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Developing an Achievement Test for the Subject of Sound in Science Education

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Abstract

The purpose of this study is to develop an achievement test which includes the basic concepts about the subject of sound and its properties in middle school science lessons and which at the same time aims to reveal the alternative concepts that the students already have. During the process of the development of the test, studies in the field and concepts about sound were reviewed. Test items were prepared by taking the views of experts. 234 9th graders during the academic year 2013-2014 participated in the study for the pilot and actual implementation. 85 questions prepared initially were reduced to 43 multiple choice questions with four choices following reliability and validity studies. KR-20 reliability coefficient of the 43 question sound achievement test was found as 0,83. The results show that the prepared sound achievement test is reliable.

Keywords: basic sound concepts, achievement test, developing test, alternative concept

1. Introduction

Students come across concepts about science and technology within a period starting from 4th grade to 8th grade in Turkey. This education has a spiral structure and the subject becomes deeper. The subject of sound and its properties is a part of this spiral education. In addition, sound is an important subject of science which is right in the middle of our lives. The subject of sound and its properties are related with a great number of different disciplines. It brings different disciplines together. For example, physic of music, mathematic of music, therapy with music, music history and music sociology. In addition to these, it is also associated with fields such as biology, art, engineering, medicine and psychology. Sound and its properties were used while developing diagnosis and treatment tools in medicine. It is one of the basic science subjects which students may encounter in their education after secondary school.

The subject of sound has abstract concepts and events. Thus, it is possible for alternative concepts to emerge. Developing a good assessment tool can be quite effective in presenting the alternative concepts and shortcomings in this field. By making use of the results of alternative concepts defined, the reasons for probable alternative concepts can be examined thoroughly by qualitative researches and the required arrangements can be made in science programs.

When the studies on sound are examined, it can be seen that more importance has been attached recently to researches about this subject in Turkey (Doğanay & Öztürk, 2013; Efe, 2007; Fide, 2011; Okur, 2009; Paliç, 2011; Pektaş et al., 2009; Tiryaki, 2009; Yücel, 2015). While there are fewer studies abroad about the subject of sound than other subjects of science, the number of these studies is still quite a lot. In these studies, there are also studies which aim to find out the preliminary information of students about the subject of sound (Hrepic, 2002; Katherine et al., 2004; Linder & Ericson, 1989; Maurines, 1992; Menchen & Thompson, 2005), studies which aim to present the misconceptions of students (Beaty, 2000; Küçüközer, 2009; Linder, 1992, 1993; Merino, 1998; Wittmann, 2002, 2003), studies which aim to find out the difference between traditional method and student centered method (Barman et al., 1996) and studies which aim to present the change in mental models (Hrepic, 2002).

In the studies conducted, the measurement tools developed or used are generally small scaled. It was found that there were no broad measurement tools which included sub titles such as sound propagation, velocity, frequency and intensity of sound, its relation with musical instruments, its energy and subjects such as its use in daily life.

The purpose of this study is to develop an achievement test which includes the basic concepts about the subject of sound and its properties in middle school science lessons and to reveal the alternative concepts that the students already have.

2. Material-Method

Conducting pilot studies before the test is prepared and to edit the questions with the help of the views of experts and teachers will greatly reduce the deficiencies of the test. Thus, the results of the prepared test will have suitable values. The "Sound Achievement Test" (SAT), which was prepared after the preliminary examinations, was developed to measure the basic concepts related to middle school sound subject. Concepts in middle school curriculum and literature were used while preparing the test. 85 questions were prepared by the researchers in line with the purposes by making use of various resources, test books and questions asked in high school entrance exams. The prepared test was administered on the students within short time intervals by using halving technique and the data were collected. The multiple choice questions prepared had four choices. The administration of each of the tests, which were grouped in two equal forms for the efficiency of the test, was completed in about 40 minutes. Table 1 shows the resources of the questions before eliminations. Table 2 shows the resources of the questions after eliminations. The questions in Table 2 were reorganized and renumbered.

