Background

In the field of science education has passed beyond the expectation of factual knowledge. Meaningful understanding constructed through scientific experiences is more important than the ability of fast solving many standardized multiple-choice types of problem. The recall of the information is now perceived as insufficient by the science education community. Students should be able to show evidence of scientific thinking and argumentation by applying the steps of scientific inquiry. They need to acquire this ability to adapt the fast development of the world. Science education should enable students to think creatively and critically, analyze current situations, solve ill structured problems, and conceptualize knowledge.

Conceptualizing knowledge is one of the components of 21st century skills. Applying, understanding, and experiencing everyday life circumstances is one of the methods of conceptualizing knowledge (Rotherham & Willingham, 2010). To achieve meaningful learning, students need to comprehend concepts of the subjects and contents that constitute the lessons. Some scientific concepts, such as action-reaction forces, showed to be difficult to reach meaningful understanding by students. One reason might be that some concepts are not directly observable such as atoms, electric fields, and potential energy, but are rather a construct (Osborne et al., 1983). Additionally, students encounter some of these scientific concepts in their everyday language which are different from scientific views (Tasker, 1980). Therefore, it causes a contradiction between student's and scientist's views. In addition, students create their own meaning about these concepts to predict future events (Driver, 1981). For instance, a stick slips over the table and a student wants to know where s/he should grasp it to prevent it from falling. Students create some explanations and expectations for this type of situations in their daily lives. Additionally, these expectations of students for some natural phenomena may differ than scientific views.

Students often come to a science classroom with well established misconceptions. These misconceptions should be taken into consideration by science teachers to plan and teach meaningful and fruitful lessons. The recognition of students' misconceptions is important for science teachers. Science teachers need to adapt their teaching methods according to students' misconceptions as well. Therefore, incorporating the fact that alternative conceptions have great importance for students' meaningful learning has now become de-facto in science education.

Problem

Real life experiences of students have been reported to cause difficulties, even hinder conceptual learning of science concepts. These alternative conceptions confuse students because they make wrong connections between what they already know and what their instructor says. For instance, some students think that the change in distance between the earth and the sun causes seasons due to elliptical orbit. However the intensity of the sunlight on different parts of the earth (due to its tilted axis) is the actual cause of the seasons (Atwood & Atwood, 1996). In another example, children are seeing a sign like “animals are not allowed,” while they enter a restaurant or shop. So, children think we are not animals, since we can enter. But, humans are classified in biology as animals and this causes a contradiction in child’s mind (Bell, 1981). Many researches were conducted about middle and high school students’ misconceptions including Turkish students. However, one can argue there is a need for a new study that sheds some new light about current situation of students’ misconceptions on general science subjects in Turkey.

Purpose

The purpose of this study was to investigate Turkish students’ levels of misconceptions on general science subjects. Students’ experiences before coming to science classes have great effect on what they will learn (Osborne et al., 1985). Some of the concepts build on experience and may differ from the accepted scientific explanations. In order to unveil students’ misconceptions, a questionnaire which was developed by Osborne, Freyberg, & Bell (1985) was used in this study. The focus of this study was on middle and high school students’ misconception.

Research questions

The following five research questions were explored to determine Turkish students’ levels of misconceptions on general science subjects.

1. What are students’ misconceptions on general science subjects?

2. Are there gender differences in the students' levels of misconceptions on general science subjects?
3. Do students' levels of misconceptions on general science subjects change according to school type?
4. Do students' levels of misconceptions on general science subjects change from middle to high school aged students?
5. How do students' levels of misconceptions on general science subjects compare with their grades of science, biology, physics and chemistry courses?

Significance

The predominant pedagogical philosophy in Turkey was based on behaviorism. However, this learning and teaching approach has been now replaced in many countries. The new approach is based on constructivism. The behavioristic model does not foster conceptual learning. Neither is the behavioristic approach sensitive towards the lack of meaningful learning. Mostly, students tend to memorize the information for exams and then they might forget most of the memorized information afterwards (Akgun & Aydin, 2010). Hence one can argue that students do not have opportunities for meaningful conceptual learning. Moreover, constructivist approach such as rich hands-on activities are usually not a major part of the current educational approach in Turkey. The students are rarely given the opportunity to practice and apply their knowledge in schools. All these above claims are also reflected in the low rankings at international assessments. According to results of the Program for International Student Assessment (PISA), Turkey is under the OECD average in all categories (OECD, 2016). Turkey's performance in science is ranked 52nd out of 72 countries. Turkey is ranked 50th in the reading which is related to the understanding of one's own language (mother tongue). In 2004, the Ministry of National Education (MoNE) in Turkey changed its approach to education system for addressing problems reported through the PISA study. Thus, MoNE has suggested that the education system has to be constructivist in its nature (MoNE, 2006).

Constructivism demands conceptual learning as in comparison to behaviorism. Conceptual learning is one of the pillars of constructivism. It requires students to apply their knowledge to hands-on activities and daily life problems. Additionally, scientific concepts are key factors which students have problem in comprehending. Studies revealed that even high-achieving students have misconceptions on general scientific concepts. This is one more reason why teachers should give credit to what students bring to science classes (Gilbert et al., 1982). This will enable teachers to incorporate students' misconceptions into their lessons and try to overcome students' pre-conceptions. To this end, the Turkish students' levels of misconceptions on general science subjects will be investigated in the present study. In that way, we could be one step closer to determine efficiency of our education system as far as conceptual understanding is concerned.

Definition of key terms

Concept: Carnap (2003) defined concepts as "properties and classes, relations in extension and intension, states and events, what is actual as well as what is not."

Constructivism: Piaget (1973) described constructivism as "A student who achieves a certain knowledge through free investigation and spontaneous effort will later be able to retain it; he will have acquired a methodology that can serve him for the rest of his life."

Misconception: Beliefs of students which are partly or completely different than accepted scientific views (Driver, 1981). There are several other terms that are referred as "misconception" such as "alternate frameworks", "pre-conception" (Novak, 1977), "alternative conception" (Driver & Easley, 1978), and 'children's science' (Gilbert et al., 1982).

Meaningful learning: Meaningful learning is defined as a learner's ability to explain and use knowledge in circumstances which is different than what was initially learned (Novak, 2002).

Achievement tests: "(1) examinations in individual courses of instruction in schools of all kind at all levels, (2) measures of achievement (course examinations) used routinely by all instructors in particular units, and (3) commercially distributed tests of achievement used thought the country" (Nunnally, 1978).

Diagnostic test: Diagnostic test is defined as identifying a student's needs and abilities and the student's readiness to obtain the knowledge and skills stated in the curriculum (Popham, 2009).

CHAPTER 2: REVIEW OF RELATED LITERATURE

Introduction

This research study was intended to investigate Turkish students' levels of misconceptions on general science subjects. The purpose of this literature review was to discuss information regarding research conducted on students' misconceptions.

In the first part, general knowledge regarding students' misconceptions in science education was provided. Additionally, various definitions of misconception from pioneer researchers were presented. In the second part, information on the number of studies which were conducted on students' misconceptions in science and their corresponding percentages in each discipline were reported. These studies were classified according to science disciplines (e.g. biology, chemistry, and physics). In the third part, types of research methods which were commonly used to investigate students' misconceptions were reported. Moreover, the way of development of surveys with students' non-scientific ideas which have been collected in interviews were provided. Some of the most known or used assessment instruments were also stated. In the fourth part, properties of diagnostic misconception tests were discussed. It is highlighted that incorrect responses of the students contain more valuable information than correct responses for this type of diagnostic tests. In the fifth part, knowledge about the outcomes of misconceptions studies was provided. The researcher discussed generally implications of these studies on science textbooks, curriculums, teachers, and their teaching methods. Finally, the sixth part provided the most influential learning theories. Because, meaningful learning of the students depends on construction of their own understanding, therefore, learning theories are vital for the conceptual understanding of students.

Students' misconceptions on general science subjects

As Novak (2002) stated, the development understanding on how students learn requires school and university education to foster meaningful learning. Meaningful learning demands conceptual understanding rather than memorizing knowledge. The most important single factor influencing learning is what the learner already knows. Ascertain this and teach them accordingly (Ausubel, 1968, p. iv).
Before being exposed to formal science instruction, students acquire substantial information about how the world around them is functioning (Osborne, Bell, & Gilbert, 1983; Driver & Easley, 1978). This acquired information sometimes causes misconceptions on general scientific concepts. Driver (1981) defined misconceptions as beliefs of students which are partially or not consistent with scientist's view. In the literature misconceptions are also referred to "pre-conception" (Dykstra, Boyle, & Monarch, 1992; Novak, 1977), "alternative frameworks" (Northfield & Gunstone, 1983; Driver & Easley, 1978), "alternative conception" (Heller & Finley, 1992), and "children's science" (Gilbert et al., 1982).

Dykstra, Boyle, & Monarch (1992) described pre-conceptions as the prior explanation of students exposed to formal science education on how the world around them works, and it differs from scientist's view. Driver & Easley (1978) referred to this understanding as "alternate frameworks." Heller & Finley (1992) used the term "alternative conception" as the ideas of students which are not compatible with scientific views or are even completely different to them. Gilbert, Osborne, & Fensham (1982) defined “children’s science” as the conceptual structures which enable plausible understanding of the world from the child’s perspective. Thus, students’ misconceptions were widely studied by many researchers and called in different ways in science education as stated in the above.

Studies conducted on students’ misconceptions

In the early 1980s, researchers have given great emphasize to students’ comprehension of scientific concepts and many researches were conducted in science education. Earlier researches concentrated on concepts mostly taught in mechanics (physics), while follow-up researches investigated numerous interrelated concepts both within and across science disciplines: biology, physics, and chemistry.

Pfundt & Duit (1994) examined about 1000 researches which probed the students’ comprehension of scientific concepts. Their meta-analysis covered journals, research presented at conferences and to some extend unpublished studies as well. Approximately, two third of these researches focused on students’ misconceptions in physics. Around 20% of these researches investigated students’ misconceptions of scientific concepts in biology and around 13% in the chemistry.

Wandersee, Mintzes, & Novak's (1994) work suggests that 700 studies were conducted on physics related topics and took place initially in the USA. The also reported that the sample mostly is constituted of high school and college students. Around 300 of these studies investigated students’ misconceptions in mechanics. Topics such as force, motion, velocity, acceleration, and gravity were intensively studied. Around 160 of these studies investigated concepts in electricity. Around 70 of these studies were each allocated to concepts of the molecular nature of matter and energy, optics, and heat. Around 35 of these studies investigated concepts of the earth and science. Only 10 of these studies were related to concepts of relativity and quantum theory.

Many studies (Gilbert & Watts, 1983; Clement, 1982; Minstrell, 1984) demonstrated that large number of students had beliefs which slightly or completely differ than accepted scientific views. Students' misconceptions construct obstacle for meaningful learning in science. Therefore, they should be revealed and eliminated to provide a gateway for meaningful learning on general scientific concepts (Driver & Bell, 1986).

Types of research approaches in misconception studies

Researchers used several different approaches to explore students' misconceptions in science. These approaches were interview (Driver, Guesne, & Tiberghien, 2000), interview about instances (Osborne & Gilbert, 1980), interview about events (Osborne, 1980), survey (Osborne, Freyberg, & Bell, 1985), concept maps (White & Gunstone, 1992), and students' drawing (White & Gunstone, 1992).

In the interview approach, the researcher interviews a student at a time about his/her comprehension of concepts or words (e.g. animal, plant, and living) or natural events (e.g. state of change of water). The purpose of the researcher is to reveal students' beliefs about concepts, words, and events. This interview protocol avoids consciously the use of leading questions, refusing wrong responses or approving correct responses. Additionally, the researcher avoids from verbal and non-verbal reflections which may affect students' responses.

In the Interview about instances (IAI) and interview about events (IAE) approaches, drawings and pictures can be used to initiate conservation with students and assess their comprehension of words and natural phenomenon. Interview about Instances (IAI) approach was developed by Osborne and Gilbert (1980). The researchers used cards that each show a line-drawn instance or non-instance of concepts. In the interviews with students, they are asked to categorize the cards and clarify their reasons.

For the IAE approach, the researcher probed students' meaning and comprehension of physical events (Osborne, 1980). First, some pictures (e.g. spider or tree) are shown to the student. Later, the researcher asked the student to explain what is happening. Then, insights of students on natural phenomenon are gained with their explanations, descriptions, and predictions.

In the survey approach, researchers had sufficient information about students' misconceptions about scientific concepts, so they used this knowledge to transform interview methods to survey method. The advantage of survey method is to apply it to large number of students in a short amount of time. Since it is applicable to large number of students, researchers can find out prevalence of each misconceptions held by students.

In the concept mapping approach, students' conceptual structures and comprehension of interconnection between each concept are revealed (Chin, 2001). The researcher should determine important concept for the topic (e.g. photosynthesis) and then ask students to write concepts (e.g. carbon dioxide, oxygen, and sugar) on cards. Then, students will draw concept maps by linking the concepts and write statement on interconnections. This approach is very beneficial to find out students' prior beliefs and misconceptions before instruction.

In the student drawing approach, students' comprehension of scientific concepts can be ascertained with open-ended drawings. Students' drawings can also reveal some of their disguised conceptions which could not be obtained in verbal responses. These approaches found out that the incorrect answers of students were not random and in some cases, the incorrect answers of the students were not in common.

In the prior research approaches, researchers mostly used one to one approaches such as interview and concept mapping. But then, they passed from these approaches to large scale multiple-choice type of misconception surveys to ascertain students' misconceptions. These large number of approaches can be used to assess students' prior knowledge, their comprehension of concepts, and natural phenomenon.

Properties of misconception tests

Misconception tests differ than traditional achievement tests in some aspects. The primary purpose of misconception tests is to reveal students' misconceptions. That means a low score in a misconception test indicates that the student has had many misconceptions. A low score on an ordinary achievement test on the other hand reveals that the student did not master the course objectives. Usually the distractors of misconception tests are formed using the results of students' qualitative interviews and open-ended questions (Tamir, 1971) obtained from procedures as described in the previous section. Thus, the distractors refer to common well documented students' misconceptions (Treagust, 1988). Incorrect responses of the students are informative as much as correct one's (Hestenes, Wells, & Swackhamer, 1992).

Many diagnostic misconception tests were developed by using this methodology. Most known of these misconceptions tests are "The Force Concept Inventory" (Hestenes, Wells, & Swackhamer 1992) and "Mechanics Baseline Test" (Hestenes & Wells, 1992).

Outcomes of misconception studies

In the early 1980s, researchers in the USA conducted initial studies on students' misconceptions in science. After that, similar studies soon were spread out to other countries around the world. Today, a large amount of knowledge about students' understanding of general scientific concepts were obtained. Thus, these knowledge lead to improvement in some areas of science education such as science curriculum, textbooks, teachers, and their teaching methods.

Science curriculum has important role on refutation of students' misconceptions on general science concepts (Osborne & Gilbert, 1980). Clement (1993) suggested that physics should start with momentum, because the nation of momentum is similar to the idea of impetus which is a very wide held and resistive misconception. Some countries have now taken this misconception literature results into account and already adjusted their science curriculum by considering students' misconception about general science concepts. For example, The National Science Teacher Association in the United States provided some resources to deal with students' misconceptions and implement this knowledge into instruction (Larkin, 2012).

Science textbooks may also cause misconceptions by providing incorrect definitions and/or diagrams (Sanger & Greenbowe, 1999). Therefore, science textbooks should carefully examined in terms of pictures, drawings, definitions, statements to avoid from creating misconceptions (King, 2010). Now, science lesson textbooks in developed countries give great importance to students' misconceptions (Hewitt, 1990). For instance, Hewitt (1990) proposed that Newton's 2nd law should be used to guide to thinking rather than calculation of quantity in the equation $F=ma$ for the freely falling objects.

Science teachers should be educated more about student centered teaching and learning methods. The need is also to learn ways to elicit students' misconceptions and then be able to refute those wrong and incomplete ideas (Ecevit & Şimşek, 2017). There are many studies that focus on how science teachers can reveal students' misconceptions and eliminate them (Chin, 2001). These studies proved that constructivist teaching methods improve students' meaningful learning more than traditional methods (Hake, 1998). Therefore, science teachers should embrace constructivist teaching strategies and implement them in their classroom (Beck, Czerniak, & Lumpe, 2000).

Researches on students' misconceptions started in 1990s in Turkey. The first research investigated physics students' misconceptions on topics related to introductory mechanics at the university level (Eryilmaz, 1992). Over the past years, more follow-up research studies on students' misconceptions were conducted. To list a few Cataloglu, 1996; Topkaya, 1996; Baser, 1996; Aydoğan & Güneş, 2003; Ateş & Polat, 2005; Ates & Cataloglu, 2007; Kapucu & Yildirim, 2013; Bilican, Cakiroglu, & Oztekin, 2015 in physics and general sciences in Turkey. Moreover, a recently published book by Güneş (2017) reported the students' misconceptions on topics such as force & motion, electricity & magnetism, thermodynamics, waves, and modern physics.

Ates & Cataloglu (2007) reported the relation between freshman year students' conceptual understanding, reasoning, and problem solving abilities in introductory mechanics. The sample consisted of 165 students, 86 females and 79 males. The survey method was used in their study. Force Concept Inventory (FCI) and the Classroom Test of Scientific Reasoning (CTSR) were administered at the beginning of the course. At the end of the course, FCI and the Mechanics Baseline Test (MBT) were administered. The results demonstrated that there were no statistically significant differences in conceptual understanding levels of pre-test and post-test mean scores for the FCI, among concrete, formal, and post formal reasoners. No statistical difference was found between the mean scores of formal and post formal reasoners, while statistically significant differences were found between mean scores of concrete and formal reasoners and concrete and post formal reasoners for the MBT.

Küçüközer, Bostan, Kenar, Seçer, & Yavuz (2008) ascertained 9th grade Turkish students' misconceptions about simple electric circuits. The sample consisted of 76 students from a school in Balıkesir, Turkey. The Conceptual Understanding Test (CAT) was administered to all students and interviews were conducted with 9 students. Some misconceptions were found in Turkish students such as "no bulb lights on if the switch is off" and "bulbs connected in parallel give better light than those connected in series." Misconceptions, reported in the literature such as "the consumption of current" and "batteries are constant current resources" were observed in their study.

Outcomes of misconception studies on gender

Sencar & Eryilmaz (2004) investigated effect of gender on students' misconceptions on electricity and reason of observed gender difference. The number of participants was 1678 students from 13 different state schools in Ankara, Turkey. They used survey research method in their study. The instrument called "electric circuits misconception test and the survey of attitude and experience toward electric topics" was administered to the students. Electric circuits misconception test was constituted of 2 tier 16 multiple-choice types of question which are based on experience and theory. The survey of attitude and experience toward electric topic included 17 Likert type questions. The result of the study demonstrated that mean score of male students was greater than mean score of female students on experience-based question, while there was nearly no difference between mean scores of genders on theory-based questions. However, effect of gender in experience-based questions was eliminated when scores of attitude and experience survey were included in the analysis.

Ateş & Karaçam (2008) investigated the relationship between gender and students' conceptual understanding levels of motion laws. Three different techniques (multiple choice, open-ended, and structural communication grids) were used to measure students' levels of conceptual understanding. The sample consisted of 136 students, 87 males and 49 females from different high schools in Bolu, Turkey. The results of their study indicated that there was statistically significant difference between male and female students' conceptual understanding levels in favor of male students for the multiple-choice test. However, there were no statistically significant difference between male and female students' conceptual understanding levels for the open-ended and structural communication grids.

Outcomes of misconception studies on school type

Bulunuz, Jarrett, & Bulunuz's (2009) purpose was to determine the effect of school type on students' misconceptions by comparing public and private middle school students' understanding of Boyle's law and Bernoulli Principle. Causal comparative research method was conducted in their study. The sample consisted of 106 public middle school and 61 private middle school students. A test with 13 multiple-choice type of questions was administered to students. The results showed that there was no statistically significant difference between mean scores of public and private middle schools students.

Outcomes of misconception studies on grade

Adadan & Yavuzkaya's (2018) study investigated students' understanding of thermal concepts. This research was a cross-sectional study. A number of 656 Turkish students from grade 8, 10, and first year of college participated in this study. The results demonstrated that students' misconceptions on thermal concepts generally decreased with higher grade levels, however, specific misconceptions were observed in each grade levels. Additionally, use of non-scientific ideas was decreased with higher grade levels, while use of scientific ideas increased.

Outcomes of misconception studies on age

Akgun & Aydin (2010) aimed to determine students' misconceptions on chemical and physical changes in chemistry. Cross-aged study method was used in this study. The sample consisted of 160 students of ages 11, 12, 13, and 14 years old. Each age group included 40 students. This study was conducted with 6^{th}, 7^{th}, and 8^{th} graders of school which was located in Adiyaman, Turkey. Tests called "application test" and "theoretical test" were administered to students. The results showed that 13 and 14 years old students had better understanding of chemical and physical changes among all age groups. However, specific misconceptions were detected in students' responses for all age groups.

Outcomes of misconception studies on school level

Çepni & Keleş (2006) explored Turkish students' understanding of simple electric circuits. They used a cross-sectional research method in their study. The sample of their study consisted of 250 students at primary, secondary, and university levels in Trabzon, Turkey. Data were collected from students' drawings and explanations to open-ended questions. The results demonstrated that 5^{th} graders have mostly understanding of unipolar model (Model A), and 9^{th} graders have understanding of the current consumed model (Model C) in electric circuits. Moreover, university students still had understanding of Model C in electric circuits.

Learning theories

Students create their own understanding to make the world around them sensible and plausible and this of course starts before formal instruction (Osborne & Gilbert, 1980). This then should come not as a surprise that students have knowledge about some scientific concepts even before they receive formal education. Traditional teaching approach would threat the students mind as “tabula rasa” (Driver, 1981) e.g. blank slate. Teachers are agents that need to write the correct information on these slates. However, students’ beliefs and prior knowledge have a great effect on what they will learn in science classes (Gilbert et al., 1982). Thus, learning theories are important too, to make sense of the misconception literature.

