Development of a Two Tiered Test for Determining Differentiation in Conceptual Structure related to “Floating-Sinking, Buoyancy and Pressure” Concepts

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SYNOPSIS

INTRODUCTION

Two-tiered tests enter to education environment with the Treagust’s (1988) study entitled “the development and use of diagnostic instruments to evaluate students’ misconceptions in science”. Two-tiered tests are separated from multiple choices tests with at least one dimension having a second phase in which the reasons for the marked choices of the first phase are required to be stated. According to the related literature, two-tiered tests could be prepared in three ways;

i) Two phases of the test could be prepared as multiple choices,

ii) Two phases could be prepared as multiple choices then one more phase could be added for students to write their own ideas as “the other” in open ended form.

iii) First phase of the test could be prepared as multiple choices and the second one could be open ended. In this way, students have chance to write their own ideas. This phase is important to measure students’ reasoning abilities and to determine if there are more alternative conceptions different from the related literature.

When the two tiered tests in the literature are examined, it has seen that, often in the first phase of testing, two or three choices are not standard. These choices most often include choices like “yes-no”, “increased- decreased- stable”, instead of the situations indicating students’ possible alternative conceptions. In the second stage of the tests, students’ alternative situations are limited in choices with the data from the literature. When the studies in the literature were examined, it has not been met any two-tiered tests including “floating”, “sinking”, “buoyancy force of liquids and gases”, “solid pressure, liquid pressure and gas pressure”. When all of these data are taken into consideration, developing a two tiered test to determine students’ alternative conceptions and providing differentiation in their conceptual
structure about the concepts in the “force and motion” unit may contribute to the national and international literature in this field.

**PURPOSE OF THE STUDY**

The purpose of this study was to develop a two-tiered test for determining differentiation in conceptual structures related to “floating-sinking, buoyancy and pressure” concepts existed in the 8th grade “force and motion” unit and to test its validity and reliability.

**METHODOLOGY**

In the developing of the two-tiered “Determining Differentiation in Conceptual Structure Test (DDCST)”, the method suggested by Treagust and Chandrasegaran (2007) was used. The method consists of three steps. The first stage is to determine the content; second stage is to have knowledge about students’ alternative concepts and the third one is to develop the two tiered test. These three steps were followed in the process of developing the two-tiered DDCST.

First phases of the each question of the developed two tiered tests included four choices. These choices are the situations that students are having alternative conceptions. In the developed test, the situations including students’ alternative conceptions given in the first phases were also shown with pictures. This aspect of the test questions were similar with the pictorial questions used by Bowen and Bunce (1997). Second phases of the each question included an open ended section starting with “because” for students to write their reasons for their selection the choice in the first phase freely.

**a) The Sample**

The sample of the study consisted of 78 8th grade students from two different primary schools in Giresun. After the teaching environment was prepared according to the related concepts, the DDCST was applied to 30 8th grade primary school students. Additionally, before the teaching the DDCST was applied to 48 8th grade primary school students.

**b) Analysis of the Data Obtained from DDSCT**

Categories organized by Abraham and his colleagues (1992) were used in the analysis of the data obtained from the DDCST. Marks are given to the first and second stages of the test and the total marks of these stages are calculated.

**c) Reliability Analysis of DDSCT**

Cronbach alpha reliability coefficient value was found as 0.8137 and standardized Cronbach alpha coefficient value of the DDSCT was found as 0.8122. As the reliability coefficient of the test was 0.81, it can be concluded that the test was reliable.

**d) Validity Analysis of DDSCT**

Six experts, 2 physics teachers and 3 science teachers’ opinions were taken to ensure the content validity of the DDSCT. Factor analysis for structure validity of the test was not carried out as the DDSCT was a classified scale and the obtained data did not show a normal distribution. Moreover, to make sure whether the data obtained from the DDSCT were suitable or not for factor analysis, Kaiser-Meyer- Olkin (KMO) was conducted and its value was observed as 0.40. To test the construct validity of the DDSCT, the data gathered from the independent samples to which instruction about the unit was applied and instruction about the
unit was not applied, were compared with Mann Whitney U test. Before the teaching of “floating, sinking, buoyancy and pressure” concepts, the DDSCT was applied to 48 students and after the instruction, it was implemented to 30 students after. When the test scores of the independent sample groups were compared, a significant difference was found in favor of the sample group having instruction about the unit. This means that the test had the construct validity (internal consistency).

DISCUSSION and CONCLUSION

Two-tiered tests were not only used to determine the level of differentiation of the students’ conceptual frameworks but also for the main causes underlying on students’ thinking. At the same time by the two-tiered tests, whether or not the student is aware of his/her own knowledge can also be determined. Moreover, two-tiered test can also contribute to the building relationships between the cause and the result of the knowledge. Similarly, two-tiered tests for the different units could also be prepared and applied for determining students’ conceptual structure in different concepts.