Table 1. The resources of the questions before eliminations

Resources	**Item No**
Questions from high school entrance exams	6,12,17,24,29,41,64,71,78,
Various resources	1,2,3,4,5,7,8,9,10,11,13,14,15,16, 18,19,20,21,22,23
Developed by the researcher	25,26,27,28,30,31,32,33,34,35,36,37,38,39,40,42,43, 44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60, 61,62,63,65,66,67,68,69,70,72,73,74,75,76,77,78,79, 80,81,82,83,84,85

Table 2. The resources of the questions after eliminations

Resources	**Item No**
Questions from high school entrance exams	2,3,8,10,12,20,31,36
Various resources	1,4,5,7,9,11,13,14,15,16,18,19,21,22,23,24
Developed by the researcher	25,26,27,28,29,30,32,33,34,35,37,38,39,40,41,42,43

Table 1 and Table 2 show the questions prepared by the researchers as well as the high school entrance examination questions which were checked for validity and reliability. After the eliminations, 7 questions were eliminated from high school entrance examination questions and the remaining 36 questions were prepared by the researchers by making use of various resources.

2.1 Sample

The sample of the study consisted of 234 students who studied at four schools, two Anatolian high schools, one high school and one art high school during the Academic Year 2013-2014. The research was conducted on 9th graders because this unit and the concepts of this unit are in the science curriculum until the 8th grade. Thus, it can be accepted that the students learned all of the concepts in the test. The SAT which was prepared was administrated as a pilot and the questions which the students had difficulty in understanding were found and taken out of the test.

2.2 SAT Development Process

The procedures conducted during the development of the study are as follows:

- First of all, the science education program and the concepts in literature were found and the content was formed.

- At least three questions were formed about each content and these questions were addressed in terms of different points of views. Thus, if there were any questions that had to be eliminated, there were other types of questions in the test to meet the concept need.
- These questions were formed by revising the questions asked in high school entrance exam and various resources.
- 85 questions prepared as draft and the 43 questions formed afterwards were addressed within the framework of five different general dimensions basically. These are "propagation and production of sound", "velocity of sound", "sound energy", "relation with musical instruments" and "properties of sound". Table 3 gives the number of question items corresponding to dimensions.

Table 3. Questions numbers based on dimensions

Dimensions	Item No	Total Item
Sound propagition	5, 13, 16, 19, 30,36	6
Velocity of sound	1, 4, 11, 20, 32, 35	6
Sound energy	9, 14, 15, 21, 23, 34	6
Musical instrument & Sound	7, 24, 26, 27, 31, 39, 40, 41, 42, 43	10
Property of sound	2, 3, 6, 8, 10, 12, 17, 18, 22, 25, 28, 29, 33, 37, 38	15

- The views of experts on the field were taken for test validity. The researchers and teachers who analyzed have been working for more than 10 years. Of the experts, two are professor doctors, two assistant professor doctors, one is research assistant and four are science and technology teachers. The experts were informed about the test and they were asked to assess the test in the light of this information. There are studies in literature which make use of the views of teachers and academics for the content validity of the test (Çalık & Ayas, 2002; Abraham et al., 1994; Peterson & Treagust, 1989).
- After the views of experts were taken, eight 9th graders read the questions and they were asked to state the questions they did not understand. The parts stated by the students were fixed. The test prepared by 85 questions was divided into two parts with the halving method and each was completed in about 40+40 minutes.
- The pilot of the test was administered and a total score was obtained for the student by giving 1 point for correct questions and 0 point for incorrect questions and the for the questions which the students gave two answers or no answers at all. Analyses were made from these points.
- As a result of the analyses and examinations, the 43-question test which included basic concepts and which was suitable in terms of reliability and validity was finalized.