Researchers such as Bruner, Piaget, Vygotsky and Ausubel had great influence on learning theories (Gilbert & Watts, 1983). As stated above, Ausubel (1968) expressed that what students already know is the most important factor in learning science. Other cognitive theorists also take students’ background knowledge as a baseline. For instance, Piaget (1950) suggested disequilibration, assimilation, and accommodation as necessary conditions for conceptual change. If the student can explain an event under held conditions, it is assimilation. Otherwise, the student enters the state of cognitive disequilibrium. Accommodation occurs for the student by adjusting existing ideas to new concepts. Then, new knowledge is acquired with conceptual change and the student enter again the state of cognitive equilibrium (Strike & Posner, 1992).

Moreover, Vygotsky (1962) claimed that construction of new knowledge occurs at what he labeled as the “zone of proximal development.” The student constructs new knowledge by accepting new or changing ideas in social environment. Vygotsky also described “scaffolding” as assistance of the environment for the student to learn new concepts and develop his/her understanding. This assistance should be suitable for student’s mental level for occurrence of learning.

These cognitive theorists give great emphasize to students’ background knowledge for the construction of new knowledge. As stated by Osborne, Freyberg, & Bell (1985), what students already know, should be taken into account to foster conceptual understanding. That way, students can eliminate misconceptions about general scientific concepts and achieve scientific view.

CHAPTER 3: METHOD

Introduction

The purpose of this study was to investigate Turkish students' levels of misconceptions on general science subjects. This study provided an overall view considering the current situation of students' levels of misconceptions on general science subjects compared to the past.

This chapter contained six sections. These are research design, context, participants, instrumentation, data collection and data analysis. In the research design section, the research method used in this study and the reason of choosing the method was described. Information regarding the participant schools and the sample which took part in the study were explained in the context. In the participants section, sampling strategy and description of population were stated. The reliability and validity of the instrument were addressed in the instrumentation. In the data collection section, the researcher explained how descriptive data were collected and ethical issues regarded regulation of Ministry of National Education (MoNE). In addition, analysis based on the research questions were explained in the data analysis.

Research design

This study used a descriptive quantitative research methodology to investigate middle and high school students' levels of misconception on general science subjects. To this end, a multiple-choice type of questionnaire was used to collect data on students' misconceptions on general science subjects. The following research questions were addressed:

1. What are students' misconceptions on general science subjects?
2. Are there gender differences in the students' levels of misconceptions on general science subjects?
3. Do students' levels of misconceptions on general science subjects change according to school type?
4. Do students' levels of misconceptions on general science subjects change from middle to high school aged students?
5. How do students' levels of misconceptions on general science subjects compare with their grades of science, biology, physics and chemistry courses?

The research method was used to capture current situation of students' misconceptions on general science subjects. To this end, descriptive quantitative research method (Gay, 1981, p.12) was employed in the present study. Ayiro (2012) stated that descriptive research method is the approach that provides knowledge about conditions, situations, and events that exist in the current state. Williams (2007) defined descriptive research method as basic research approach which investigates the circumstance, as it occurs in the present. Fox & Bayat (2007) explained the purpose of descriptive research as shedding light on current situations or events by collecting data which describes the situation investigated. Since the main aim of the analysis was to understand and provide descriptive statistics regarding students' misconceptions in general science, descriptive research method fits the purpose of this research. Thus, this method enabled the researcher to explore the students' levels of misconceptions in relation to variables such as gender, school type, grade, age and school level. To this end, a questionnaire was used which enabled the study to investigate students' misconceptions on various science topics.

The questionnaire called "A survey of some science-related ideas" was used to investigate students' misconceptions on general science subjects. The questionnaire was composed of different subjects such as "animal," "plant," "living," "electric current," "change of state of water," and "weather and climate." Therefore, the researcher will examine students' levels of misconceptions for the selected scientific concepts by analyzing students' responses to each question in the questionnaire. Furthermore, the analyses regarding possible correlations between total scores of students in the questionnaire and their grades of science, biology, physics and chemistry courses were conducted.

Context

This study was conducted in state and private schools in Çankaya, Ankara during the fall term of 2017-18 academic year. The multiple-choice type "A survey of some science-related ideas" questionnaire was administered in all participant schools under the same conditions. Students were given 25 minutes to finish the questionnaire.

The sample of this study consisted of middle and high school students from two private schools and four state schools that were located in the Çankaya district of Ankara. Information of the participant schools and number of students whom took part in the study from each school were presented in table 1.

Table 1
Schools and number of the participant students

School	School type	School level	Number of students
School 1	S	H	96
School 2	S	H	84
School 3	S	M	75
School 4	S	M	147
School 5	P	H	217
School 6	P	M	130

Note. S: State school. P: Private school. H: High school. M: Middle school.

Participants

The study was conducted in Çankaya, Ankara. Students from two state middle schools, two state high schools, one private middle school, and one private high school participated in the study voluntarily. For this study, the researcher used convenience sampling to select approximately 90 participants from each grade level of the participating schools. In total, 749 students participated in the present research study.

As reported in figure 1, the percentage of male students in the sample was 49% and that is 364 males took the questionnaire.

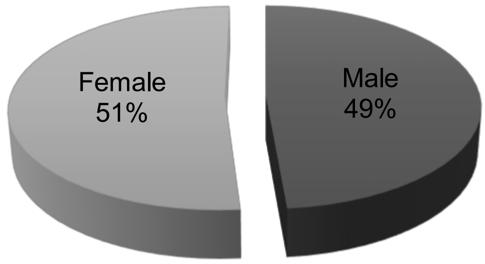


Figure 1. The percentage of female and male students

Moreover, the percentage of female students in the sample was 51% and that is 385 females took the questionnaire. As can be seen in figure 1, ratio of male students to female students was approximately equal.

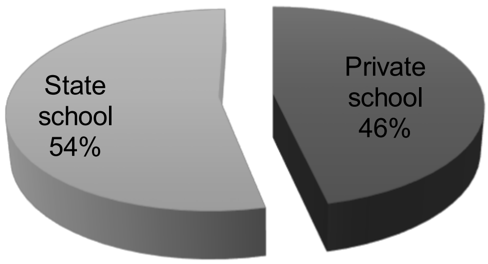


Figure 2. The percentage of state and private school students

As shown in figure 2, the percentage of state school students to all students in the sample was 54% and it equals to 402 students. In addition, the percentage of private school students in the sample was 46% and it corresponded to 347 students. As can be seen on figure 2, percentage of private school students was slightly lower than the percentage of state school students.

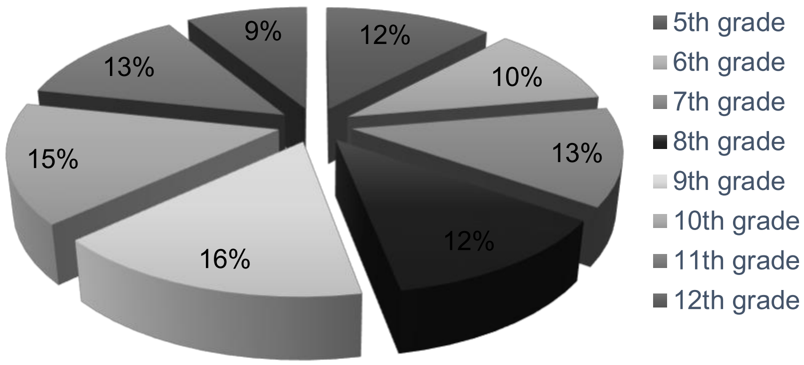


Figure 3. The percentage of students' grades

As reported in figure 3, the percentage of all grade levels were close to each other. Moreover, the percentages of grade levels were 12% for grade 5 (*N* = 90), 10% for grade 6 (*N* = 77), 13% for grade 7 (*N* = 93), 12% for grade 8 (*N* = 92), 16% for grade 9 (*N* = 121), 15% for grade 10 (*N* = 114), 13% for grade 11 (*N* = 97) and 9% for grade 12 (*N* = 65).

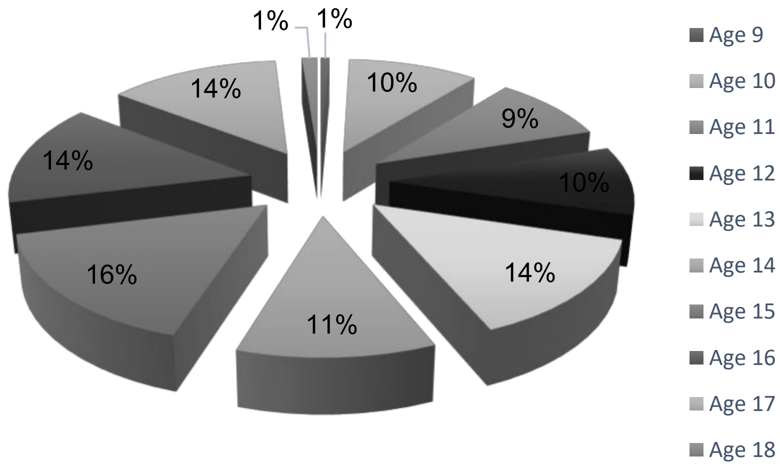


Figure 4. The percentage of students' ages

As shown in figure 4, the percentage values of ages of students were close to each other except for age 9 and 18. The percentage values of ages of students were 1% for age 9 (*N* = 5), 10% for age 10 (*N* = 76), 9% for age 11 (*N* = 69), 10% for age 12 (*N* =

72), 14% for age 13 (N = 105), 11% for age 14 (N = 84), 16% for age 15 (N = 122), 14% for age 16 (N = 107), 14% for age 17 (N = 100), and 1% for age 18 (N = 9).

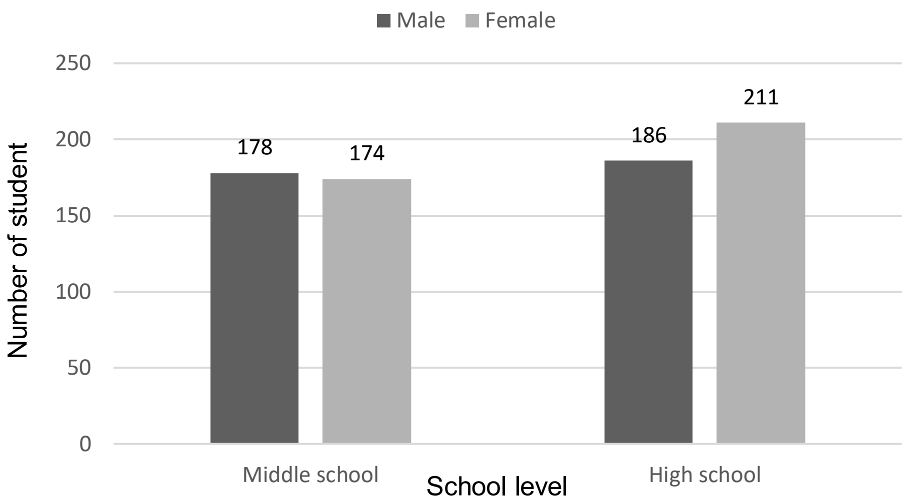


Figure 5. The percentage of female and male students based on school level

As reported in figure 5, the number of male students (N = 178) was nearly the same as the number of female students (N = 174) for the middle school. In addition, the number of male students (N = 186) was lower than the number of female students (N = 211) for the high school.

The percentage values of male and female students in the sample was similar to percentage values of the population of Turkey. As an example, for gender the percentage of male students was 51.7% and the percentage of female students was 48.3% in Turkey (TUİK, 2017). The percentages of male and female students in this study were very close to the gender proportions published by TUİK of the Turkish population.

Instrumentation

A questionnaire called "A survey of some science-related ideas" which was developed by Osborne, Freyberg, & Bell (1985) to asses common students' misconceptions on general science concepts was used in the current study. In Appendix A, the original English version was presented. The validity of questionnaire was determined by Osborne & Gilbert (1980). The questionnaire has two main parts to it. The first part of the instrument included "yes" and "no" questions that measured students' understanding regarding the meaning of words such as "animal," "plant" and "living." The second part of the questionnaire constituted of multiple-choice type questions. These questions were related to concepts of "electric current," "change of state of water," and "weather and climate."

Since, the original language of the questionnaire was English, the researcher used a panel study approach to adapt the questionnaire to the Turkish language. First, the researcher translated the original questionnaire into Turkish. Then, the translated version of the questionnaire was sent to members of a panel. This panel was composed of three English, two mathematics, one biology and one physics pre-service teachers. The panel members translated the Turkish version into English and sent their individual translations to the researcher. The differences between translations of panel members and original questionnaire were determined by the researcher. Later, the researcher met with panel members to discuss the differences between original questionnaire and translations. As a result of this discussion, the panel members reached consensus that resulted in the final version of the Turkish questionnaire; see Appendix B. The panel meeting lasted 3 hours and took place in March 2017 at Bilkent University. The aim of this panel study was to validate a

Turkish version of this questionnaire and to make sure it was appropriate for Turkish students.

Moreover, the Turkish translation of the questionnaire was addressed via a pilot study. The questionnaire was administered to 16 students to check for possible misunderstandings including graphical representation on the questionnaire. A reliability analysis was also conducted by using the Statistical Package for the Social Sciences (SPSS). The Cronbach's alpha value was found as .75 which is a typical value for such questionnaire.

Method of data collection

A proposal that included chapters which listed as the research study, research questions, method of data collection and analysis, and permission from developer of the used questionnaire and list of selected schools to conduct questionnaire was written. Then, this proposal was submitted to MoNE in order to obtain official permission to conduct the research in MoNE schools. After necessary permission from MoNE, the questionnaire was administered in these particular schools in person during the fall term of 2017-18 academic year.

The researcher contacted each school principals in person to confirm the permission awarded by MoNE. In addition, permission was also taken from principle since, principle had the right to not allow administration of the questionnaire despite of permission from MoNE. Furthermore, principle directed the researcher to school counselors or vice principals, since they were generally in charge of research studies in schools. Afterwards, the multiple-choice questionnaire was administered to students.

Method of data analysis

Statistical Package for the Social Sciences (SPSS) 24.0 and MS Excel were used to analyze the data. In this way, typical descriptive statistical analysis was conducted to compute the following statistics; mean, median, mode, range, standard deviation, skewness, kurtosis, and frequency. Then, same descriptive statistical analysis was applied to data based on variables such as gender, school type (private and state schools), grade levels, age and school level (middle and high schools). Furthermore, a one-way ANOVA was used to determine whether difference between mean scores of grades was statistically significant.

In order to gain further insight regarding students' misconceptions, each question in the questionnaire was investigated. In addition, independent samples t-test was conducted to determine whether the difference between gender and school types were statistically significant. Moreover, Pearson correlation coefficient was computed to find out if there were relationships between total score of students and their grades of science, biology, physics, chemistry courses.

This chapter provided information about the research design, context, participants, instrumentation, data collection and analysis. A rational why the research design was used and an argument why it fits the present study was explained. Then, demographic structure of the sample, procedures, and data collection techniques were mentioned as well. In the next chapter, results of analyses were reported.

CHAPTER 4: RESULTS

Introduction

This chapter provided detailed information on the statistical results of the study that was computed through the descriptive analysis. Independent samples t-test, one-way ANOVA, and Pearson correlation were used. The results were reported in three main sections. In the first section, general descriptive analysis of students' total score was reported with respect to variables such as gender, school type (private or state school), grade, age, and school level (middle or high school). In the second section, each item of the questionnaire was analyzed in order to understand students' levels of misconceptions based on percentages of their answers. In the third section, independent samples t-test was conducted to compute possible statistically significant differences between mean scores of variables such as gender and school type. One-way ANOVA was conducted to calculate possible statistically significant differences between mean scores grades. Furthermore, the correlations between total correct answer and grades of science, biology, physics, and chemistry courses were analyzed to reveal whether there was any statistically significant correlation.

The first descriptive analysis of the sample provided an overall picture of Turkish students' misconceptions on general science subjects. These results provided information for the first research question. The descriptive results were listed in terms of the following statistics: mean score, median, standard deviation, skewness, kurtosis, range, minimum, and maximum. In the distribution figures of total score of students, x-axis referred to number of total score and y-axis referred to number of student. In the sub section, the descriptive data analyses were conducted on the following variables: gender, school type, grade, age, and school level. The total scores of all students were examined with respect to gender to find out whether there was a difference between mean scores of male and female students. This analysis was useful for the investigation of second research question. Same descriptive analysis was also conducted to compare results of private and state schools to gather information about the third research question. In addition, descriptive analysis of total score of students with respect to age and grade enabled researcher to observe the trend in students' levels of misconceptions. These results provided explanation for the fourth research question. Furthermore, total scores of all students was analyzed descriptively with respect to two variables which were gender and school level. Thus, the researcher was able to capture overall picture of students' levels of misconceptions changed in terms of variables (gender, school type, grade, age, and school level) by analyzing total score of students.

In the second section, each item of the questionnaire was analyzed respectively to obtain individualized item statistics of students' responses. As described in chapter 2, each distractor refers to a common misconception. The researcher found out which misconceptions were more prevalent among students by computing percentages of responses. Moreover, the change in the students' levels of misconceptions for each item was shown with respect to grade. These figures in the item wise analyses section gave a clue about resistances of misconceptions for each item, since it presented students' levels of misconceptions for each grade. That wat, the researcher stated whether the findings of analyses align with results in the literature.

In the third section, independent samples t-test and one-way ANOVA were applied to total score of students with respect to all variables. Data were analyzed with respect to gender. It provided further information about the second research question and it revealed whether there was a statistically significant difference or not between male and female students' mean scores. Same analysis was repeated for the other four variables to gather detailed information about the third and fourth research questions. Moreover, correlation coefficient was computed to determine if there were statistically significant correlations between total scores of students and grades of science, biology, physics and chemistry courses. This correlation results provided further information regarding the fifth research question.

The descriptive results on achievement scores of students

The first general result was about all students' performance based on their answers to the questionnaire. Table 2 in the below provided information about the first research question which was "what are students' misconceptions on general science subjects?" There were twenty items in the questionnaire and students were awarded one point for each correct answer.

The questionnaire was administered to 749 students and the results of analyses were presented in table 2. Mean score of total scores of all students was found to be 13.92 and median was found to be 14.00. Since, values of mean and median scores were very close to each other, achievement score distribution was symmetric. Likewise, skewness (-.152) and kurtosis (.048) were very close to the zero which suggested that the data was relatively normally distributed. Moreover, the value of the standard deviation (2.372) in the table 2 showed that there was not a wide spread in the distribution of the data. This indicated that scores of majorities of the students were located between 12 and 16.

Table 2
Descriptive statistical result of students' total scores

N	Mean	Median	SD	Skewness	Kurtosis	Range	Min.	Max.
749	13.92	14.00	2.372	-.152	.048	15	5	20

Note. SD: Standard deviation.

As shown in the table 2, range value of the score was 15. Figure 6 showed the distribution of number of student with respect to total correct answers. For instance, 117 students (which corresponds to 15.62% of the sample) answered 14 items in the questionnaire correctly. It should be notated that five students answered all questions correctly. Note that the chance score of the questionnaire is about 7. Two students scored the below the chance score.

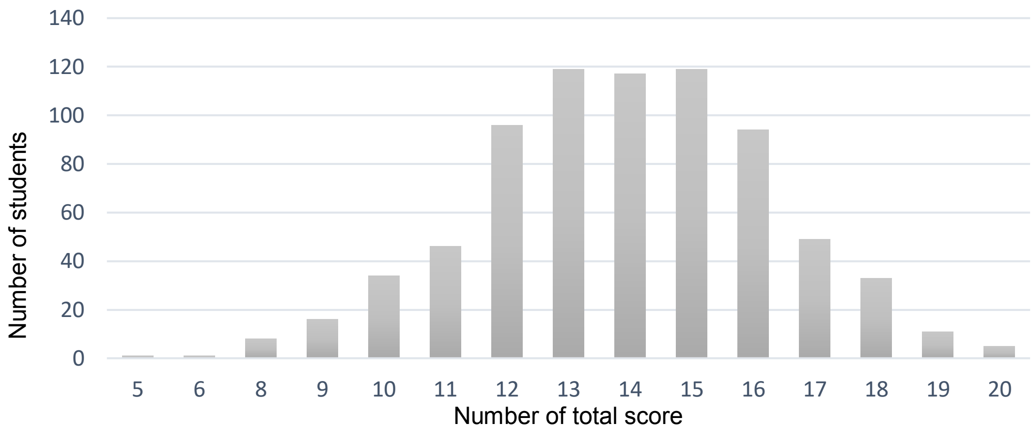


Figure 6. The distribution of students with respect to total score

As shown in figure 6, most of the students were populated between the score values of 13 and 15 which included 47.4% percent of the sample. Because, distribution of student was similar to normal distribution, number of students was increasing towards to mean score 13.92 and was decreasing towards to maximum number of total score.

The second research question was “Are there gender differences in the students’ levels of misconceptions on general science subjects?” Statistical result was shown in table 3 below which provide information on this question.

Table 3
Descriptive statistical result of students’ total scores with respect to gender

Gender	N	Mean	Median	SD	Skewness	Kurtosis	Range	Min.	Max.
Male	364	13.97	14.00	2.450	-.054	-.320	12	8	20
Female	385	13.88	14.00	2.298	-.273	.473	15	5	20

Note. SD: Standard deviation.

There were 364 male students which comprised of 48.60% of the sample and 385 female students which comprised of 51.40% of the sample respectively. As can be seen in the table 3, the ratio of male and female students was nearly equal. Furthermore, mean score of male students was a slightly higher than female students’ mean score. For both genders had the same median score was 14.00. Male students score distribution skewness value was -.054 and the kurtosis value was -.320. Female students’ skewness value was found to be -.273 and the kurtosis value was found to be .473. This indicated that scores were normally distributed. Moreover, female students had greater range value of +3 (*R*=15) than male students (*R*=12). Likewise, total scores of female students showed more spread distribution than male students and female students had standard deviation value of 2.450 and male students had standard deviation value of 2.298. There were both male and female students who answered all items in the questionnaire correctly. But, two lowest total score were from the female students as shown in figure 7.