REFERENCES


Appendix 1

Two Tiered Test for Determining Differentiation in Conceptual Structure

Dear Students,

Questions below include two phases. At the first phase, you should mark the correct answer of the question from the choices. In the second phase, write why you think that your choice is true into the area starting with “Because”. Good luck…

Research Assistant Dr. Çiğdem ŞAHİN

Question 1:

Which one or ones of the above pictures is affected by the buoyancy force? (Flying balloon and plastic ball are in the same environment).

a) Swimmer
b) Swimmer and flying balloon
c) Swimmer and marble
d) Swimmer, marble, flying balloon and plastic ball*

Because:………………………………………………………………………………………………………….
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Question 2:

In the next picture, a monkey has gone to sea to catch fish. Which of the following statements can be said about the liquid pressure that sea has applied to monkeys’ boat, big fish, small fish and fish feed?

a) The liquid pressure affects all equal.
b) The liquid pressure affects the big fish and fish feed equal.
c) The liquid pressure acting on monkey’s boat is the largest one.
d) The fluid pressure acting on the small fish is the largest one.*

Because:……………………………………………………………………………………………………………
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Question 3:

In the below pictures, substances with the same volume are left into the barrels filled with water. Which one of these substances will cause to overflow equal amounts of water from the barrels?

a) II and IV  b) II and III*  c) III and IV  d) I and IV

Because:…………………………………………………………………………………………………………
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Question 4:
I. A marble with 50 gr mass
II. A tray with 1000 gr mass
III. A square shaped bell jar with 100 gr mass
If we put these above substances into water, which one of the following is absolutely true about floating and sinking situations of these substances in the water?
a) Tray with 1000 gr mass sinks.
b) Square shaped bell jar with 100 gr mass floats
c) Marble with 50 gr mass floats.
d) Nothing can be said about floating and sinking situation of substances in water.
Because:

Question 5: When a student put an egg into water, it sinks. What the student should do for the egg to float in the water?
a) He should add water into the container
b) He should solve a very big amount of salt in water*
c) He should add olive oil into the water
d) He should vaporize somewhat water
Because:

Question 6: In the figure, objects numbered 1, 2, 3 and 4 are in a balance in water. Accordingly which statements given below are correct?
I. Just the object numbered 4 is floating in water.
II. Objects numbered 1, 2 and 3 are sinking in water.
III. Objects numbered 2, 3 and 4 are floating in water.
a) Only I  b) I and II  c) Only III*  d) I, II and III
Because:

Question 7: Berkan in the next image;
In case 1, is standing on one of his leg;
In case II, is standing on two of his legs;
In case 3, is sitting.
Which one of the things said below about the pressure that Berkan has applied to ground is true?
a) Berkan applies more pressure to the ground when he is standing on one leg.*
b) Berkan applies more pressure to the ground when he is standing on his two legs.
c) Berkan applies more pressure to the ground when he is sitting.
d) Pressure that Berkan applies to the ground in all three cases is equal.
Because:
Question 8:
I- Exploration of the flying balloon after some time rising in atmosphere
II- A woodpecker blowing an inflated balloon with its beak
III- Crimpling of a balloon attached to the bottom of an empty pool by adding water on it.
Which one or ones of the situations given above occur with effect of the pressure?
   a) Only I       b) I and II     c) Only III     d) I, II, III*

Because: .................................................................

Question 9:
A closed box filled with water in the Figure 1 has been reversed as in the Figure II. Which one or ones of the following are true for both of the figures?

   a) Pressure that boxes applied to the ground are equal.
   b) Weight of the water applied to the bottom of the boxes increased.
   c) Liquid pressure of the water applied to the bottom of the boxes is equal.*
   d) Compressive force that the box applied to the ground in Figure I is bigger.

Because: .................................................................

Question 10: There are two fish at the same depth in different places in the aquarium in the next figure. Which of the statements said about the effect of liquid pressure on fish is true? (Liquid in both sides of the aquarium is the same)

   a) Liquid pressure effecting on fish in both sides are equal.*
   b) Liquid pressure affects more on the fish in the first side.
   c) Liquid pressure affects more on the fish in the second side.
   d) Nothing can be said about the liquid pressure effecting on fish.

Because: .................................................................

Question 11: Different liquids are found at the same height in the next figure. Accordingly, which of the following is correct sequence of the fluid pressure in points K, L and M such as P_K, P_L and P_M (d_water=1gr/cm^3; d_mercury=13.6 gr/cm^3; d_oil=0.8 gr/cm^3)

   a) P_K= P_L= P_M
   b) P_L> P_M> P_K
   c) P_K> P_L> P_M
   d) P_M> P_L> P_K*

Because: .................................................................
Question 12: Which one or ones of the following pictures having gas pressure? (Flying bird, flying bear, and standing cat are all in the same place)

a) I and II b) IV and V c) I, II, IV and V d) I, II, III, IV and V *

Because: …………………………………………………………………………………………………………………
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Question 13:

When Ayşe tied the flying balloon to the ground at home with the dynamometer, dynamometer distended like in the figure. Ayşe measured the tension as 4 Newton. If Ayşe tied her flying balloon to the Zigana Mountain, which is placed higher than her house, which one of the above does she measure in the dynamometer?

Because: …………………………………………………………………………………………………………………
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Question 14: Which conclusion does a student could not reach who is observing the progress of a balloon flying upwards?

a) Increase in the total mass of the balloon *
b) Increase in the volume of the balloon and the balloon become inflated
c) Increase of the buoyancy force of the air applied to balloon
d) Decrease of the density of the balloon

Because: …………………………………………………………………………………………………………………
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**Question 15:** Which of the following reasons stated is different from the others?

a) While a player has his leg back to hit the ball, having cramp in his leg*

b) Blockage of the ear during the trip to the plateau.

c) One’s nose bleeding during the journey with a flying balloon in the atmosphere.

d) Occlusion of a person’s ear when he/she went closer to seaside from the plateau.

*Because:* ……………………………………………………………………………………………………………………
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**Question 16:** Which of the following choices could be applied for increasing of solid pressure?

a) The tank wheels are made with large surfaces.

b) The number of wheels of the train is very much.

c) The edges of the ships are made sharp*.

d) To make the furniture and feet of the armchairs larger.

*Because:* ……………………………………………………………………………………………………………………
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* It represents the correct answer of the question.