3. Findings and Discussion

In order to test the neutrality of the groups, the scores of the groups from pre-test were compared. The purpose while doing this was to determine whether the groups were homogeneous and equal. In order to determine the normal distribution of data, the data obtained from SAT were assessed with Kolmogorov Smirnov-Z test. In order to test whether a randomly chosen sample data has a normal distribution or not, Kolmogorov Smirnov-Z goodness of fit test is used (Akgül, 2005; Yazıcıoğlu & Erdoğan, 2004; Ural & Kılıç, 2005; Gorder & Foreman, 2009). Normality test was used in the analysis part of the test and the assessments were made in the light of these data.

Table 4. Normal distribution conformity of the data

SAT	Pilot	Final
Kolmogorov- Simirnov (Z)	1,340	0,979
p	0,55*	0,293*

* p>0,05

The fact that the significance (p) values in Table 4 were higher than 0.05 shows that the results confirmed with normal distribution.

After it was found that he questions had normal distribution, item analyses were made and the total scores of the students were ordered from the highest to the lowest based on their total scores. After this, upper group and lower group students were determined. This determination was in the form of 27% (N: 63) of the students from the upper group and 27% (N: 63) of the students from the lower group.

Item difficulty index and item discrimination should be checked to determine the quality of the questions in the test. The difficulty of a test item is the rate of the students who answered the question correctly. When the difficulty intervals are examined, 0,00-0,29 represent difficult items, 0,30-0,49 represent moderately difficult items, 0,50-0,69 represent easy items and 0,70-1,00 represent very easy items. For an achievement test, difficulty between 0.20 and 0.80 is important for the validity of the test (Özçelik, 1992).

In terms of item discrimination, if the difference between the number of students who answer correctly in lower and upper groups increases, discrimination rate will also increase. Items which have high discrimination rates are an important factor for the reliability and validity of the test. Discrimination rates can be interpreted as follows: 0,40 and over means a very good item, 0,30-0,39 means a good item, but still can be improved, 0,20-0,29 means the item should certainly be improved, 0,19 and less means that the item is very weak and should be eliminated from the test (Büyüköztürk et al., 2010). Table 5 gives the item discrimination index and difficulty index values.

Table 5. Item analysis of pilot SAT

Item no	Pj	Difficulty	rjx	Discrimination	Upper Group Correct Answer Score	Lower Group Correct Answer Score	Dimensional equivalents of the questions Their numbers on the last test
1	0,35	Average	0,22*	Straightened	31	17	
2	0,43	Average	0,15*	Very Low	28	18	
3	0,89	Very Easy	0,21*	Straightened	62	49	
4	0,82	Very Easy	0,22*	Straightened	56	42	
5	0,64	Easy	0,39*	Çalışılabilir	52	27	
6	0,71	Very Easy	0,54	Very Good	61	27	5. Dimension (3. Item)
7	0,73	Very Easy	0,36*	Çalışılabilir	59	36	
8	0,84	Very Easy	0,12*	Very Low	59	51	
9	0,87	Very Easy	0,27*	Straightened	61	44	
10	0,62	Easy	0,29*	Straightened	42	24	
11	0,60	Easy	0,49	Very Good	55	24	1. Dimension (5. Item)
12	0,71	Very Easy	0,51	Very Good	58	26	5. Dimension (2. Item)
13	0,69	Easy	0,35*	Good	54	32	
14	0,82	Very Easy	0,38*	Good	60	36	
15	0,62	Easy	0,25*	Straightened	44	28	
16	0,85	Very Easy	0,32*	Çalışılabilir	61	41	
17	0,66	Easy	0,40*	Very Good	54	29	
18	0,90	Very Easy	0,24*	Straightened	62	47	
19	0,20	Difficult	0,17*	Very Low	30	19	
20	0,61	Easy	0,49	Very Good	57	26	3. Dimension (23. Item)
21	0,13	Difficult	0,11*	Very Low	20	13	
22	0,74	Very Easy	0,35*	Çalışılabilir	57	35	
23	0,31	Average	0,13*	Very Low	31	22	
24	0,54	Easy	0,40*	Very Good	46	21	
25	0,40	Average	0,29*	Straightened	49	31	
26	0,71	Very Easy	0,29*	Straightened	57	39	
27	0,40	Average	0,41	Very Good	42	16	2. Dimension (11. Item)
28	0,71	Very Easy	0,33*	Good	52	31	
29	0,44	Average	0,57	Very Good	47	11	5. Dimension (12. Item)
30	0,50	Easy	0,62	Very Good	52	13	4. Dimension (7. Item)