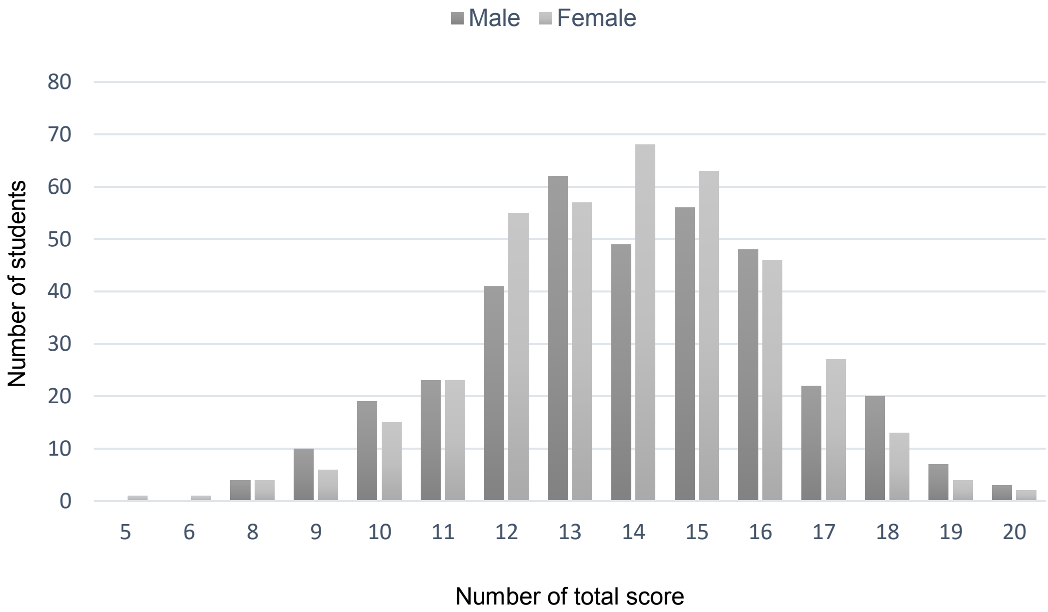


Figure 7. The distribution of total scores of students with respect to gender

As shown in the figure 7, number of male students was greater than female ones in top three highest number of total score. The number of female students were highest for the number of total scores of 14 and 15 (~34.10% of total female students). Correspondingly, the number of male students were highest for scores between 13 and 15 (~32.40% of total male students).

The third research question was "do students' levels of misconceptions on general science subjects change according to school type?" Table 4 below displayed statistical results conducted on this variable.

Table 4
Descriptive statistical result of students' total scores with respect to school type

School type	N	Mean	Median	SD	Skewness	Kurtosis	Range	Min.	Max.
Private school	347	14.20	14.00	2.452	-.052	-.342	12	8	20
State school	402	13.68	14.00	2.276	-.319	.373	15	5	20

Note. SD: Standard deviation.

As reported in the table 4, private school students (*N*=347) comprised 46.33% of the sample and state school students (*N*=402) comprised 53.67% of the sample respectively. Moreover, median score was found to be 14 for the both school types. Private school had very small skewness value (-.052) and kurtosis value (-.342) and state school had also very small skewness value (-.319) and kurtosis value (.373) as in table 4. Thus, data of two groups were normally distributed. Furthermore, standard deviation value of private school (2.452) was greater than standard deviation value of state school (2.276).

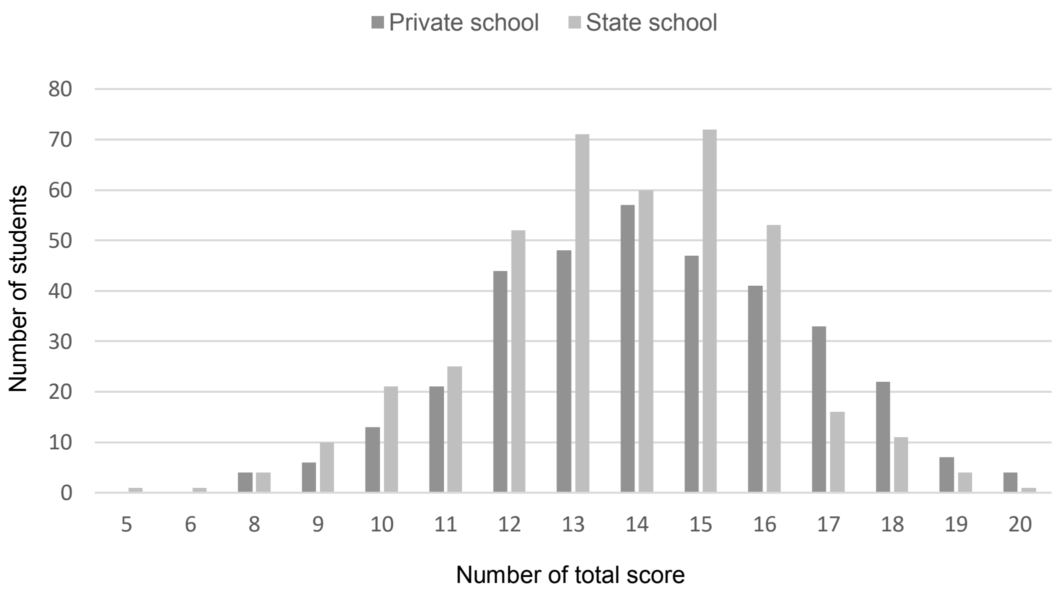


Figure 8. The distribution of total scores of students with respect to school type

As shown in figure 8, private school students (comprise of 19.00% of all private school students) did better than state school students (comprise of 7.90% of all state school students) in top four highest number of total score. In addition, state school students were highest in number of total score 15 (17.90% of all state school students) and 13 (17.70% of all state school students). Respectively, private school students were highest in number of total score 14 (16.40% of all private school students) and 13 (13.80% of all private school students).

The fourth research question was "Do students' levels of misconceptions on general science subjects change from middle to high school aged students?" Table 5 below displayed statistical results conducted on this variable.

As reported in table 5, grade 9 (*N*=121) and grade 10 (*N*=114) had highest participant number. Moreover, mean scores were generally increasing with higher grades. Grade 6 had higher mean score than grade 7 interestingly. There was similar tendency for median scores as in median score. It showed direct proportionality with grade.

Table 5
Descriptive statistical result of students' total scores with respect to grade

Grade	N	Mean	Median	SD	Skewness	Kurtosis	Range	Min.	Max.
5th grade	90	12.08	12.00	2.001	-.290	-.668	8	8	16
6th grade	77	13.25	13.00	1.879	-.148	-.373	8	9	17
7th grade	93	12.60	13.00	1.940	-.322	.490	11	6	17
8th grade	92	13.86	14.00	2.094	-.153	-.579	9	9	18

Table 5 (cont'd)
Descriptive statistical result of students' total scores with respect to grade

9th grade	121	14.60	15.00	2.120	-.441	.705	11	8	19
10th grade	114	14.82	15.00	2.207	-.382	.458	12	8	20
11th grade	97	14.95	15.00	2.219	-.097	-.467	10	10	20
12th grade	65	14.88	15.00	2.690	-.615	1.677	15	5	20

Note. SD: Standard deviation.

In addition, standard deviation value of the grade 12 was the highest, so there was higher spread in distribution. Furthermore, data of all grade group were symmetrical distributed except for grade 12 which had a kurtosis value of 1.677. For the grade 5, maximum score was 16 and the range value was 8. Grade 5 also had lowest mean score among all grades. For the grade 11, minimum score was 10 and range value was 10. Likewise, mean score of this grade (14.95) was also highest among all grade groups.

In the figure 9 below, the percentage of students within the same grade was reported. All grades from 5 to 12 were printed out black and white (grey). In addition, distribution of percentage of students showed generally normal distribution for all the grade groups. As shown in the figure 9, distribution of grade 5 began in number of total score 5, but distribution of grade 11 began in number of total score 10. Furthermore, distribution of middle school grades was centered in lower number of total score than high school grades. For instance, grade 6 was centered in number of total score 13, while grade 12 was centered in number of total score 15.

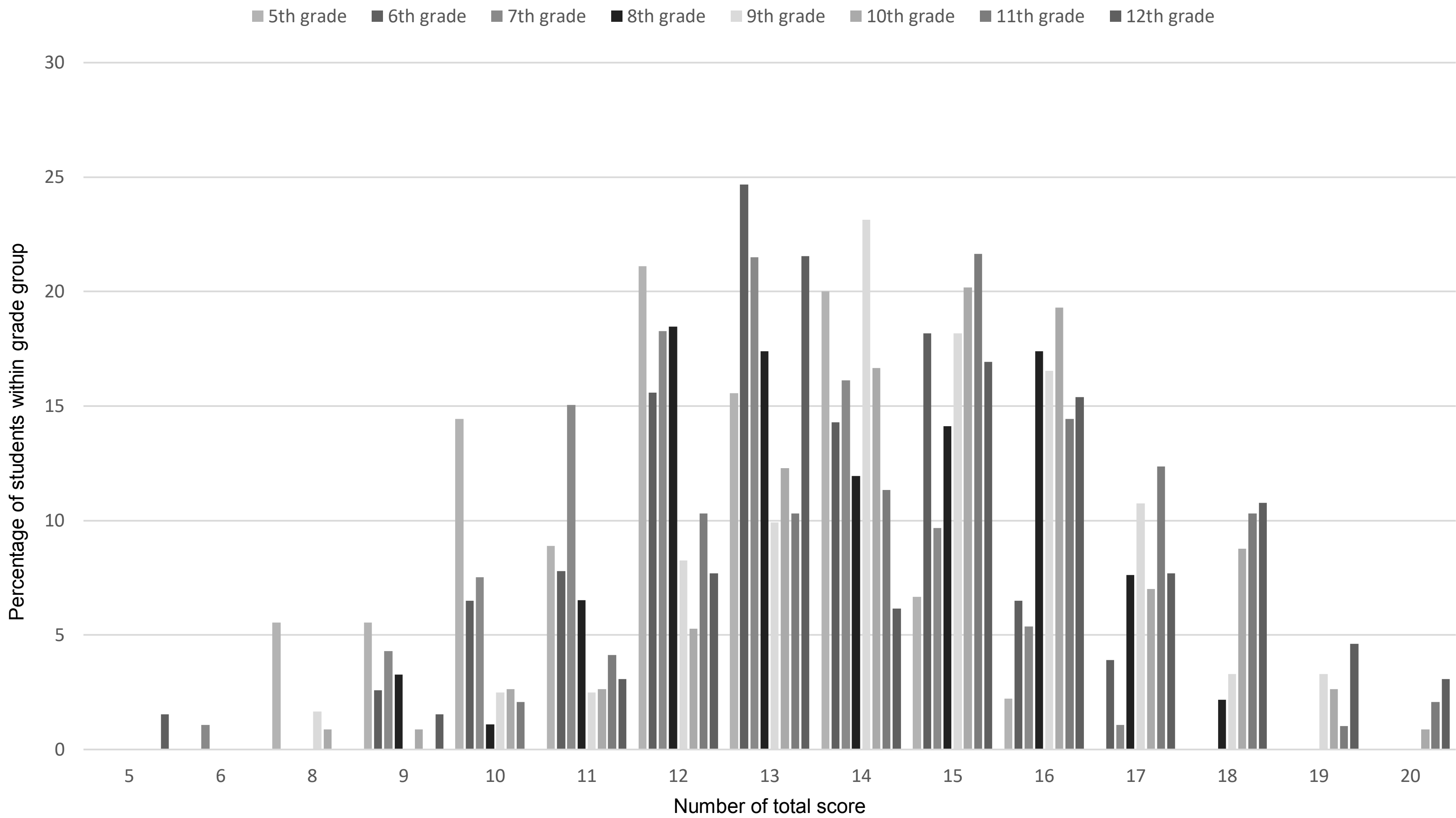


Figure 9. The distribution of total scores of students with respect to grade

Table 6 also provided further information about fourth research question. The result to the grade variable but, provided additional information regarding change from middle to high school aged students.

Table 6
Descriptive statistical result of students' total scores with respect to age

Age	N	Mean	Median	SD	Skewness	Kurtosis	Range	Min.	Max.
9	5	12.60	13.00	1.140	-.405	-.178	3	11	14
10	76	12.14	12.00	2.146	-.193	-.558	9	8	17
11	69	12.93	13.00	1.865	-.116	-.464	8	9	17
12	72	12.85	13.00	2.005	-.583	.628	10	6	16
13	105	13.53	13.00	2.126	-.004	-.583	9	9	18
14	84	14.17	14.00	2.302	-.318	.390	11	8	19
15	122	14.74	15.00	2.036	-.503	.442	11	8	19
16	107	14.88	15.00	2.273	-.073	-.283	10	10	20
17	100	14.99	15.00	2.346	-.002	-.431	11	9	20
18	9	13.78	15.00	3.833	-1.596	3.370	13	5	18

Note. SD: Standard deviation.

In the table 6, mean score values generally increased with respect to age. But, highest mean score was observed for age 17 rather than age 18. Lowest mean score value was observed for age 10 rather than age 9. Moreover, age 18 had standard deviation value of 3.883 which means it had wide distribution along the number of total score. As shown in table 6, some students in age 16 and 17 answered all question correctly. But, students in age 18 had maximum number of total score 18. Furthermore, age 15 had greatest number of participant and also one of the highest mean scores. Standard deviation score of age 15 was lowest among first five highest mean scores which showed larger portion of age 15 students were around number of total score 15.

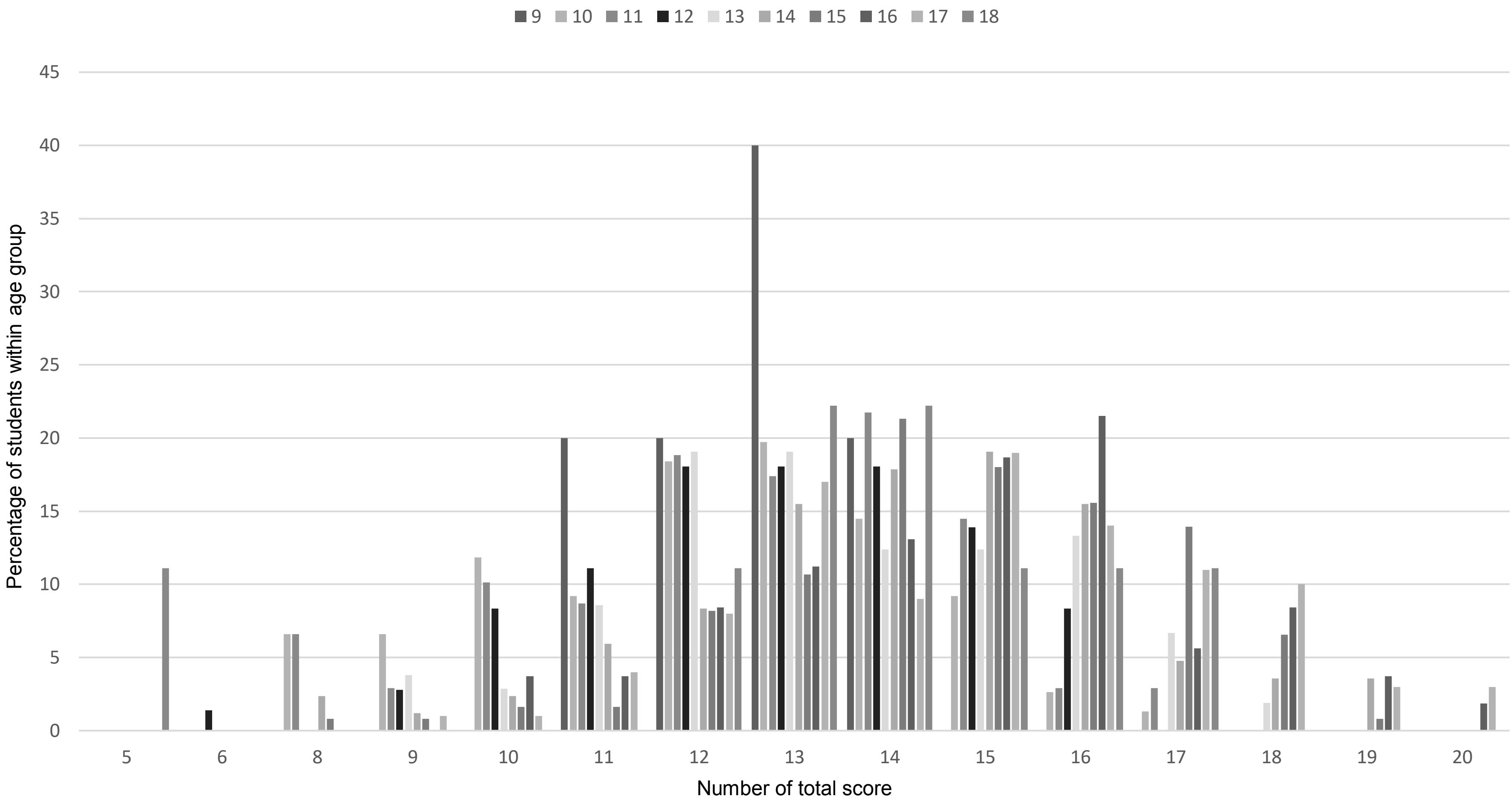


Figure 10. The distribution of total scores of students with respect to age

In figure 10 above, percentage of students with respect to age was spreader than percentage of students with respect to grade, since it had broader x-axis. In addition, there was a peak in age 9 for score value 13. But, it stemmed from lower number of participant (*N*=5). Similar result with figure 9 can also be seen in figure 10. Middle school aged students were located in lower bound of x-axis, while high school aged students were located in upper bound of x-axis.

Table 7
Descriptive statistical result of students' total scores with respect to school level and gender

	School level					
	H		M		Total	
	Male	Female	Male	Female	Male	Female
N	186	211	178	174	364	385
Mean	15.01	14.61	12.88	12.99	13.97	13.88
Median	15.00	15.00	13.00	13.00	14.00	14.00
Std. Deviation	2.307	2.217	2.105	2.078	2.450	2.298
Skewness	-.249	-.536	-.137	-.188	-.054	-.273
Kurtosis	-.085	1.509	-.448	.143	-.320	.473
Range	12	15	10	12	12	15
Minimum	8	5	8	6	8	5
Maximum	20	20	18	18	20	20

Note. H: High school, M: Middle school.

In the table 7, participants were allocated four groups according to their gender and their school level (middle and high school). High school students achieved higher scores in general than middle school students as expected. Moreover, male students (mean score was 15.01) achieved higher scores than female students (mean score was 14.61) in high school. The opposite situation can be seen in middle school, female students (mean score was 12.99) were slightly more successful than male students (mean score was 12.88). Furthermore, the highest score that middle school students achieved was 18 in the questionnaire. Additionally, there were both male and female students who achieved this score.

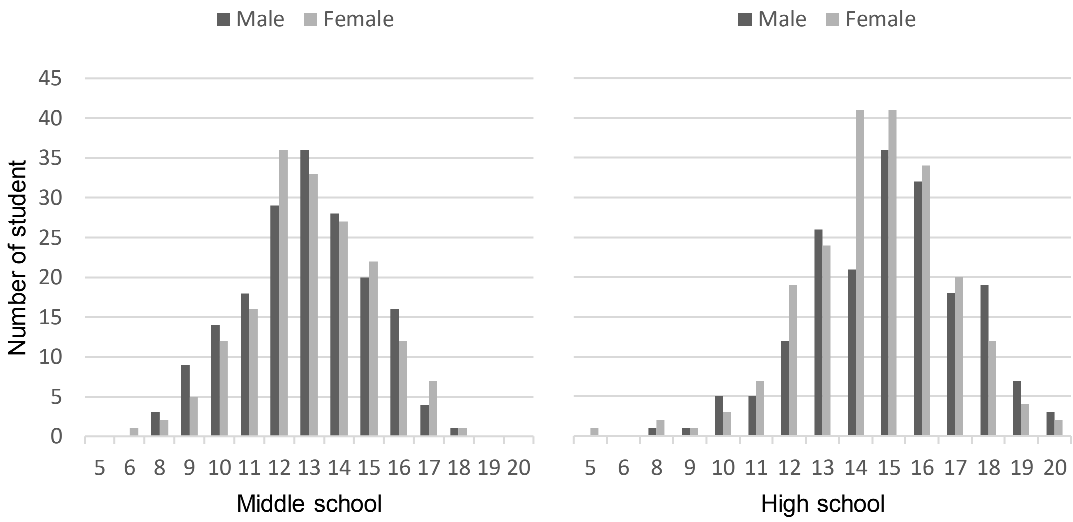


Figure 11. The distribution of students' total scores with respect to school level and gender

As reported in figure 11, number of male and female students were very close to each other for each score in the middle school. Furthermore, number of male students was highest in score of 13 and number of female students was highest in score of 12 respectively. For the high school, there are some significant difference between male and female students as shown in some bars in figure 11. For example, number of female students were greater than male students around mean score. But, number of male students were more than female students in the upper part of the figure 11.

The results of misconception analysis item wise

In this section, students' responses for each question was analyzed individually. The first ten questions were the "yes", "no" questions and the other 9 questions were "multiple choice" type and the last question was an "open-ended" type question. For the first ten items, figures were reported as percentage of positive response of students with respect to their grade. In addition, questions were labeled at the top of each figures and sample size for grades were represented at the below of x label. Moreover, line chart was used to show the tendency of percentage of correct response through the grade.

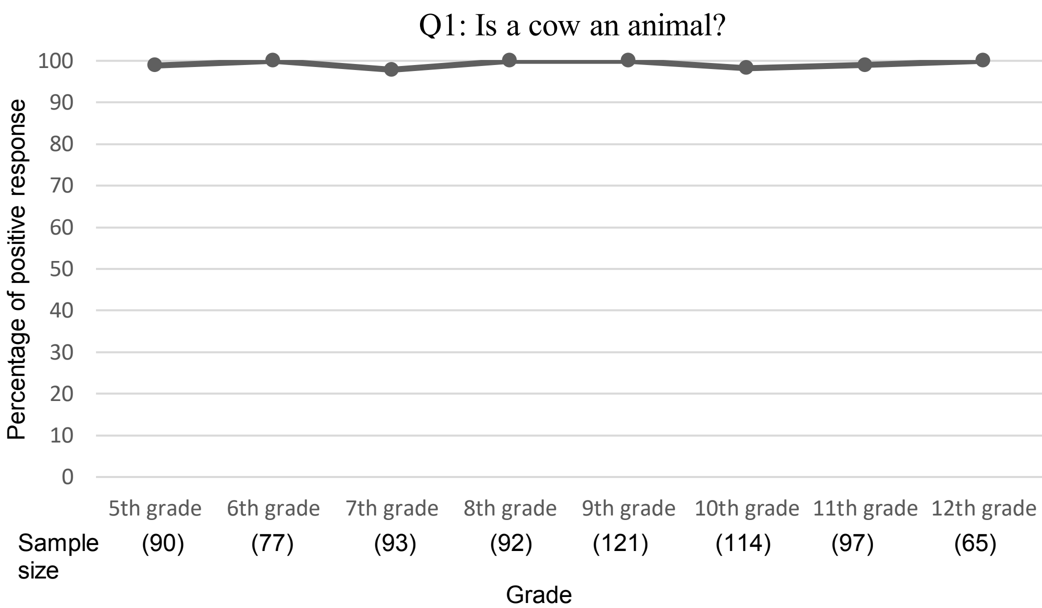


Figure 12. The distribution of percentage of correct response with respect to grade for the question 1

As shown in the figure 12, percentage of correct response was about 100% for each grade. There was slightly change through grades, but it was negligible. Lowest percentage was found in grade 7 with 97.8%.

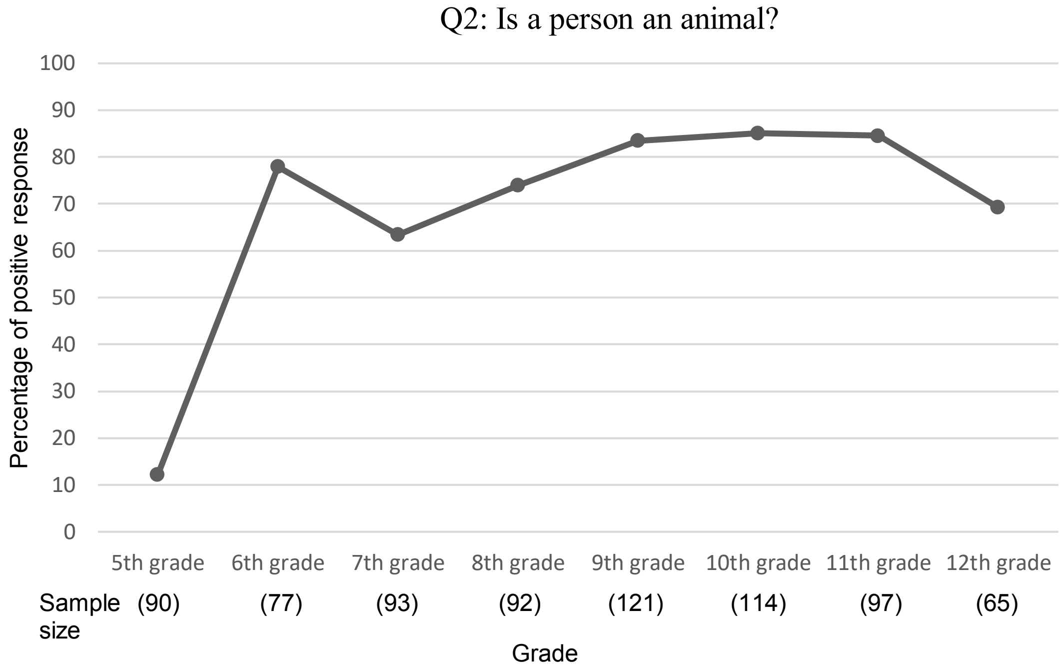


Figure 13. The distribution of percentage of correct response with respect to grade for question the 2

In the second question, there was a positive tendency with grade level. As reported in figure 13, only 12.2% of grade 5 students answered this question correctly. Moreover, second lowest percentage of correct response was found in grade 7 with 63.4%. In addition, grade 10 and 11 achieved highest percentage of correct response for this question with 85%. Furthermore, percentage of correct response dropped in grade 12 interestingly, after increasing tendency begin in grade 7.

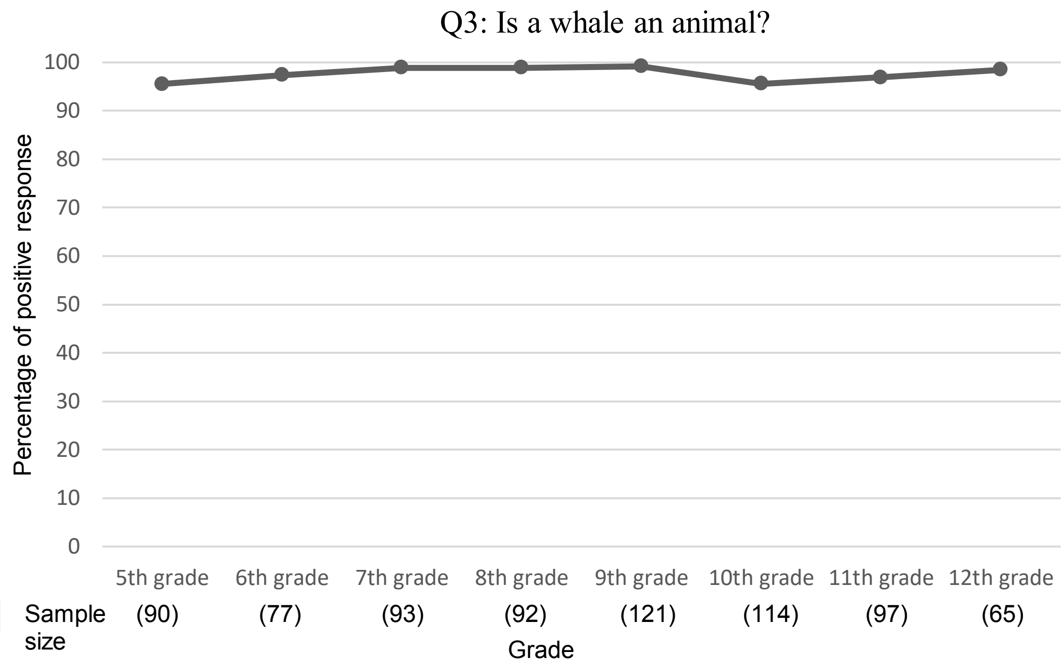


Figure 14. The distribution of percentage of correct response with respect to grade for the question 3

In the third question, similar result was obtained as in figure 12. Almost all the students answered it correctly. Lowest percentages of correct response were found in both grade 5 and 10 with 95.6% as reported in figure 14.

For the fourth question, the results revealed fluctuation of the mean scores when compared by grade. Moreover, lowest percentage of correct response was obtained in grade 8 with 78.3%. In addition, highest percentage of correct response was found in grade 12 with 96.9%.

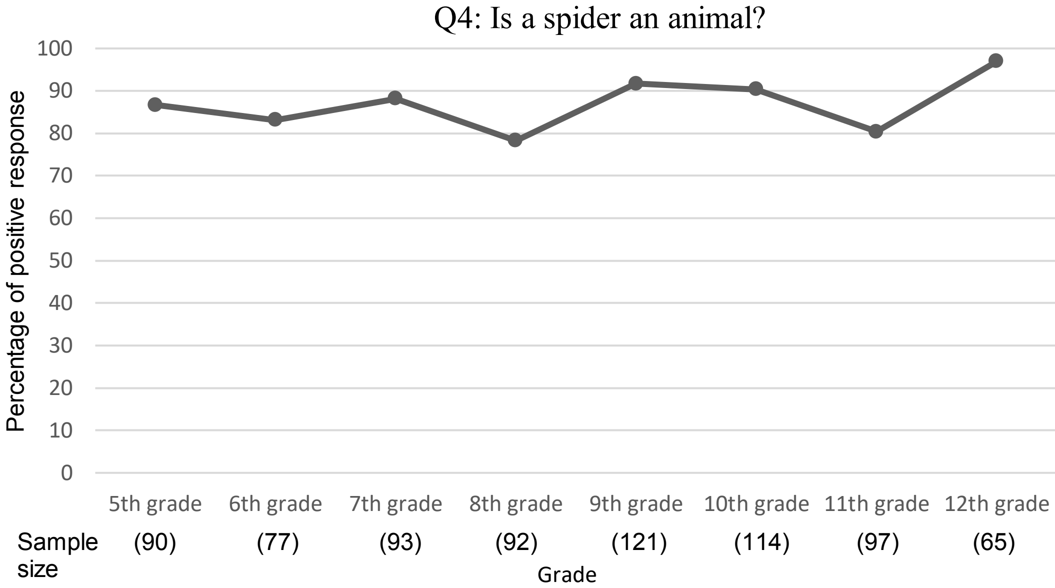


Figure 15. The distribution of percentage of correct response with respect to grade for the question 4

For the fifth question, percentages of correct response changed between 80% and 94% as shown in figure 16.

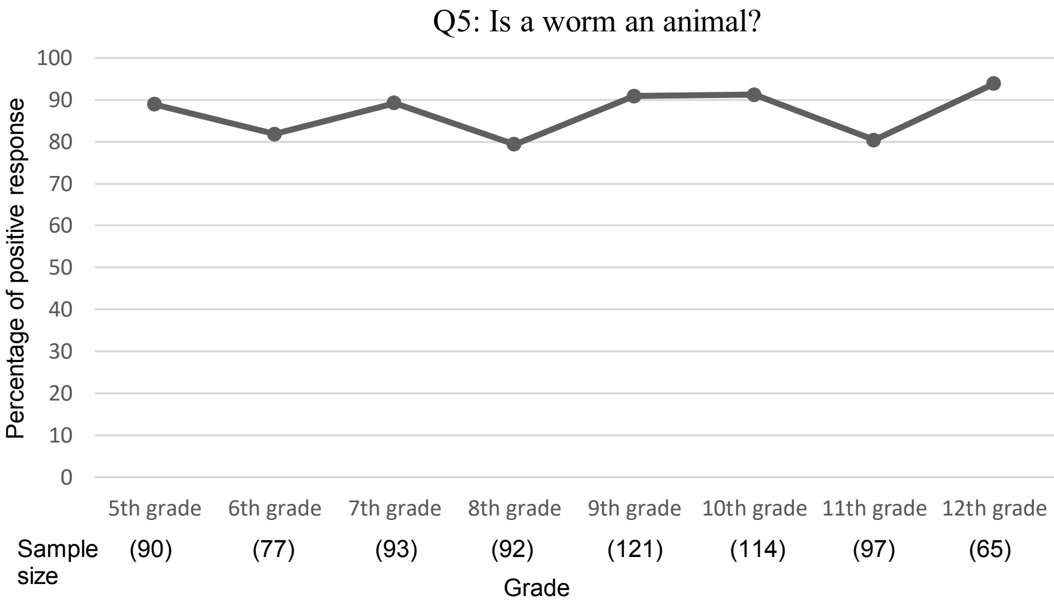


Figure 16. The distribution of percentage of correct response with respect to grade for the question 5

The distribution of obtained result revealed fluctuation too as figure 15. Again, highest percentage of correct response was found in grade 12 with 93.8%.

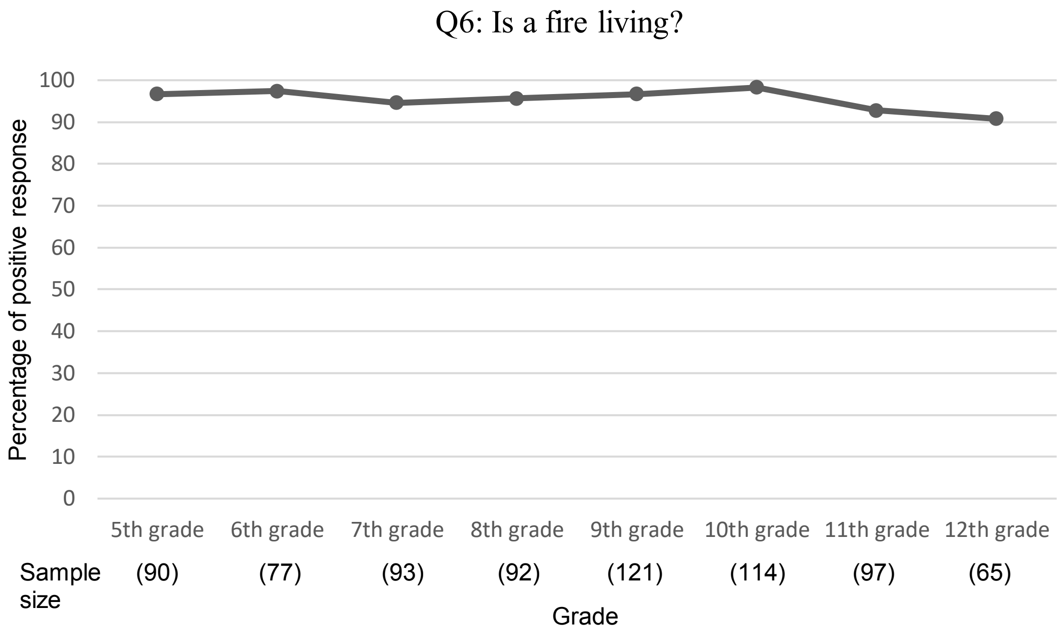


Figure 17. The distribution of percentage of correct response with respect to grade for the question 6

For the sixth question, most of the students answered it correctly. But, lowest two percentages of correct response were obtained for grades 11 and 12 interestingly as shown in figure 17. Percentage of correct response for the grade 11 was 92.8% and for the grade 12 was 90.8%.

For the seventh question, very high percentage of correct response was observed in all the grade levels as reported in figure 18. All the students in grades 5, 6, 7, 9 and 11 answered every question correctly.

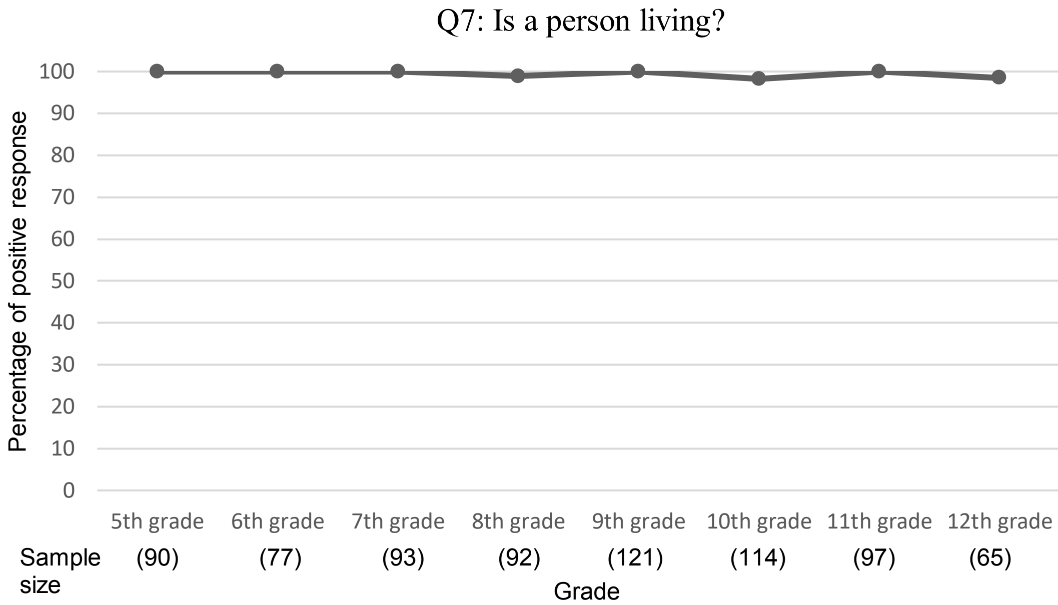


Figure 18. The distribution of percentage of correct response with respect to grade for the question 7

For the eighth question, tendency of percentage of correct response was increasing up to grade 9.

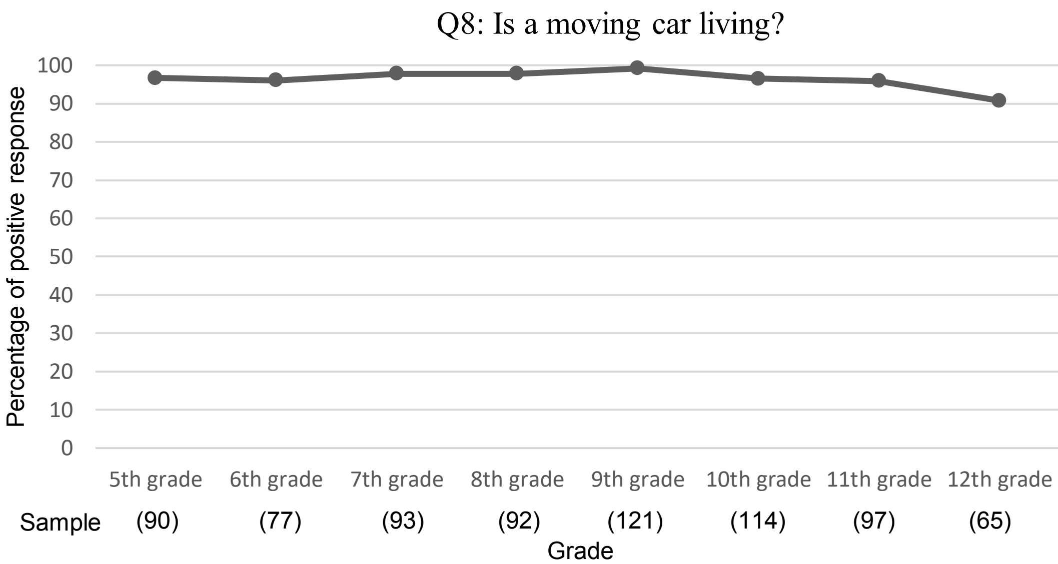


Figure 19. The distribution of percentage of correct response with respect to grade for the question 8

After grade 9, tendency of percentage of correct response was decreasing up to grade 12 as reported in figure 19. Moreover, percentages of each grade were changing between 90% and 100%. The lowest percentage of correct response was achieved in grade 12 with 90.8%.

For the ninth question, tendency of percentage of correct response was generally increasing with grade level as in figure 20. Furthermore, there was a rapid increment from grade 5 to grade 6. The lowest percentage or correct response was found in grade 5 with 61.1%.

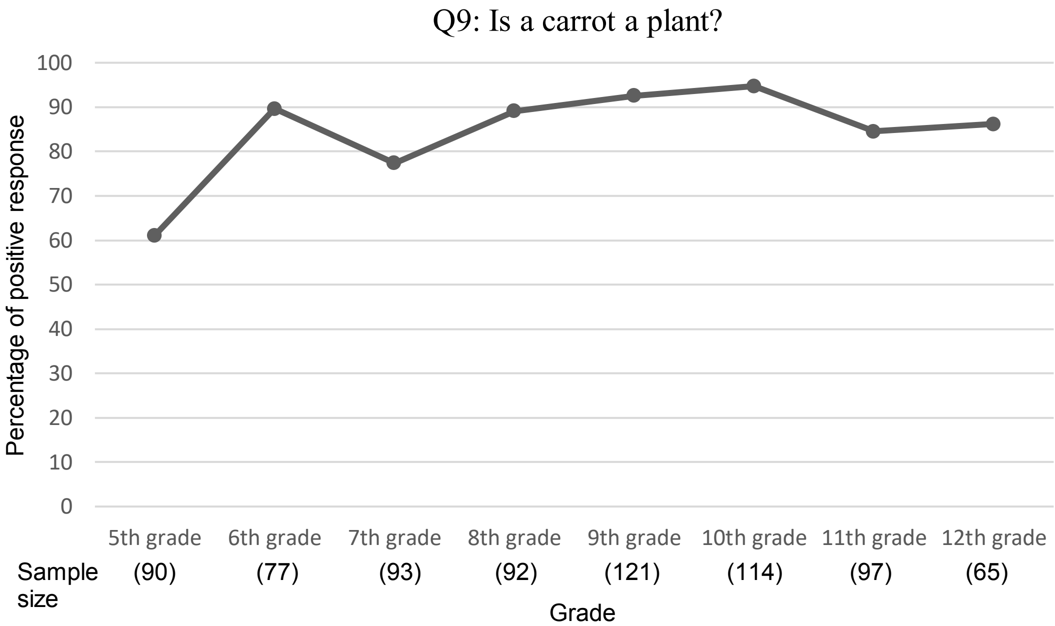


Figure 20. The distribution of percentage of correct response with respect to grade for the question 9

For the tenth question, generally increasing tendency for percentage of correct response was observed as in figure 21. Moreover, all of the students in grade 11 and 12 answered this question correctly. Lowest percentage of correct response was found grade 5 with 93.3%.