31	0,59	Easy	0,37*	Good	47	24	
32	0,42	Average	0,51	Very Good	47	15	3. Dimension (14. Item)
33	0,64	Easy	0,52	Very Good	54	21	5. Dimension (6. Item)
34	0,64	Easy	0,48	Very Good	53	23	3. Dimension (15. Item)
35	0,64	Easy	0,51	Very Good	57	25	3. Dimension (9. Item)
36	0,21	Difficult	0,22*	Straightened	28	14	
37	0,44	Average	0,44	Very Good	42	14	5. Dimension (17. Item)
38	0,54	Easy	0,57	Very Good	50	24	5. Dimension (18. Item)
39	0,57	Easy	0,41	Very Good	56	30	2. Dimension (20. Item)
40	0,70	Very Easy	0,52	Very Good	57	24	5. Dimension (8. Item)
41	0,37	Average	0,37*	Good	37	14	
42	0,61	Easy	0,73	Very Good	60	14	3. Dimension (21. Item)
43	0,67	Easy	0,30*	Good	51	32	
44	0,61	Easy	0,52	Very Good	53	20	5. Dimension (22. Item)
45	0,73	Very Easy	0,43	Very Good	60	33	5. Dimension (29. Item)
46	0,26	Difficult	0,15*	Very Low	26	16	
47	0,50	Easy	0,38*	Good	45	21	
48	0,47	Average	0,35*	Good	41	19	
49	0,51	Easy	0,44	Very Good	44	16	4. Dimension (24. Item)
50	0,52	Easy	0,62	Very Good	53	14	1. Dimension (16. Item)
51	0,23	Difficult	0,17*	Very Low	25	14	
52	0,66	Easy	0,43	Very Good	54	27	1. Dimension (19. Item)
53	0,49	Average	0,56	Very Good	51	16	5. Dimension (25. Item)
54	0,70	Very Easy	0,48	Very Good	59	29	4. Dimension (26. Item)
55	0,39	Average	0,56	Very Good	47	12	4. Dimension (27. Item)
56	0,65	Easy	0,40	Very Good	55	30	5. Dimension (10. Item)
57	0,78	Very Easy	0,41	Very Good	63	37	1. Dimension (13. Item)
58	0,72	Very Easy	0,37*	Good	58	35	
59	0,38	Average	0,30*	Good	33	14	
60	0,25	Difficult	0,11*	Very Low	27	20	
61	0,29	Difficult	0,16*	Very Low	29	19	
62	0,70	Very Easy	0,59	Very Good	61	24	2. Dimension (1. Item)
63	0,70	Very Easy	0,57	Very Good	60	24	5. Dimension (28. Item)
64	0,37	Average	0,22*	Straightened	31	17	
65	0,59	Easy	0,59	Very Good	57	20	4. Dimension (31. Item)
66	0,68	Easy	0,51	Very Good	57	25	2. Dimension (4. Item)
67	0,56	Easy	0,57	Very Good	56	20	1. Dimension (30. Item)
68	0,10	Difficult	0,16*	Çok zayıf	23	13	
69	0,31	Average	0,17*	Çok zayıf	33	22	
70	0,70	Very Easy	0,56	Very Good	59	24	5. Dimension (38. Item)
71	0,36	Average	0,37*	Good	38	15	
72	0,74	Very Easy	0,68	Very Good	63	20	2. Dimension (32. Item)
73	0,73	Very Easy	0,40	Very Good	57	32	3. Dimension (34. Item)
74	0,64	Easy	0,52	Very Good	57	24	1. Dimension (36. Item)
75	0,66	Easy	0,65	Very Good	62	21	5. Dimension (33. Item)
76	0,68	Easy	0,51	Very Good	57	25	5. Dimension (37. Item)
77	0,45	Average	0,57	Very Good	49	13	2. Dimension (35. Item)
78	0,41	Average	0,38*	Good	44	20	
79	0,33	Average	0,27*	Straightened	33	16	
80	0,36	Average	0,38*	Good	36	12	
81	0,51	Average	0,59	Very Good	54	17	4. Dimension (39. Item)
82	0,40	Average	0,59	Very Good	48	11	4. Dimension (40. Item)
83	0,42	Average	0,46	Very Good	41	12	4. Dimension (41. Item)
84	0,56	Easy	0,57	Very Good	56	20	4. Dimension (42. Item)
85	0,45	Average	0,65	Very Good	53	12	4. Dimension (43. Item)
Mean	0,55	Easy	0,57	Very Good	49	24	