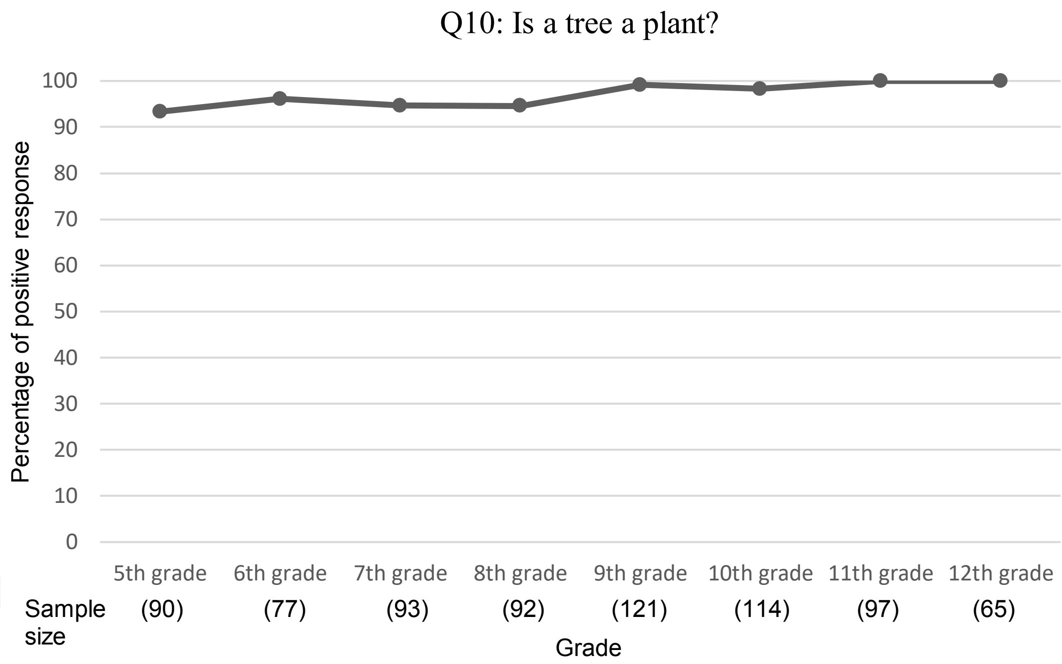
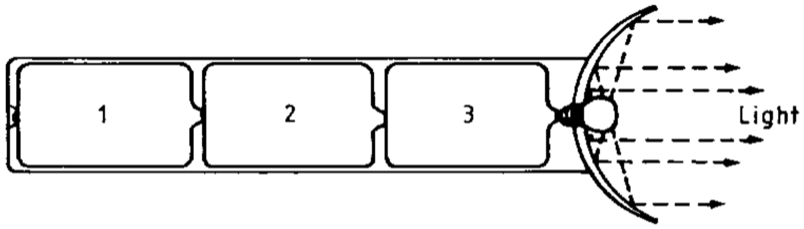


Figure 21. The distribution of percentage of correct response with respect to grade for the question 10

The last ten items comprised of nine multiple-choice type of questions and an open-ended question. Multiple choice questions contained at least three and at most five distractors. The questions 14 and 16 had three distractors, the questions 12, 13, 17, 18 and 19 had four distractors, the questions 11 and 20 had five distractors. In addition, percentages of each distractors were represented with different dashed lines and color tones in figures.

For the eleventh question, there were five options where the respective question was represented in figure 22.

A torch has three batteries in it, as shown in the diagram.



The torch is switched on and the lamp is glowing. Five students all have different ideas about the electric current through the batteries. Which one of the following ideas do you think is the best idea?

Figure 22. The question 11 in the questionnaire (Osborne, Freyberg, & Bell, 1985, p.173)

As can be seen in figure 23, percentage of the correct response was increasing through higher grades, while other responses were decreasing. Furthermore, the third distractor “no. 3 will have the most current” was selected most among all the distractors. The percentage of correct answer was 48.4% and highest selected distractor was 35.5% for the grade 7 which were close to each other.

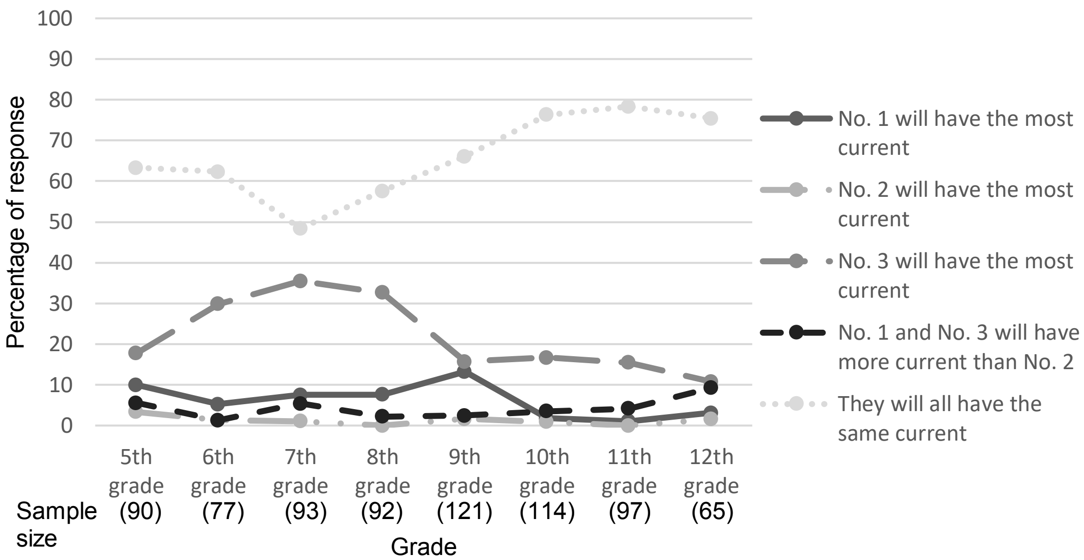


Figure 23. The distribution of percentages of responses with respect to grade for the question 11

For the twelfth question, there were four options where the respective question was represented in figure 24.

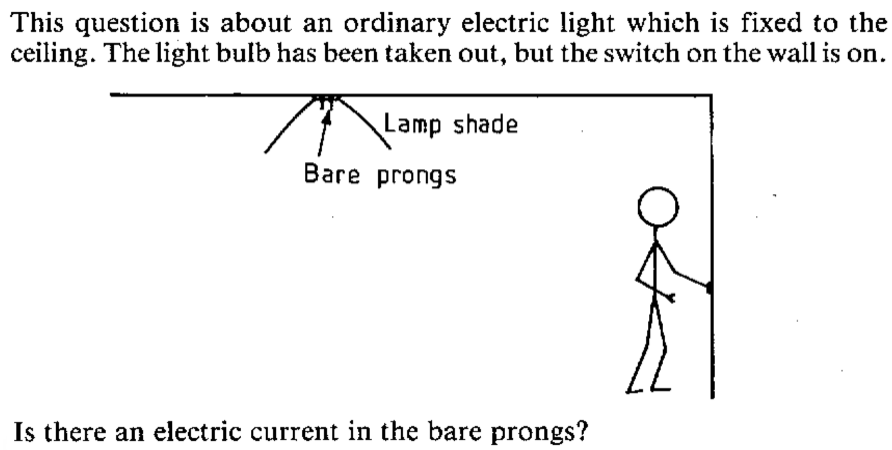


Figure 24. The question 12 in the questionnaire (Osborne, Freyberg, & Bell, 1985, p.173)

As reported in figure 25, percentages of all the options were close to each other. Moreover, percentage of correct response was very low and it was less than one of the distractor which was “yes, because if you put a bulb there it will glow” for the all grades.

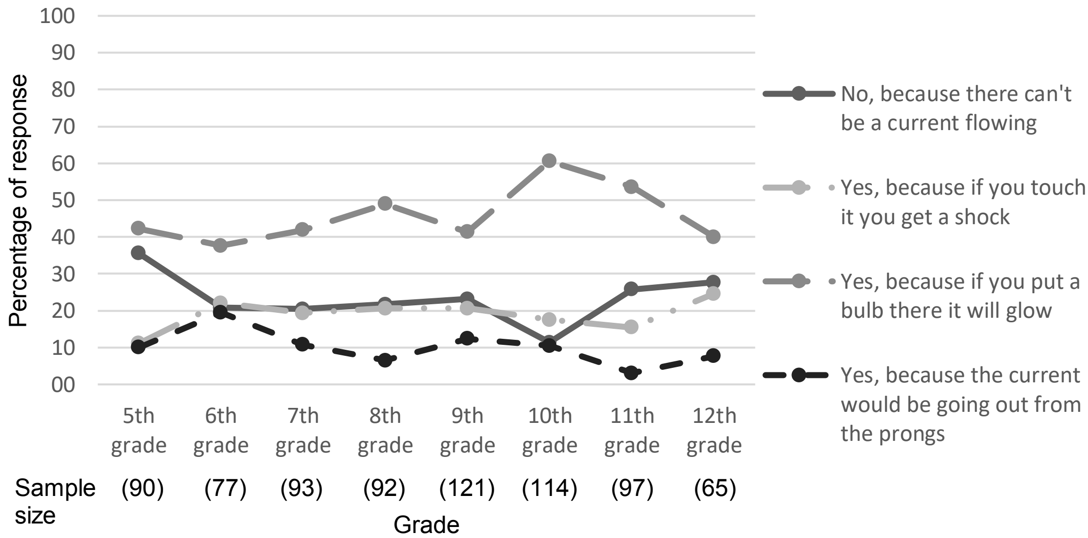


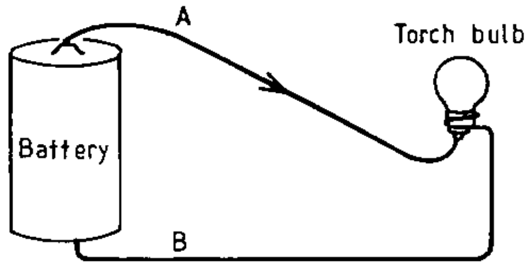
Figure 25. The distribution of percentages of responses with respect to grade for the question 12

The highest percentage of the correct response was found in grade 12 with 27.7%. But, the highly selected distractor achieved 60.5% for grade 10 as reported in figure 25.

For the thirteenth question, there were four options where the respective question was reported in figure 26.

The following information is for questions 13 and 14.

A battery is connected to a torch bulb as shown.



The bulb is glowing and the electric current in the wire marked A is shown by the arrow pointing from the battery to the bulb.

Which of the following is the best sentence about electric current *in wire B*?

Figure 26. The question 13 in the questionnaire (Osborne, Freyberg, & Bell, 1985, p.174)

As reported in figure 27, correct answer which was “there is same electric current in wire B as in wire A” had highest percentage among all the options. Its maximum percentage was found in grade 10 and 11 with 64.9% and its minimum percentage was reported in grade 7 with 39.8%. Furthermore, the highest selected distractor was “there is some electric current in wire B but less than in wire A.” The increasing tendency of this distractor was also observed with grade levels.

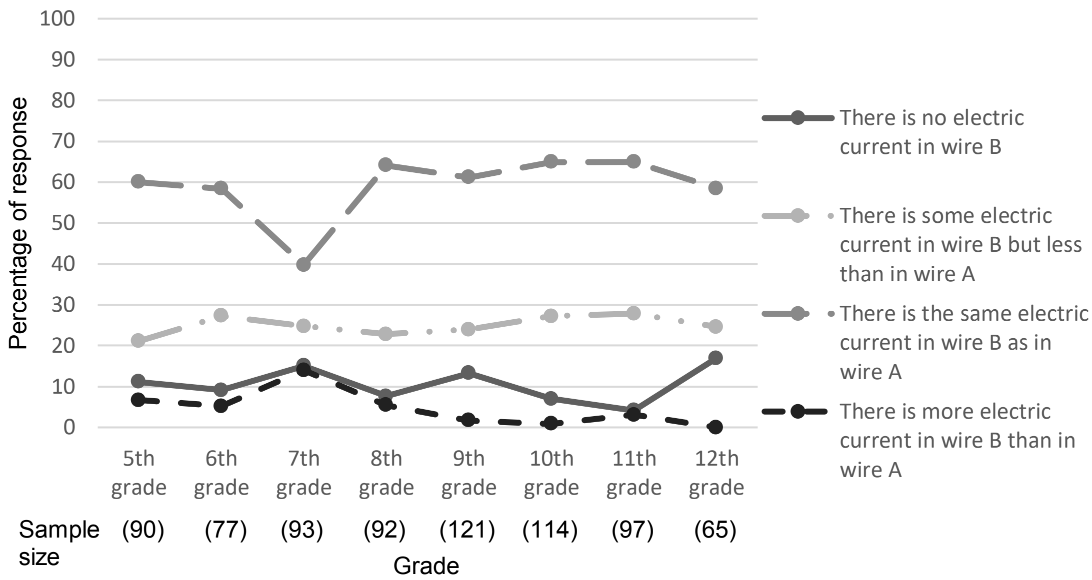


Figure 27. The distribution of percentages of responses with respect to grade for the question 13

For the fourteenth question, the figure 26 was used again. The question was "which of the following is the best sentence about the direction of electric current in wire B" and it had three options.

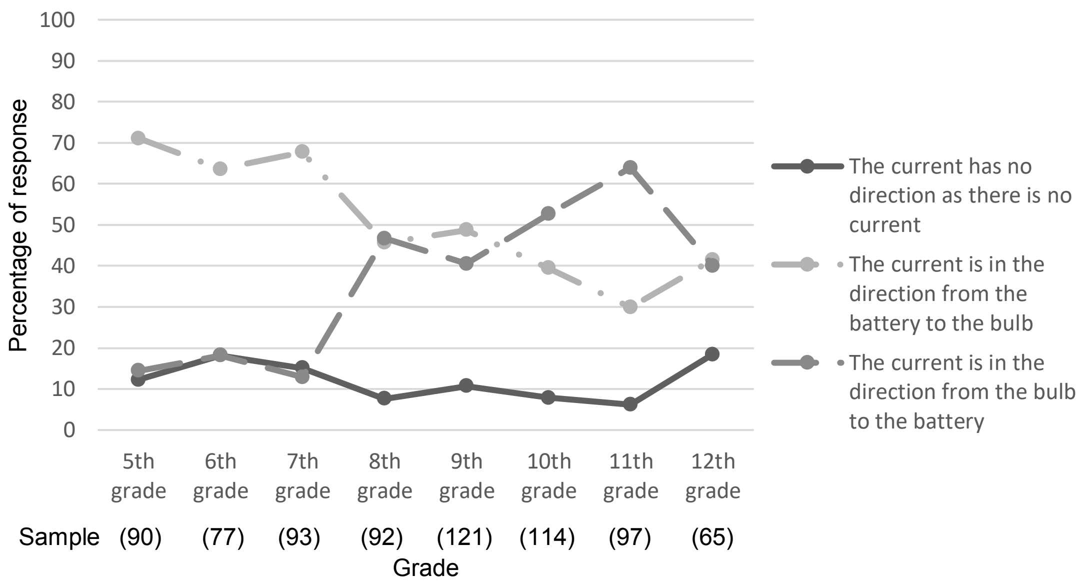
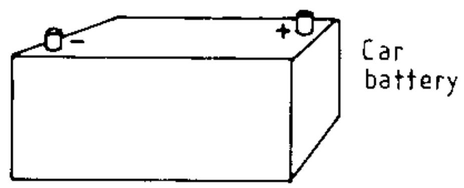


Figure 28. The distribution of percentages of responses with respect to grade for the question 14

The correct response for question 14 was “the current is in the direction from the bulb to the battery.” The percentage of correct response was generally showed increasing tendency but, it dropped in the grade 12. In addition, it achieved highest percentage in grade 11 with 63.9%. Furthermore, the percentage of the distractor (the current is in the direction from the battery to the bulb) was highest in grade 5 with 71.1% but, it decreased through the grade levels. Moreover, there were some students who thought “the current has no direction as there is no current.”

For the fifteenth question, it was an open-ended question as in figure 29 and students were asked to justify their answers. Thus, this question was analyzed by two dimensions. The first step was to evaluate students’ “yes” or “no” response and the second step was to review their responses whether it was “rational” or “irrational.”

A car battery has been fully charged but has not yet been placed in the car. It is sitting on the bench in the garage and is not connected up to anything.



Is there an electric current in the battery?

Figure 29. The question 15 in the questionnaire (Osborne, Freyberg, & Bell, 1985, p.174)

As reported in figure 30, percentages of students who were saying “there is electric current in the battery” and “there is electric current in the battery” were close to each other. The correct response for this question was the second one and percentage of this response indicated fluctuation through the grade levels. For some grade levels, the correct response was stated less than wrong response. For instance, students stated wrong response with 50.5% and correct response with 37.6% in grade 7. Nevertheless, the correct response was more preferred than wrong one in grades 5, 8, 9, 11 and 12.

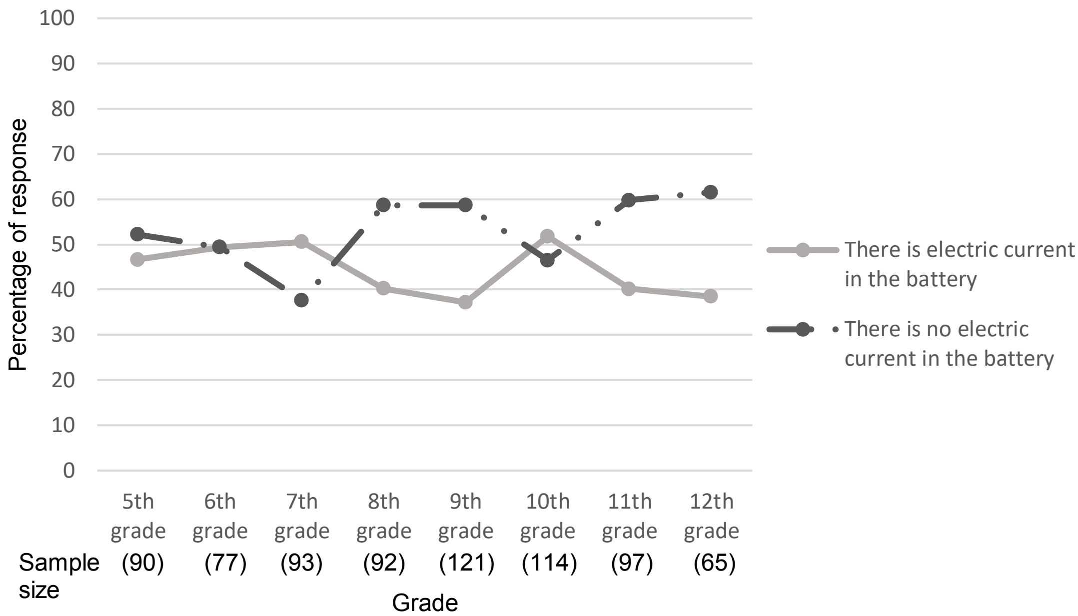


Figure 30. The distribution of percentages of responses with respect to grade for the question 15

The rationality result of the question 15 was reported in figure 31. It founded out that the percentage of rational response was only greater than the percentage of irrational response for grades 9 and 11. In addition, percentage of rational response in figure 31 was always less than percentage of correct response in figure 30. This revealed that there were some students who answered question 15 correctly but justify their response with an irrational statement. For example, 61.5% of grade 12 students answered question correctly, but only 43.1% of grade 12 students stated rational response.

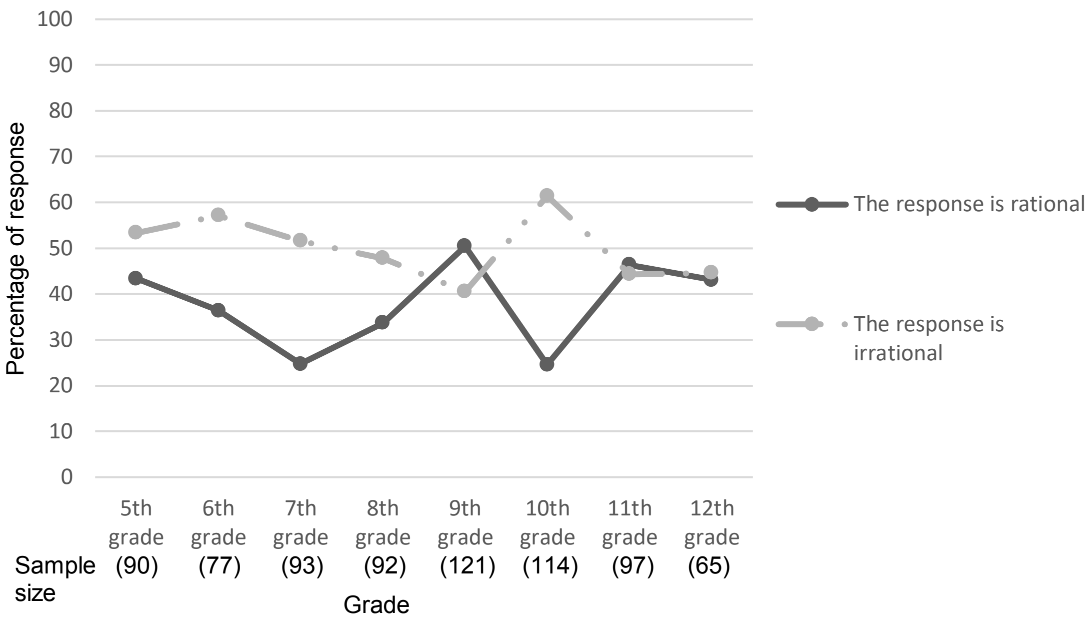


Figure 31. The distribution of percentages of rationality of responses with respect to grade for the question 15

Furthermore, the highest percentage of rational response was found in grade 9 with 50.4% and the lowest percentage of rational response was revealed in grade 10 with 24.6%.

For the sixteenth question, it was the three-item multiple choice question as seen in figure 32.

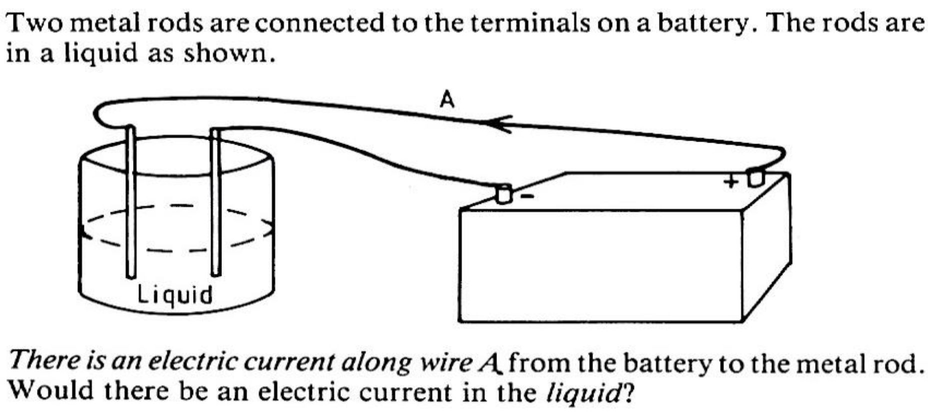


Figure 32. The question 16 in the questionnaire (Osborne, Freyberg, & Bell, 1985, p.175)

The correct response for this question was “it depends on what the liquid is”. As can be seen in figure 33, the percentage of correct response was increasing with grade levels and its maximum value was in grade 11 with 80.4%. Moreover, the percentages of distractors were decreasing with grade levels. In addition, the percentage of distractor “there would not be a current in the liquid” was nearly 0% for grade 7, 10 and 11.

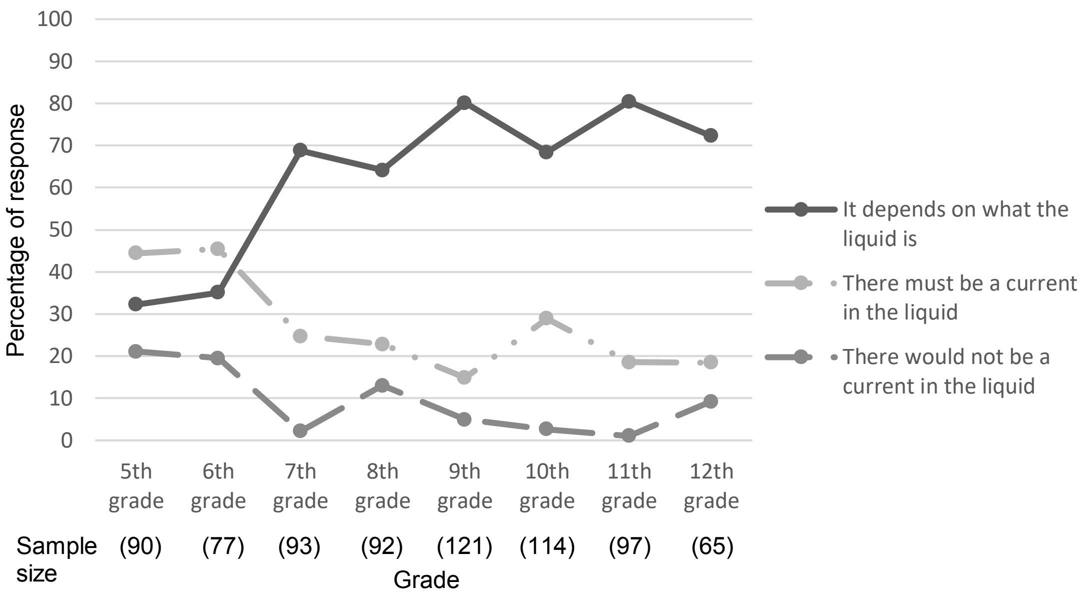


Figure 33. The distribution of percentages of responses with respect to grade for the question 16

For the seventeenth question, there were four options where the respective question was represented in figure 34.

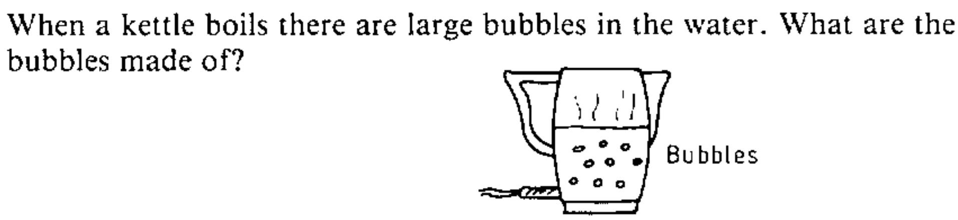


Figure 34. The question 17 in the questionnaire (Osborne, Freyberg, & Bell, 1985, p.175)

The correct response for this question was “steam” and its percentage was mostly increasing with grade levels. The 64.6% of grade 12 students answered question correctly. Furthermore, the percentages of all the distractors were below 40% and generally decreasing with grade levels.

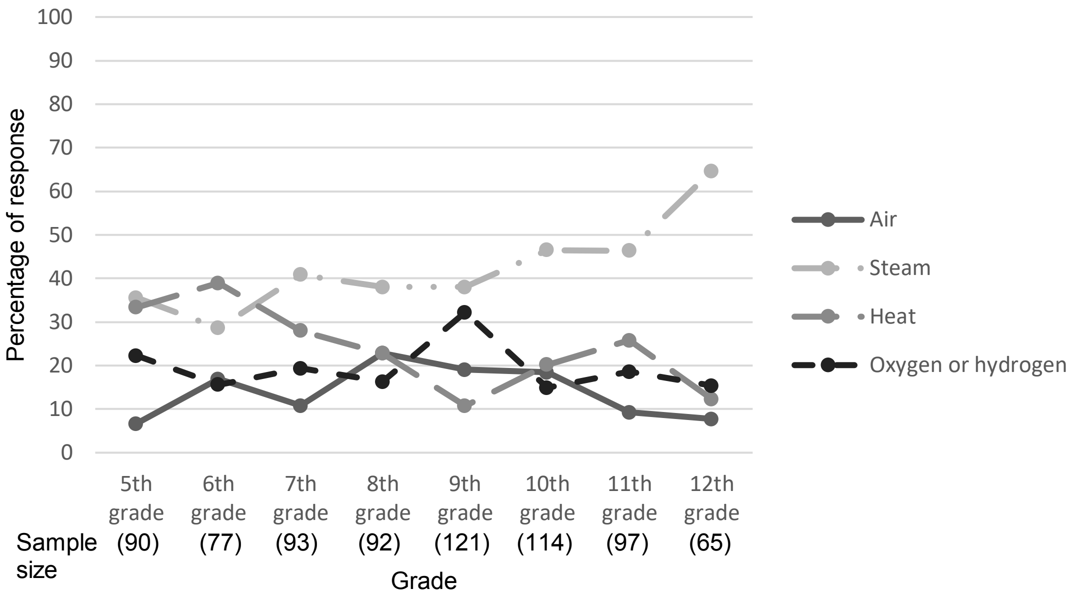


Figure 35. The distribution of percentages of responses with respect to grade for the question 17

For the eighteenth question, there were four options where the respective question was represented in figure 36.

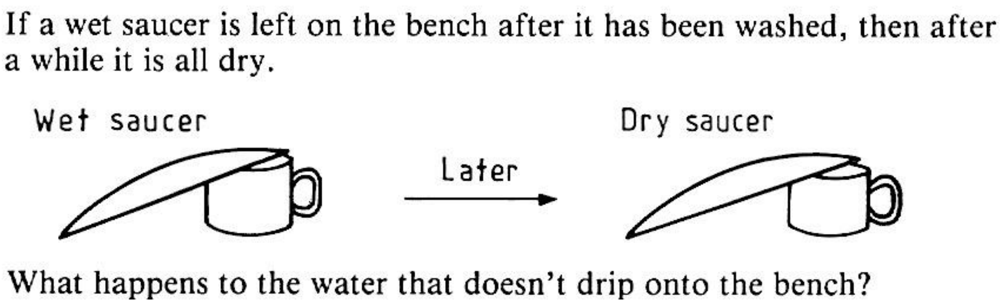


Figure 36. The question 18 in the questionnaire (Osborne, Freyberg, & Bell, 1985, p.175)

Two options were highly selected by students. The correct response for this question was the "it goes into the air as very small bits of water." Its highest percentage was found in grade 9 with 54.5%. Moreover, the distractor "it changes into oxygen and hydrogen in the air" was selected more than correct answer in grade 5, 6, 7 and 9. It highly selected by grade 5 and 9 students with 52.2% and 54.5% respectively.

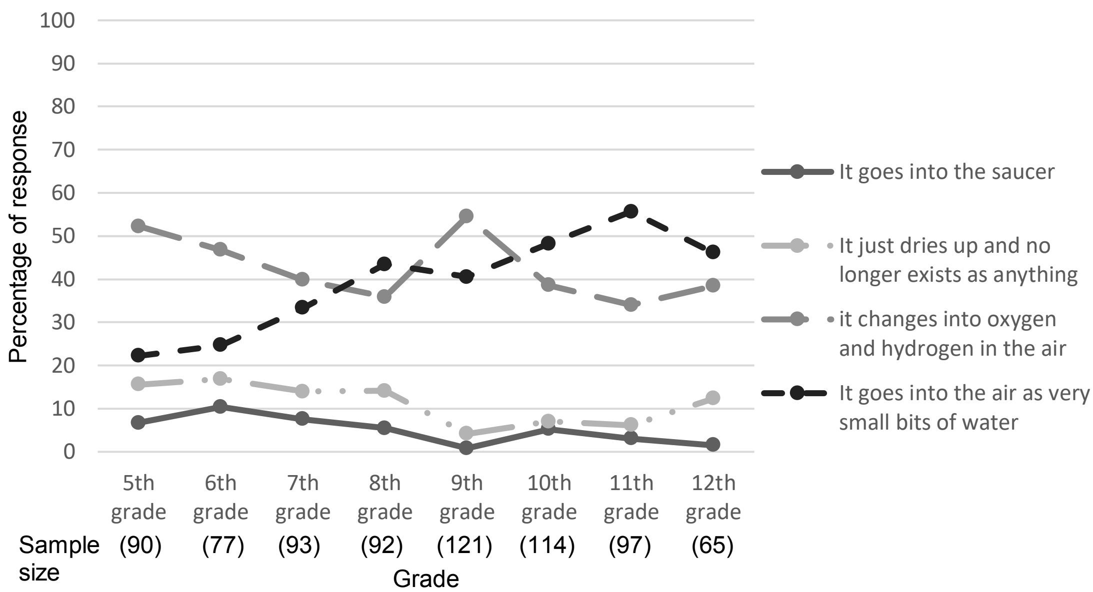


Figure 37. The distribution of percentages of responses with respect to grade for the question 18

For the nineteenth question, there were four options where the respective question was represented in figure 38.

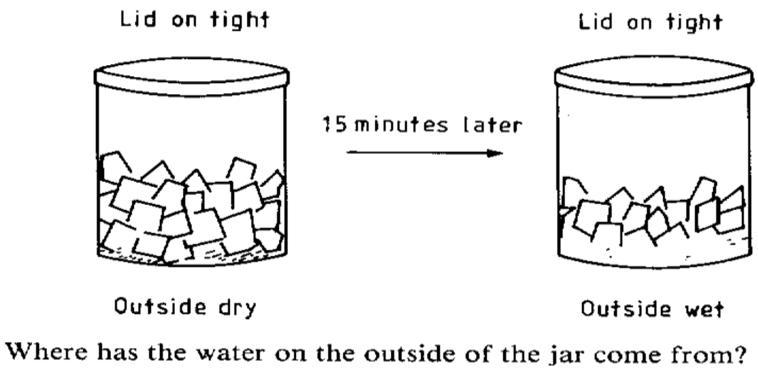


Figure 38. The question 19 in the questionnaire (Osborne, Freyberg, & Bell, 1985, p.176)

The correct answer for this question was "the water in the air sticks to the cold glass" but, it was selected by students in a low percentage. The highest percentage in correct answer was achieved in grade 6 with 35.1%. Furthermore, the distractor "the coldness causes oxygen and hydrogen in the air to form water" had very high percentages for all the grade. Besides, the percentage of this distractor generally indicated positive tendency with grade levels as can be seen in figure 39.

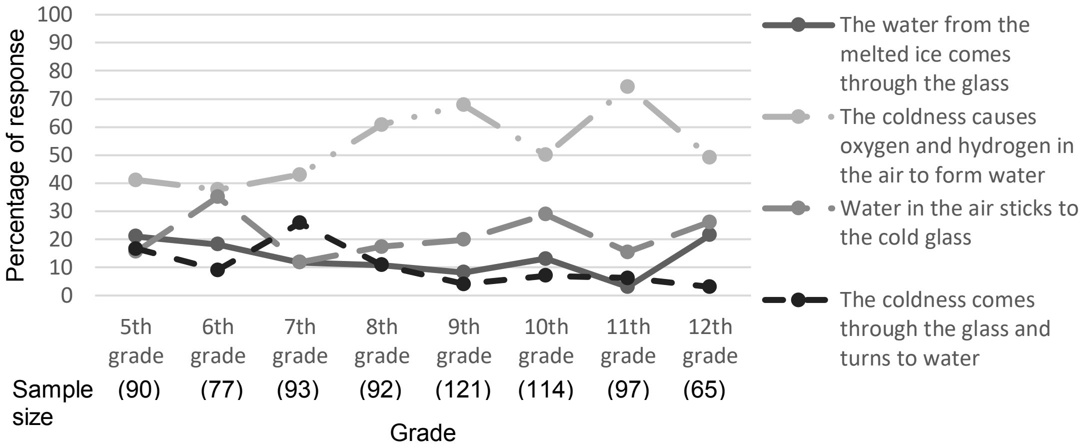


Figure 39. The distribution of percentages of responses with respect to grade for the question 19

For the twentieth question, there were five options where the respective question was represented in figure 40. The following diagram is a weather map. The big letter H mid-way between Turkey and Turkish Republic of Northern Cyprus shows:

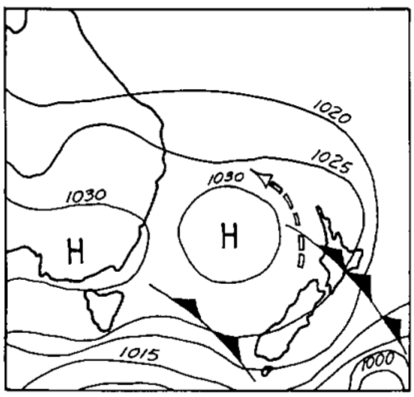


Figure 40. The question 20 in the questionnaire (Osborne, Freyberg, & Bell, 1985, p.176)

Two options “high air pressure” and “humidity” were highly selected by students as in figure 41. The percentage of these two options were mostly increasing with grade levels.

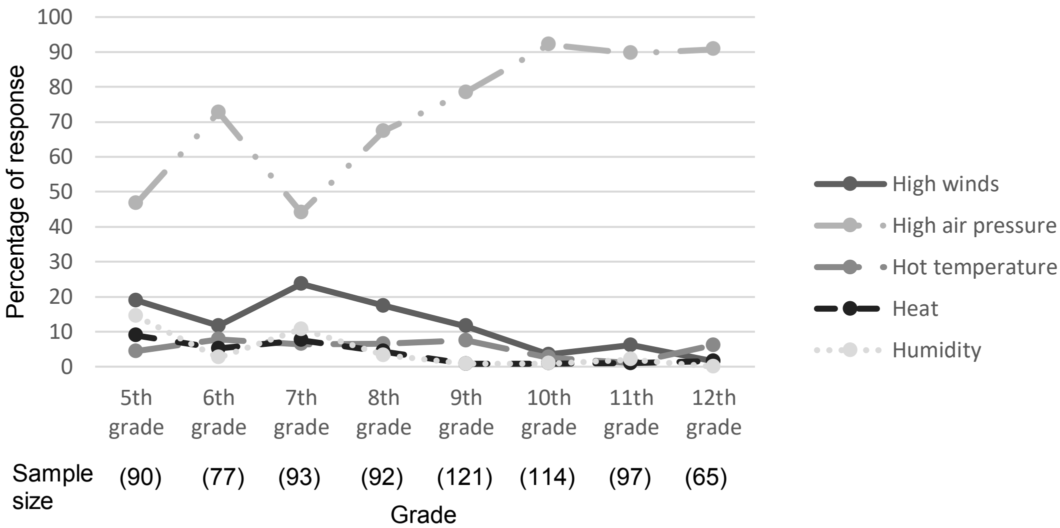


Figure 41. The distribution of percentages of responses with respect to grade for the question 20

Furthermore, the correct response for this question was “high air pressure.” It was the highest among all options for all grade levels except grade 5 and 7. Moreover, it reached highest percentage in grade 12 with 90.8% and lowest percentage in grade 7 with 44.1%.

Further evidence towards instrument validity

The general descriptive results were given for the all students compared to their gender, school type, grade, age and school level (middle or high school). In this section, the researcher found out whether the difference between these compare groups was statistically significant or not. In addition, correlations of total scores of students with grades of science, biology, physics, and chemistry courses were reported. These results provided information for the fifth research question.

As shown in table 8, independent samples t-test was used to evaluate if there was a statistically significant difference between mean scores of male and female students based on total scores. Moreover, the researcher used an alpha level of .05 for this statistical test. A homogeneity of variance test was conducted prior the test in order to check for the assumption of variances dependency. The null hypothesis for this assumption was “there is no statistically significant difference between variances of male and female students.” Levene’s test for equality of variances was met for the presented analysis, *F* (747) = 2.368, *p* = .124 since, the null hypothesis is failed to be rejected. The results of statistical test found out that there was no statistically significant difference in mean scores of male students (*M* = 13.97, *SD* = 2.45) and female students (*M* = 13.88, *SD* = 2.30), *t* (747) = .514, *p* = .608.

Table 8
Independent samples t-test result of total score with respect to gender groups

		F	Sig.	t	df	Sig. (2-tailed)	Mean difference
Total score	Equal variances assumed	2.368	.124	.514	747	.608	.089
	Equal variances not assumed			.513	736.3	.608	.089

As reported in table 9 below, independent samples t-test was conducted to calculate statistically significant difference between mean scores of private school students and state school students with respect total scores. In addition, the researcher used an alpha level of .05 for this statistical test. Furthermore, Levene’s test for equality of variances was satisfied for the presented analysis, *F* (747) = 2.533, *p* = .112 because, the null hypothesis is failed to be rejected. The result of statistical test revealed that there was a statistically significant difference in mean scores of private school students (*M* = 14.20, *SD* = 2.45) and state school students (*M* = 13.68, *SD* = 2.28), *t* (747) = -3.02, *p* < .05.

Table 9
Independent samples t-test result of total score with respect to school type groups

		F	Sig.	t	df	Sig. (2-tailed)	Mean difference
Total score	Equal variances assumed	2.533	.112	-3.023	747	.003	-.523
	Equal variances not assumed			-3.007	712	.003	-.523

As can be seen in table 11, one-way ANOVA was conducted to calculate mean difference between grade levels based on the total score of students. Furthermore, it was found that there was statistically significant difference between mean scores of grades 5 and 6, 5 and 8, 5 and 9, 5 and 10, 5 and 11, 5 and 12, 6 and 9, 6 and 10, 6 and 11, 6 and 12, 7 and 8, 7 and 9, 7 and 10, 7 and 11, 7 and 12, 8 and 10, 8 and 11.

Table 10
Test of Homogeneity of Variances

Levene's statistic	df1	df2	Sig.
1.378	7	741	.211

Moreover, the researcher used an alpha level of .05 for the present statistical test. In addition, Levene's test for equality of variances was met for the presented analysis, *F* (7,741) = 1.378, *p* = .211.

Table 11
One-way ANOVA result of total score with respect to grade

	Sum of squares	df	Mean square	F	Sig.
Between groups	812.737	7	116.105	25.337	.000
Within groups	3395.616	741	4.582		
Total	4208.352	748			

The result of analysis revealed statistically significant difference between the mean scores of grade levels on total score, F (7,741) = 25.337, p < .05. Furthermore, one-way ANOVA compared the mean scores between grade levels and determined which grades' mean scores were statistically significantly different based on the total score of students. The mean scores of grade levels, 5 (M = 12.08, SD = 2.00), 6 (M = 13.25, SD = 1.88), 7 (M = 12.60, SD = 1.94), 8 (M = 13.86, SD = 2.09), 9 (M = 14.60, SD = 2.12), 10 (M = 14.82, SD = 2.21), 11 (M = 14.95, SD = 2.22), and 12 (M = 14.88, SD = 2.69).

Table 12
The mean difference result of Bonferroni post-hoc test

	Mean difference (I-J)							
	(J) Grade							
(I) Grade								
5th grade		-1.169*	-.524	-1.781*	-2.517*	-2.747*	-2.871*	-2.799*
6th grade	1.169*		.645	-.612	-1.348*	-1.578*	-1.702*	-1.630*
7th grade	.524	-.645		-1.257*	-1.993*	-2.222*	-2.346*	-2.275*
8th grade	1.781*	.612	1.257*		-.736	-.966*	-1.090*	-1.018
9th grade	2.517*	1.348*	1.993*	.736		-.230	-.353	-.282

Table 12 (cont'd)
The mean difference result of Bonferroni post-hoc test

10th grade	2.747*	1.578*	2.222*	.966*	.230		-.124	-.052
11th grade	2.871*	1.702*	2.346*	1.090*	.353	.124		.072
12th grade	2.799*	1.630*	2.275*	1.018	.282	.052	-.072	

*. The mean difference is significant at the 0.05 level.

Since, the homogeneity of variances assumption was satisfied, Bonferroni post-hoc test was conducted to determine which grades' mean scores were statistically significantly different. The result was represented in table 12.

Table 13
The correlation between total score and grade of science course

		Grade of science course	Total score
Grade of science course	Pearson Correlation	1	.127*
	Sig. (2-tailed)		.015
	N	367	367

*. Correlation is significant at the 0.05 level (2-tailed).

Furthermore, correlation between total scores of students and grades of science course was computed. As reported in table 13 above, the result of Pearson correlation indicated that there was a statistically significant positive association between total scores of students and their grades of science course, r (365) = .127, p = .015.

Table 14
The correlation between total score and grade of biology course

		Grade of biology course	Total score
Grade of biology course	Pearson Correlation	1	.279**
	Sig. (2-tailed)		.000
	N	333	333

**. Correlation is significant at the 0.01 level (2-tailed).

In addition, correlation between total scores of students and grades of biology course were analyzed. As shown in table 14 above, the result of Pearson correlation revealed that there was a statistically significant positive association between total scores of students and their grades of biology course, r (331) = .279, $p < .01$.