According to Table 5, the items with a discrimination value of between 0,1 and 0,40 were eliminated and thus, the first step was taken for the reliability of the test. Questions with a discriminative value of greater than 0,40 are considered as good items. When the difficulty index of questions with a discriminative value of 0,40 and more were examined, they were found to be between 0,39 and 0,73. The values above show that the questions were reliable. 42 questions were eliminated and the test was finalized with 43 questions.

Table 6 shows the item difficulty index and discrimination index of the finalized test after item elimination.

Table 6. Item analysis of the finalized SAT

Item no	Pj	Difficulty	rjx	Discrimination	Upper Group Correct Answer Score	Lower Group Correct Answer Score	Dimensional equivalents of the questions Their numbers on the last test
6	0,71	Very Easy	0,54	Very Good	61	27	5. Dimension (3. Item)
11	0,60	Easy	0,49	Very Good	55	24	1. Dimension (5. Item)
12	0,71	Very Easy	0,51	Very Good	58	26	5. Dimension (2. Item)
20	0,61	Easy	0,49	Very Good	57	26	3. Dimension (23. Item)
27	0,40	Average	0,41	Very Good	42	16	2. Dimension (11. Item)
29	0,44	Average	0,57	Very Good	47	11	5. Dimension (12. Item)
30	0,50	Easy	0,62	Very Good	52	13	4. Dimension (7. Item)
32	0,42	Average	0,51	Very Good	47	15	3. Dimension (14. Item)
33	0,64	Easy	0,52	Very Good	54	21	5. Dimension (6. Item)
34	0,64	Easy	0,48	Very Good	53	23	3. Dimension (15. Item)
35	0,64	Easy	0,51	Very Good	57	25	3. Dimension (9. Item)
37	0,44	Average	0,44	Very Good	42	14	5. Dimension (17. Item)
38	0,54	Easy	0,57	Very Good	50	24	5. Dimension (18. Item)
39	0,57	Easy	0,41	Very Good	56	30	2. Dimension (20. Item)
40	0,70	Very Easy	0,52	Very Good	57	24	5. Dimension (8. Item)
42	0,61	Easy	0,73	Very Good	60	14	3. Dimension (21. Item)
44	0,61	Easy	0,52	Very Good	53	20	5. Dimension (22. Item)
45	0,73	Very Easy	0,43	Very Good	60	33	5. Dimension (29. Item)
49	0,51	Easy	0,44	Very Good	44	16	4. Dimension (24. Item)
50	0,52	Easy	0,62	Very Good	53	14	1. Dimension (16. Item)
52	0,66	Easy	0,43	Very Good	54	27	1. Dimension (19. Item)
53	0,49	Average	0,56	Very Good	51	16	5. Dimension (25. Item)
54	0,70	Very Easy	0,48	Very Good	59	29	4. Dimension (26. Item)
55	0,39	Average	0,56	Very Good	47	12	4. Dimension (27. Item)
56	0,65	Easy	0,40	Very Good	55	30	5. Dimension (10.Item)
57	0,78	Very Easy	0,41	Very Good	63	37	1. Dimension (13. Item)
62	0,70	Very Easy	0,59	Very Good	61	24	2. Dimension (1. Item)
63	0,70	Very Easy	0,57	Very Good	60	24	5. Dimension (28. Item)
65	0,59	Easy	0,59	Very Good	57	20	4. Dimension (31. Item)
66	0,68	Easy	0,51	Very Good	57	25	2. Dimension (4. Item)
67	0,56	Easy	0,57	Very Good	56	20	1. Dimension (30. Item)
70	0,70	Very Easy	0,56	Very Good	59	24	5. Dimension (38. Item)
72	0,74	Very Easy	0,68	Very Good	63	20	2. Dimension (32. Item)
73	0,73	Very Easy	0,40	Very Good	57	32	3. Dimension (34. Item)
74	0,64	Easy	0,52	Very Good	57	24	1. Dimension (36. Item)
75	0,66	Easy	0,65	Very Good	62	21	5. Dimension (33. Item)
76	0,68	Easy	0,51	Very Good	57	25	5. Dimension (37. Item)
77	0,45	Average	0,57	Very Good	49	13	2. Dimension (35. Item)
81	0,51	Easy	0,59	Very Good	54	17	4. Dimension (39. Item)
82	0,40	Average	0,59	Very Good	48	11	4. Dimension (40. Item)
83	0,42	Average	0,46	Very Good	41	12	4. Dimension (41. Item)
84	0,56	Easy	0,57	Very Good	56	20	4. Dimension (42. Item)