Table 15
The correlation between total score and grade of physics course

		Grade of physics course	Total score
Grade of physics course	Pearson Correlation	1	.304**
	Sig. (2-tailed)		.000
	N	330	330

**. Correlation is significant at the 0.01 level (2-tailed).

Moreover, correlation between total scores of students and grades of physics course was investigated. As shown in table 15 above, the result of Pearson correlation revealed that there was a statistically significant positive association between total scores of students and their grades of physics course, r (328) = .304, $p < .01$.

Table 16
The correlation between total score and grade of chemistry course

		Grade of chemistry course	Total score
Grade of chemistry course	Pearson Correlation	1	.239**
	Sig. (2-tailed)		.000
	N	331	331

**. Correlation is significant at the 0.01 level (2-tailed).

Furthermore, correlation between total scores of students and grades of chemistry course was analyzed. As shown in table 16 above, the result of Pearson correlation revealed that there was a statistically significant positive association between total scores of students and their grades of chemistry course, r (329) = .239, $p < .01$.

CHAPTER 5: DISCUSSION

Introduction

In this chapter, the major findings that were computed and reported in the previous chapter were discussed. The conclusion on students' general levels of misconceptions related on general science concepts was explained in the first section, which were also answers to the first four research questions. In the next section, changes in the students' levels of misconception with respect to the grade level was discussed which happens to be the answer for the fourth research question. Finally, correlation results between total score of students and course grades of science, biology, physics, and chemistry lessons were explored. These results were used to support further evidence on test validity. This discussion of correlation results was related to the fifth research question. The chapter concludes with a discussion on the possible implications for further research and reports on limitations of the present study.

Overview of the study

The present research study was intended to determine Turkish students' levels of misconceptions about general science subjects. The first part of this research dealt directly with students' levels of misconceptions and possible variables such as gender, school type, grade, age, and school level. Moreover, it tried to infer how students' misconceptions changed over the passage of time. The second part was discrete item analysis of students' responses which provided trends in students' levels of misconceptions when compared to grade level. The third part was a correlation study which adds further evidence towards the validity of the instrument being used in this research.

To reiterate, the following five research questions were explored to determine students' levels of misconceptions on general science subjects.

1. What are students' misconceptions on general science subjects?
2. Are there gender differences in the students' levels of misconceptions on general science subjects?
3. Do students' levels of misconceptions on general science subjects change according to school type?
4. Do students' levels of misconceptions on general science subjects change from middle to high school aged students?
5. How do students' levels of misconceptions on general science subjects compare with their grades of science, biology, physics and chemistry courses?

In the early 1980s, initially in the USA many studies regarding students' misconceptions were conducted in science education. Clement (1993) defined misconception as beliefs, ideas or concepts of students which are partly or totally different than the accepted scientific views. The surprising results of these research showed that students have high levels of misconceptions about scientific phenomenon. This fact sparked a worldwide interest on research based on students' misconceptions. Since then, many researches have been conducted on students' understanding regarding basic scientific concepts and/or misconceptions. The following scholars are some of the pioneer researchers whom had published influential studies on students' misconceptions: Champagne, Klopfer, & Anderson, 1980; Driver, 1981; Clement, 1982; Osborne & Wittrock, 1983; Halloun & Hestenes, 1985; Gilbert & Pope, 1986; Brown, 1989; Rozier & Viennot, 1991.

Studies about students' misconceptions in Turkey dates back to the 1990s. The first research was conducted on physics students' misconceptions on topics typically covered in introductory mechanics (Eryilmaz, 1992) at the univeristy level. Over the past twenty-six years, more follow-up research studies about students' misconceptions were conducted. To name a few Cataloglu, 1996; Topkaya, 1996; Baser, 1996; Aydoğan & Güneş, 2003; Ateş & Polat, 2005; Ates & Cataloglu, 2007; Kapucu & Yildirim, 2013; Bilican, Cakiroglu, & Oztekin, 2015 in physics and general sciences in Turkey. Similar results were reported in these research as in the rest of the world.

One might argue that after 30 years of misconceptions studies, schools' science teachers are now very well informed and aware regarding students well documented misconception and its effect on teaching and learning. However, as stated in chapter one, one can argue the need for a new study about current situation of students' misconception on general science subjects. Therefore, this study aimed to do a descriptive research on the current situation of students' misconceptions on general science subjects.

The purpose of the present study was to determine students' levels of misconceptions related to general science concepts. Therefore, a questionnaire which diagnoses students' misconceptions on general science subjects was chosen. This questionnaire was developed by Osborne, Freyberg, & Bell (1985) one of the pioneers in this field of research; see Appendix A.

Misconception tests have some differences than traditional achievement tests. In addition to the achievement tests, misconception test aims to probe students' misconceptions rather than measuring students' level of knowledge. The distractors of misconception test refer to common well documented students' misconceptions. Usually the distractors of misconception test were formed using the students' misconceptions gathered through clinical interviews.

The research's informal observations and interviews with science teachers in private and state schools led the researcher to conclude that traditional teaching and learning methods were the main methods used in classrooms. However, the results of research on misconceptions revealed clearly that traditional lecturing has limited effect on meaningful learning. Novak (2002) claimed that traditional teaching methods do not foster meaningful learning at a satisfactory level. A proposed solution for science teachers is to adopt a constructivist based approach to reinforce meaningful learning. Hake (1998) claimed that learner centered methods promote conceptual understanding of students in introductory mechanics more than conventional ones. Hence, alternative approaches towards meaningful understanding were employed in many western countries. However, teachers in Turkey still seem to use predominantly traditional teaching methods. Furthermore, the results of the program for international student assessment (PISA) also support the inference, since PISA was based on concept knowledge and skills of students. Turkey is ranked below the OECD average in all categories Taş, U. E., Arıcı, Ö., Ozarkan, H. B., & Özgürlük

(2016). In addition, Turkish students' performance in science is ranked 52nd out of 72 countries. In the light of indicators, witnessing significant positive changes in students' levels of misconception was not expected as the result of this study.

As it was stated in chapter 3, the questionnaire was administered to students enrolled in two state middle schools, two state high schools, one private middle schools, and one private high school. Moreover, the research design of the study was descriptive quantitative research method. Furthermore, descriptive statistical analyses and its related results were stated in the chapter 4. The general result of these data analyses showed:

The mean score of all the students was 13.92 out of 20. These results showed that students still had misconceptions about general science subjects regardless of variables such as gender, school type (private and state school), grade, age, and school level (middle and high school). The mean score of all the student was below 16 which is 80% of maximum score in the questionnaire. Therefore, conceptual understanding of students related to general science concepts were not satisfactory. A similar threshold value was used like study of Hestenes & Wells (1992). It was concluded that students have well accumulated conceptual understanding about general scientific concepts, if their scores were above the threshold. In the light of this interpretation, three types of misconceptions were obtained based on the first research question. These were misconceptions which decreased with grade level, were consistent with grade level and increased with grade level. Also, there were some questions which students' misconceptions did not observed.

There was no statistical difference between female and male students' mean scores when their levels of misconceptions were investigated. Moreover, there was no difference between private and state school students' mean scores by taking into account students' levels of misconceptions. Additionally, students' levels of misconceptions decreased from middle school students to high school students. Finally, computed correlation coefficient values indicated further evidence towards the validity of the instrument.

Major findings

Discussion of descriptive data results

This section reported results of descriptive statistical analysis of total score of students based on variables. The difference between students' mean scores on gender, school type, grade, age and school level groups were computed respectively.

The overall mean score of all students that participated in this study was found to be 13.92 (69.60%). This mean score value is below the 80% threshold set forth by Hestenes & Wells (1992). Therefore, one can argue that this particular mean score indicated that a large portion of students had still misconceptions about general science subjects. The following section will explore further the levels of students' misconceptions on general science concepts with respect to different variables such as gender, school type, grade, age, and school level.

Discussion of results on gender

The first comparison variable was based on gender. The mean score of male students was 13.97 and the mean score of female students was 13.88. A small difference of .09 was found in favor of male students. Furthermore, independent samples t-test revealed that this difference was not statistically significant, t (747) = .514, p = .608. As a conclusion, there was no statistical significant difference between male and female students' mean scores. Taking the threshold value into consideration, this result demonstrated that both male and female students had misconceptions on general science concepts at approximately similar levels. This indicated that students' levels of misconception on general science concepts did not depend on gender. This study was also in line with Sencar & Eryılmaz's (2004) findings. According to Sencar & Eryılmaz's (2004) findings, it was reported that there was a difference (but not statistically significant) between male and female students with respect to total scores, in support of male students. Additionally, no gender difference was found about comprehension of kinematics graphs (Cataloglu, 2007).

Discussion of results on school type

The second comparison variable was based on school type: private and state school. Private school students had a mean score of 14.20, whereas state school students had a mean score of 13.68. There was a .52 mean score difference between the two groups. There was a statistically significant difference between private school and state school students test mean scores, t (747) = -3.02, p < .05. According to Hake's (2007) proposed statistical analysis procedure (Hake's normalized average gain index), one can argue that the statistical difference between private and state schools was not a major descriptive difference.

The fact that there was a statistically significant mean score difference between private and state schools' students mean scores, one can use Hake's argument of normalized gain index to argue that the mean score difference should not be regarded as such. Therefore, the research argued that the results of a somewhat low mean test score showed another proof that students' misconceptions were school type independent. This is in accordance with the general findings of the misconception literature. That is the students' misconceptions showed some degree of independence to external factors or variables such as school type and culture. For example, students in different countries have similar misconceptions despite cultural differences (Osborne & Gilbert, 1979). Although there exists studies that reported Tuncer, Ertepinar, Tekkaya, & Sungur (2005) statistical significant difference between mean scores of private and state schools of students in grades 6, 7, 8 and 10, Bulunuz, Jarrett, & Bulunuz's (2009) claimed that there was no difference between private and state schools regarding students' understanding about some scientific concepts.

Discussion of results on grade

The third variable was grade level. Mean scores for each grade levels were computed. The following mean scores were computed for grade 5 ($M = 12.08$), grade 6 ($M = 13.25$), grade 7 ($M = 12.60$), grade 8 ($M = 13.86$), grade 9 ($M = 14.60$), grade 10 ($M = 14.82$), grade 11 ($M = 14.95$), and grade 12 ($M = 14.88$). As one can see the mean score range changed between the values of 12.08 and 14.95. The mean score obviously increased with the higher grade levels. Moreover, one-way ANOVA, $F(7,741) = 25.337$, $p < .05$ showed that mean scores between grade levels were statistically significantly different. Bonferroni post-hoc test revealed statistically significantly mean score differences between the following grades: grades 5 and 6, 5 and 8, 5 and 9, 5 and 10, 5 and 11, 5 and 12, 6 and 9, 6 and 10, 6 and 11, 6 and 12, 7 and 8, 7 and 9, 7 and 10, 7 and 11, 7 and 12, 8 and 10, 8 and 11. The increase in mean scores of students' total scores meant that their levels of misconceptions was slightly decreasing. This demonstrated that students developed their conceptual understanding about general science concepts with higher grades. This result was compatible with findings of some researches listed in the literature. For instance, Çepni & Keleş's (2006) found that students showed improvement in their understanding of electric circuits through their grade level. In addition, students enhanced understanding of physical change of matter from grade 6 to 8 (Akgun & Aydin, 2010).

Discussion of results on age

The fourth variable was age. Since, each grade groups were generally had a specific age, a similar outcome was obtained between variables of grade and age. For instance, grade 5 students were 9 years old and grade 12 student were 17 years old. The finding of age analysis with respect to total mean scores of students showed an increasing tendency with higher ages. Thus, the students' levels of misconceptions generally declined except questions 12, 13, 15, and 19. This showed two facts. One, if students are exposed to more formal science education then their misconceptions could decrease. Two, there are some misconceptions that do resist to change except electric current and change of state of water. The results of the present study were compatible with the literature. Adadan & Yavuzkaya (2018) claimed that students increase understanding of thermodynamics concepts from ages 13 to 16.

Discussion of results on school level

The fifth variable was school level: middle and high school. It was found that students' levels of misconceptions decreased from middle school to high school aged students. This result addressed the fourth research question. Analyses demonstrated that students' meaningful learning on general science concepts from middle school to high school happened. Additionally, students' choice of distractors demonstrated that high school students inclined to choose more sophisticated and sound scientific distractors compared to middle school students. Adadan & Yavuzkaya (2018) reported similar findings. According to their findings the number of students who used more scientific terminology increased with higher grades. However, conceptual understanding of middle and high school students on general science subjects was not satisfactory.

In conclusion, the general results of analyses related to main goal of the study indicated that meaningful learning of students on general science subjects was not at a satisfactory level when considering the threshold level of 80%. One should emphasize, although high school students are exposed to more science lessons, their conceptual understanding about general science subjects was not in desired level too.

Discussion of discrete item analysis

The literature on students' misconceptions demonstrated that some of students' misconceptions can be eliminated relatively easily, but some of them resist to change (Tunnicliffe & Reiss, 2000). Moreover, these type of students' misconceptions have been shown to be stable and often resistant to change especially when exposed to traditional science teaching (Westbrook & Marek, 1991). Thus, it is important to identify and analyze students' conceptual understanding, since alternative conceptions make teaching and learning of science difficult (Osborne and Gilbert, 1979). Because, the grade range of participants changed from 5 to 12, change in students' levels of misconceptions along the grade level was evaluated. That way, students' misconceptions which were still prevalent were determined. That is, we can use these results to speculate about relatively persistent misconceptions.

Students in higher grades are exposed to more science teaching, concepts, vocabulary and information. They are also mature cognitively (Inhelder & Piaget, 1958). Therefore, they were expected to acquired more scientific knowledge on general science subjects. In the listed questions, it was observed that students' levels of misconceptions decreased with higher grades for the questions 2, 4, 5, 9, 11, 14, 16, 17, 18, and 20. The questions 2, 4, and 5 were related to the "animal" concept (biology), the question 9 was related to "plant" concept (biology), questions 11, 14, and 16 were related to "electric current" concept (physics), the questions 17 and 18 were related to "change of state of water" concept and the question 20 was related to "weather and climate" concept (earth science). Similar results were reported from the original study by Osborne, Freyberg, & Bell (1985). They found that percentages of correct responses mostly increased from age 5 to 17 for the questions 2, 4, 5 and 9. Besides, their findings demonstrated a decrease in level of misconception for the students aged from 13 to 17 for question number 18.

The levels of students' misconceptions with respect to grade level were still high and students' misconceptions were resistant to change for the questions 13 and 15. The questions 13 and 15 assessed the students' understanding of "electric current."

Students thought that electric current is consumable in question 13. This misconception about electric circuits was related to “the current consumed model” or also referred as to Model C by Osborne, Freyberg, & Bell (1985). Students who responded as there is electric current inside the unconnected car battery in question 15 showed misconception that is called as container theory. This was one of the student’s misconception reported in study of study of Osborne & Gilbert (1979). They found consistent misconceptions in students aged from 7 to 13 for the question 15. Therefore, the increase in the students’ levels of misconceptions was not observed for the “electric current” concept. These were the indications of persistent students’ misconceptions in the literature. Furthermore, non-scientific ideas of younger students can also be observed in older students despite exposure of more formal science education (Bar & Travis, 1991).

In addition, the levels of students’ misconceptions increased with higher grades for the questions 12 and 19. So, these misconceptions were resistant to change. Question 12 was related to “electric current” concept, question 19 were related to “change of state of water” concept. Similar results were obtained compared to the study of Osborne & Gilbert (1979) about the question 12.

Moreover, significant levels of students’ misconceptions were not found in questions 1, 3, 6, 7, 8 and 10. These questions were related to meanings of words “animal,” “living,” and “plant.” Questions 1 and 3 were related to “animal” concept, the questions 6, 7 and 8 were related to “living” concept, question 10 was related to “plant” concept. A very small percentage of incorrect responses was observed in these questions. Similar results were obtained compared to the original study of

Osborne, Freyberg, & Bell (1985). They stated a very similar result for the questions 1 and 7. Most of the students answered these questions correctly. However, students' levels of misconceptions in the present study was slightly lower than the findings reported by Osborne, Freyberg, & Bell's (1985) study for the questions 3, 6, 8 and 10. Significant levels of misconceptions among students at grade range of 5 to 12 was not detected for these questions in this study.

In conclusion, the results obtained in this study revealed similar results reported by Osborne, Freyberg, & Bell (1985). This study also provided another proof that some of the students' misconceptions on general science subjects are still common and resistant to change which were compatible with the literature.

From researcher's informal observations and interviews with the science teachers in private and state schools, conventional teaching methods were still more prevalent among science teachers. These methods neither are student centered, nor use conceptual understanding and constructivist approaches. Moreover, science classes were not supported with practical works and hands-on activities which can be beneficial for conceptual understanding. Therefore, it inhibits meaningful learning of students and refutation of students' misconceptions (Aydoğan & Güneş, 2003). Additionally, some of the textbooks of Ministry of National Education (MoNE) tend to contain inadequate information about students' misconceptions and contents which may lead to misconceptions (Küçüközer, Bostan, Kenar, Seçer, & Yavuz, 2008). Atici, Keskin Samanci, & Alev Özel (2007) found out that there are some definitions and pictures in science textbooks which may lead to strengthen students' misconceptions. King (2010) claimed that misconceptions found in science textbook may foster the misconceptions of teachers and their students as well. For instance, Earth science textbooks in England contained misconception which is “plates can be made from oceanic or continental crust.” Recent science lesson textbooks published in developed countries try to incorporate the findings of research on students’ misconceptions (Hewitt, 2010; Hewitt, 2016; Hewitt, 1990). Besides, The National Science Teacher Association in the United States publishes some materials to reveal students’ conceptions and implement this knowledge into lesson planning (Larkin, 2012). Just recently, a book related misconceptions in physics was published in Turkey (Güneş, 2017).

Discussion of correlation results

In this section, results of the correlation analyses between total score of students and their grades in science, biology, physics and chemistry lessons were discussed. The instrument which was used to diagnose students’ levels of misconception, should have validity. The moderate correlations between total scores of students and their grades provided evidence that the questionnaire measures students’ levels of misconceptions on general science subjects. This addressed the fifth research question of this study.

The questionnaire was developed by Osborne, Freyberg, & Bell (1985) by using a method known as the “interview about instances” by Osborne & Gilbert (1980) and “interview about events” (Osborne, 1980). In this method, researchers ask students oral questions about some physical events which are shown in a diagram or picture. Students need to explain and justify on their responses. During these interviews, common non-scientific responses of students were collected to be used later as plausible distractors. Then, these common oral explanations were transformed to test questions for the purpose of evaluating non-scientific concepts are held by a wider range of students (Osborne et al., 1985). Therefore, distractors in the questionnaire sound plausible and sensible to students, since their own language was used in preparation of this instrument. Students' incorrect responses provide information regarding possible student misconceptions. As discussed earlier in chapter two, the distractors separate a misconception test from an ordinary achievement test.

In addition to the diagnostic misconception tests, traditional achievement tests aim to measure students' knowledge. Therefore, distractors do not provide any further information regarding students' conceptual understanding. In fact, distractors that tend to dominate a question are regarded as possible problem points in classical psychometrics. Diagnostic misconception tests, on the other hand, are designed to reflecting plausible students' alternative statements, students that choose distractors then provide an idea about his/her conceptual thinking.

The results of correlation analyses gave further evidence regarding the validity of the questionnaire. The results of the analyses showed that the correlation between total score of students and their biology grades had a degree of correlation, $r(331) = .279$, $p < .01$. The correlation between total score of students and their chemistry grades had also correlation coefficient of $r(329) = .239$, $p < .01$. Furthermore, the correlation between total score of students and their physics grades had moderate correlation coefficient of $r(328) = .304$, $p < .01$. High correlations were not expected in these analyses, since diagnostic misconception tests differ from achievement tests in science lessons. However, moderate correlations supported construct validity of the instrument.

Students' misconceptions about the electric current and change of state of water were still prevalent for both middle and high school Turkish students. Similar results were obtained in the study of Osborne, Freyberg, & Bell (1985) despite the fact that their study was conducted in New Zealand. Additionally, students' misconceptions about electric current which were investigated in the UK (Osborne & Gilbert, 1979), South East Asia (Russell, 1980) and France (Tiberghien & Delacote, 1976) showed surprisingly similar results. Furthermore, non-scientific ideas about electric current demonstrated similarity, although studies were conducted in different countries (Osborne, 1983). These studies suggested that students from different countries all show similar tendency of misconceptions despite of having different backgrounds. In another word, this shows that misconceptions tend to be culture independent.

Implications for practice

Thirdly, there are plenty of researches on students' misconceptions in general science subjects (Duit, 1993), but the related studies on implications of this knowledge are insufficient. Thus, science, biology, physics and chemistry teachers should be educated more about constructivism based on teaching methods to elicit students' misconceptions and refute them (Ecevit & Şimşek, 2017).

Although, the physics curriculum of MoNE for the 9^{th} grade focuses on more conceptual based teaching, teachers could not adopt themselves to these approaches (Isikoglu, Basturk, & Karaca, 2009). From the informal observations and interviews of the investigator, teachers still use conventional teaching methods such as teacher centered approach, chalk and talk and solving problem. However, science teachers should embrace constructivist teaching strategies and implement them in their classroom (Beck, Czerniak, & Lumpe, 2000).

Implications for further research

The result of analyses indicated that students use explanation of natural phenomenon through concepts that are different than the currently expected scientific explanation. The misconceptions about “electric current” and “change of state of water” were observed in the present study. Students thought that there is current flowing in an incomplete circuit in question 12. They also believed that electric current is consumable as assessed by question 13. A large portion thought that there is electric current inside the unconnected car battery in the question 15. Additionally, they stated that oxygen and hydrogen in the air can form water droplets on the outside of jar due to the coldness. The following two points are very important to ascertain students’ misconceptions and eliminate them. First, curriculum developers should give more emphasize to students’ misconceptions on general science subjects (Osborne & Gilbert, 1980). Curriculum developers should take into account students’ beliefs and perspective. Therefore, they should avoid from any statement that may lead to set barriers for meaningful learning. Second, textbooks may cause misconceptions with incorrect definitions (Sanger & Greenbowe, 1999). Besides, some of the textbooks of MoNE contain inappropriate information about misconceptions and contents which may lead to misconceptions (Küçüközer, Bostan, Kenar, Seçer, & Yavuz, 2008). Atici, Keskin Samanci, & Alev Özel (2007) claimed that there are some definitions and pictures in science textbooks which may cause students' misconceptions. Thus, textbooks that were selected by MoNE, should be examined carefully to avoid creating new misconceptions for students.

Limitations

Most of the items in the questionnaire were multiple-choice type of questions, two-tier type of questions could obtain more information about students' misconceptions or non-scientific ideas on general science subjects in the further research study.

Time and budget were constraints of this study, because investigator had limited resources to apply the survey to more schools.

The sample for pilot study was 16. Test reliability value should be considered within these realms.

The sample was limited to schools in Çankaya district of Ankara, Turkey.

All participants were volunteer. No extra credit or some other kind of incentive was provided. It assumed that all participating students sincerely answered the questionnaire.

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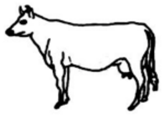
APPENDICES

Appendix A: Original of Data Collection Instrument

Appendix D1: A survey of some science-related ideas

The following questions are about the word 'animal'.

1 Is a cow an animal?
(a) Yes
(b) No



2 Is a person an animal?
(a) Yes
(b) No

3 Is a whale an animal?
(a) Yes
(b) No

4 Is a spider an animal?
(a) Yes
(b) No

5 Is a worm an animal?
(a) Yes
(b) No

The following questions are about the word 'living'.

6 Is a fire living?
(a) Yes
(b) No

7 Is a person living?
(a) Yes
(b) No

8 Is a moving car living?
(a) Yes
(b) No

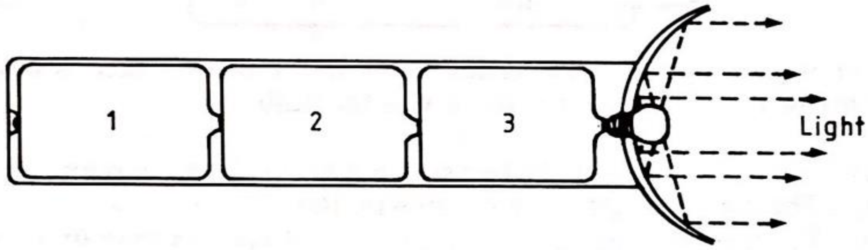
The following questions are about the word 'plant'.

9 Is a carrot a plant?
(a) Yes
(b) No

10 Is a tree a plant?
(a) Yes
(b) No

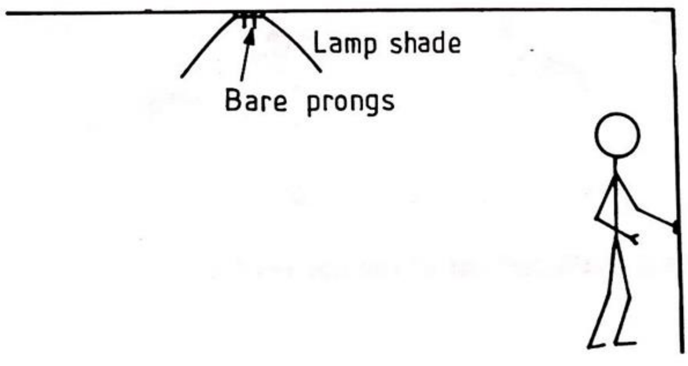
Questions 11-15 are about electric current.

11 A torch has three batteries in it, as shown in the diagram.



The torch is switched on and the lamp is glowing. Five students all have different ideas about the electric current through the batteries. Which one of the following ideas do you think is the best idea?
(a) No. 1 will have the most current.
(b) No. 2 will have the most current.
(c) No. 3 will have the most current.
(d) No. 1 and 3 will have more current than No. 2.
(e) They will all have the same current.

12 This question is about an ordinary electric light which is fixed to the ceiling. The light bulb has been taken out, but the switch on the wall is on.

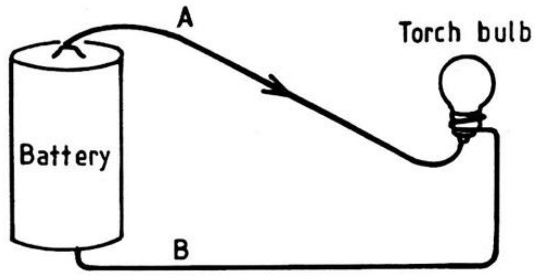


Is there an electric current in the bare prongs?
(a) No, because there can't be a current flowing.

(b) Yes, because if you touch it you get a shock.
(c) Yes, because if you put a bulb there it would glow.
(d) Yes, because the current would be going out from the prongs.

The following information is for questions 13 and 14.

A battery is connected to a torch bulb as shown.

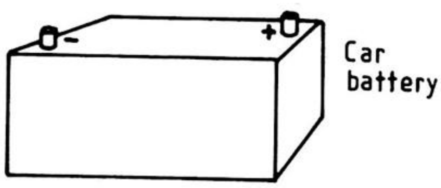


The bulb is glowing and the electric current in the wire marked A is shown by the arrow pointing from the battery to the bulb.

13 Which of the following is the best sentence about electric current *in wire B*?
(a) There is no electric current in wire B.
(b) There is some electric current in wire B but less than in wire A.
(c) There is the same electric current in wire B as in wire A.
(d) There is more electric current in wire B than in wire A.

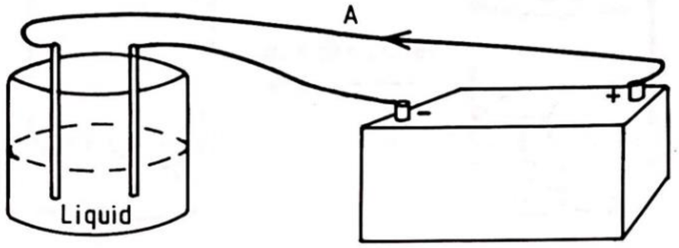
14 Which of the following is the best sentence about the direction of electric current *in wire B*?
(a) The current has no direction as there is no current.
(b) The current is in the direction from the battery to the bulb.
(c) The current is in the direction from the bulb to the battery.

15 A car battery has been fully charged but has not yet been placed in the car. It is sitting on the bench in the garage and is not connected up to anything.



Is there an electric current in the battery?

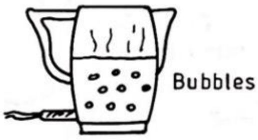
16 Two metal rods are connected to the terminals on a battery. The rods are in a liquid as shown.



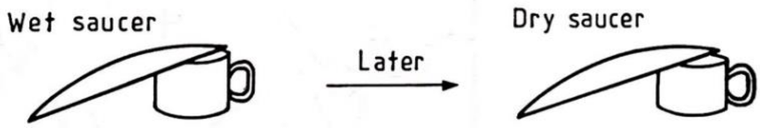
There is an electric current along wire A from the battery to the metal rod. Would there be an electric current in the *liquid*?
(a) It depends on what the liquid is.
(b) There must be a current in the liquid.
(c) There would not be a current in the liquid.

The following questions (17-19) are about things that happen in the kitchen.

17 When a kettle boils there are large bubbles in the water. What are the bubbles made of?
(a) Air
(b) Steam
(c) Heat
(d) Oxygen or hydrogen

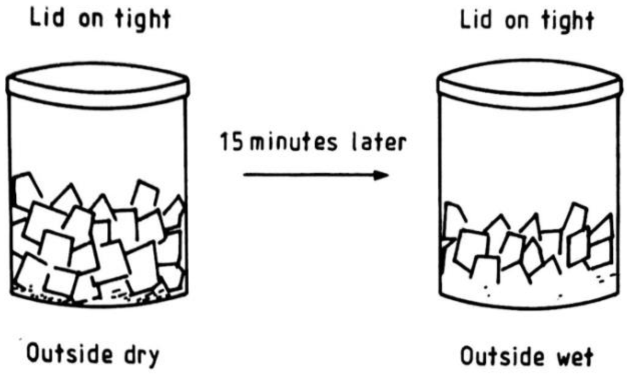


18 If a wet saucer is left on the bench after it has been washed, then after a while it is all dry.



What happens to the water that doesn't drip onto the bench?
(a) It goes into the saucer.
(b) It just dries up and no longer exists as anything.
(c) It changes into oxygen and hydrogen in the air.
(d) It goes into the air as very small bits of water.

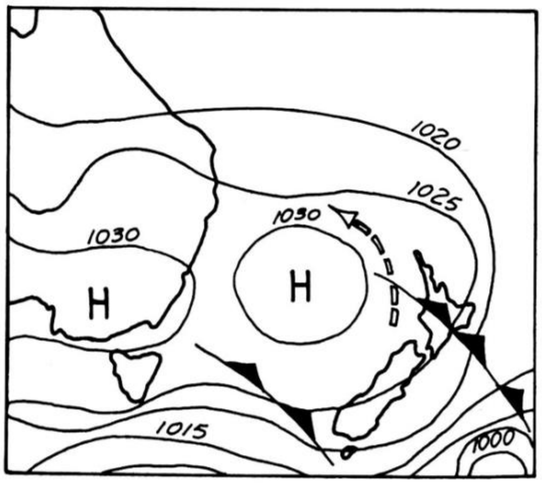
19 A small jar is filled with ice, the lid is screwed on tightly, and the outside of the glass is dried with a tea towel. Fifteen minutes later the outside of the jar is all wet.



Where has the water on the outside of the jar come from?
(a) The water from the melted ice comes through the glass.
(b) The coldness causes oxygen and hydrogen in the air to form water.
(c) Water in the air sticks to the cold glass.
(d) The coldness comes through the glass and turns to water.

20 The following diagram is a weather map. The big letter H mid-way between Australia and New Zealand shows:

(a) high winds
(b) high air pressure
(c) hot temperatures
(d) heat
(e) humidity



Appendix B: Turkish Version of Data Collection Instrument

Kısım 1: Demografik Bilgiler

1. Ad Soyad

....

2. Cinsiyet

a) Kız b) Erkek

3. Yaş

....

4. Sınıf

....

5.

a) Eğer ortaokul öğrencisi iseniz:

Geçen seneki fen bilgisi ders notunuz: …/100

b) Eğer lise öğrencisi iseniz:

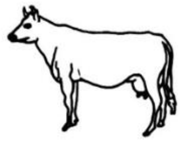
Geçen seneki biyoloji ders notunuz: …/100

Geçen seneki fizik ders notunuz: …/100

Geçen seneki kimya ders notunuz: …/100

Kısım 2: Bazı Fen Kavramlarını Belirleme Anketi

Aşağıdaki sorular 'hayvan' kelimesi ile ilgilidir.



1. İnek bir hayvan mıdır?
a) Evet
b) Hayır

2. İnsan bir hayvan mıdır?
a) Evet
b) Hayır

3. Balina bir hayvan mıdır?
a) Evet
b) Hayır

4. Örümcek bir hayvan mıdır?
a) Evet
b) Hayır

5. Solucan bir hayvan mıdır?
a) Evet
b) Hayır

Aşağıdaki sorular 'canlı' kelimesi ile ilgilidir.

6. Ateş canlı mıdır?
a) Evet
b) Hayır

7. İnsan canlı mıdır?
a) Evet
b) Hayır

8. Hareket halindeki bir araba canlı mıdır?
a) Evet
b) Hayır

Aşağıdaki sorular 'bitki' kelimesi ile ilgilidir.

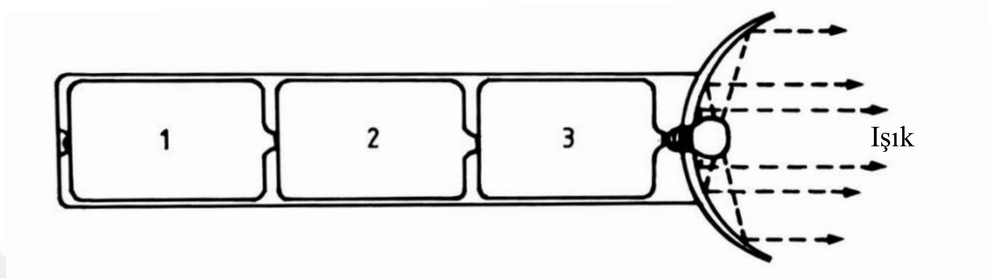
9. Havuç bir bitki midir?
a) Evet
b) Hayır

10. Ağaç bir bitki midir?

a) Evet
b) Hayır

11. - 15. soruları elektrik akımı ile ilgilidir.

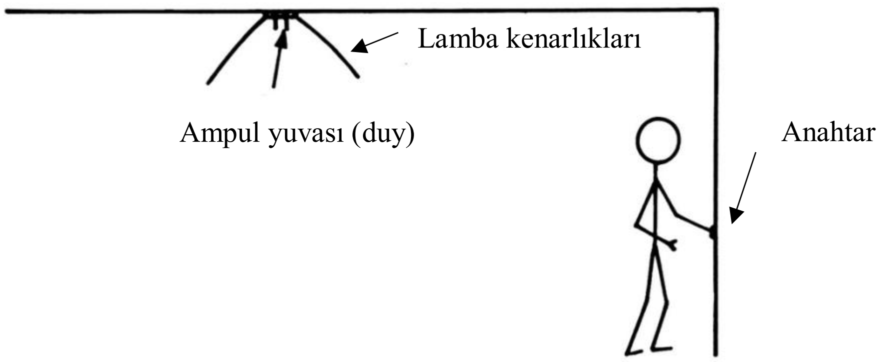
11. İçinde üç adet pil olan bir el feneri aşağıdaki şemada gösterilmektedir.



El fenerinin düğmesine basılmıştır ve ampul ışık vermektedir. Beş öğrencinin her biri, pillerin içindeki elektrik akımı hakkında farklı fikirlere sahiptir. Aşağıdaki fikirlerden sizce hangisi en mantıklısıdır?

a) 1 numaralı pil en fazla akıma sahiptir.
b) 2 numaralı pil en fazla akıma sahiptir.
c) 3 numaralı pil en fazla akıma sahiptir.
d) 1 ve 3 numaralı pil 2 numaralı pilden daha fazla akıma sahiptir.
e) Bütün piller aynı miktarda akıma sahiptir.

12. Bu soru tavana asılmış sıradan bir lamba hakkındadır. Ampul lambadan sökülmüştür ancak duvardaki lamba anahtarı basılı (açık) durumdadır.

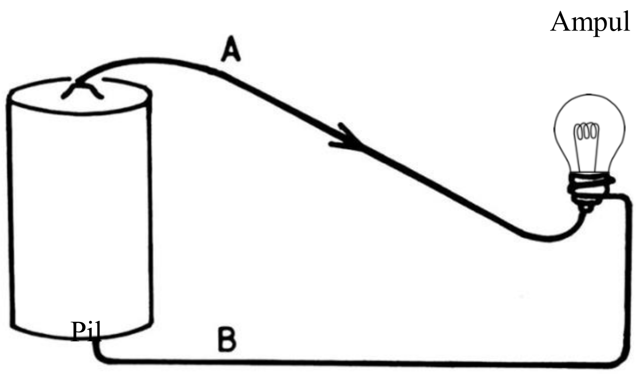


Ampul bulunmayan boş ampul yuvasında (duyda) elektrik akımı var mıdır?

a) Hayır, çünkü elektrik akımı oluşmaz.
b) Evet, çünkü sokete dokunursan çarpılırsın.
c) Evet, çünkü sokete ampul takarsan ışık verir.
d) Evet, çünkü akım soket den dışarı çıkar.

Aşağıdaki bilgi 13. ve 14. sorular içindir.

Aşağıda görüldüğü üzere pil 'A' ve 'B' elektrik kablolarıyla ampule bağlanmıştır.



Bu durumda ampul ışık veriyor. 'A' harfi ile gösterilmiş olan kablodaki elektrik akımı ok yönünde pilden ampule doğru gitmektedir.

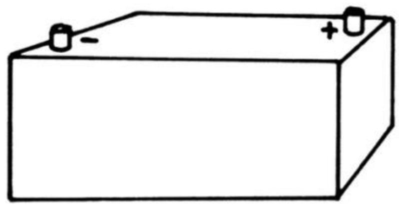
13. Aşağıdaki cümlelerden hangisi 'B' harfi ile gösterilmiş olan kablodaki elektrik akımı hakkında en doğru bilgiyi vermektedir?

a) 'B' kablosunda elektrik akımı yoktur.
b) 'B' kablosunda bir miktar elektrik akımı vardır ancak 'A' kablosundakinden azdır.
c) 'B' kablosunda ki elektrik akımı ile 'A' kablosundaki elektrik akımı aynı miktardadır.
d) 'B' kablosunda ki elektrik akımı miktarı 'A' kablosundakinden daha fazladır.

14. Aşağıdaki cümlelerden hangisi 'B' harfi ile gösterilmiş olan kablodaki elektrik akımının yönü hakkında en doğru bilgiyi vermektedir?

a) 'B' kablosunda akım olmadığı için akımın yönünden de bahsedemeyiz.
b) Akımın yönü pilden ampule doğrudur.
c) Akımının yönü ampulden pile doğrudur.

15. Bir araba aküsü tamamıyla şarj edilmiştir ama henüz arabaya bağlanmamıştır. Akü hiçbir şeye bağlı olmadan öylece tezgâhın üstünde durmaktadır.

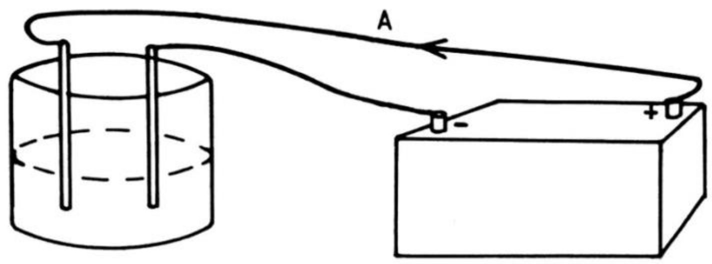


Araba aküsü

Araba aküsünde elektrik akımı var mıdır? Lütfen cevabınızı açıklayınız.

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
…………

16. Araba aküsünün kutuplarına iki metal çubuk bağlanmıştır. Çubuklar aşağıda görüldüğü gibi bir sıvının içindedir.



Sıvı

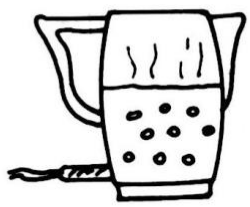
'A' kablosu üzerinde bataryadan metal çubuğa doğru bir elektrik akımı vardır. Sıvıda elektrik akımı oluşabilir mi?

a) Sıvının ne olduğuna bağlıdır.
b) Sıvıda elektrik akımı oluşmalıdır.
c) Sıvıda elektrik akımı oluşamaz.

17. - 19. soruları mutfakta olan şeyler ile ilgilidir.

17. Su ısıtıcısı içerisindeki suyu kaynattığı zaman, suda büyük baloncuklar oluşmaktadır. Baloncuklar aşağıdakilerin hangisinden oluşmuştur?

a) Hava
b) Su buharı
c) Isı
d) Oksijen veya hidrojen

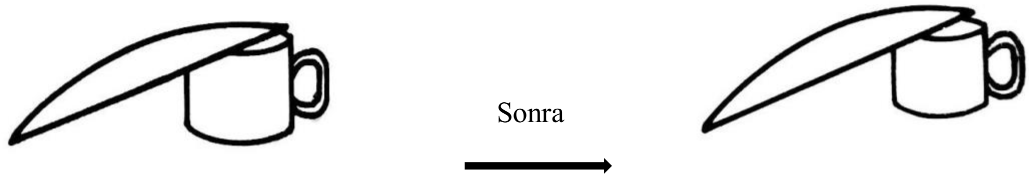


Baloncuklar

18. Bir fincan tabağı yıkandıktan sonra ıslak bir şekilde tezgâhın üstüne bırakılırsa, zamanla tamamen kuruyacaktır.

Islak fincan tabağı

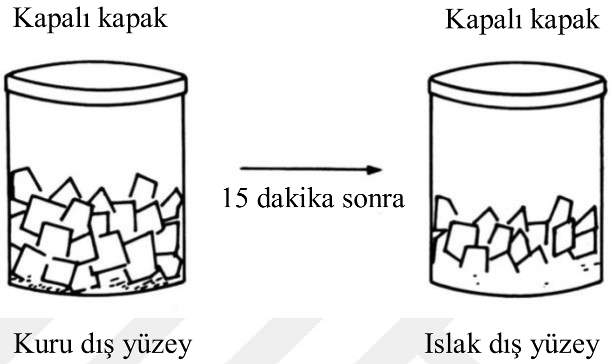
Kuru fincan tabağı



Tabağın üstünde kalan fakat tezgâhın üstüne dökülmeyen suya ne olur?

a) Fincan tabağının içine girer.
b) Kurur ve hiçbir formda var olmaz (yok olur).
c) Oksijen ve hidrojene dönüşerek havaya karışır.
d) Çok küçük su tanecikleri halinde havaya karışır.

19. Küçük bir cam kavanoz içine buz parçaları doldurulup kapağı sıkı bir şekilde kapatıldıktan sonra dışı bir havlu ile kurulanmıştır. Kavanozun dış yüzeyi on beş dakika sonra tamamıyla ıslak olarak gözlemlenmiştir.



Cam kavanozun dış yüzeyindeki su nasıl oluşmuştur?

a) Kavanozun içindeki eriyen buzdan dolayı oluşan su camdan dışarıya çıkmıştır.
b) Kavanozun içindeki soğukluk havadaki oksijen ve hidrojenin suya dönüşmesine yol açmıştır.
c) Havadaki su soğuk cama yapışmıştır.
d) Soğukluk camın içinden geçip suya dönüşmüştür.

20. Aşağıdaki harita hava durumunu göstermektedir. Türkiye ve Kuzey Kıbrıs Türk Cumhuriyeti arasındaki büyük ‘YB’ harfi neyi göstermektedir?

a) Sert rüzgarları
b) Yüksek hava basıncını
c) Yüksek sıcaklıkları
d) Isıyı
e) Nemliliği