85	0,45	Average	0,65	Very Good	53	12	4. Dimension (43. Item)
Mean	0,59	Easy	0,53	Very Good	54	21	

Table 6 shows the average values of all questions. According to these results, it can be stated that the questions were easy in general and they had very good discrimination rates.

Dimension should be dealt with separately in order to be able to assess each dimension in itself. This is given in Table 7.

Table 7. The distribution of items in SAT in terms of dimensions

Item no	Pj	Difficulty	rjx	Discrimination	Upper Group Correct Answer Score	Lower Group Correct Answer Score	Dimension Pj (Mean) Rjx (Mean)
11	0,60	Easy	0,49	Very Good	55	24	
52	0,66	Easy	0,43	Very Good	54	27	
50	0,52	Easy	0,62	Very Good	53	14	1. Dimension Pj: 0,63 Rjx: 0,51
57	0,78	Very Easy	0,41	Very Good	63	37	
67	0,56	Easy	0,57	Very Good	56	20	
74	0,64	Easy	0,52	Very Good	57	24	
27	0,40	Avarege	0,41	Very Good	42	16	
39	0,57	Easy	0,41	Very Good	56	30	
62	0,70	Very Easy	0,59	Very Good	61	24	2. Dimension Pj: 0,59 Rjx: 0,53
66	0,68	Easy	0,51	Very Good	57	25	
72	0,74	Very Easy	0,68	Very Good	63	20	
77	0,45	Avarege	0,57	Very Good	49	13	
20	0,49	Easy	0,49	Very Good	57	26	
32	0,42	Avarege	0,51	Very Good	47	15	
34	0,64	Easy	0,48	Very Good	53	23	3. Dimension Pj: 0,60 Rjx: 0,52
35	0,64	Easy	0,51	Very Good	57	25	
42	0,61	Easy	0,73	Very Good	60	14	
73	0,73	Very Easy	0,40	Very Good	57	32	
30	0,50	Easy	0,62	Very Good	52	13	
49	0,51	Easy	0,44	Very Good	44	16	
54	0,70	Very Easy	0,48	Very Good	59	29	
55	0,39	Avarege	0,56	Very Good	47	12	
65	0,59	Easy	0,59	Very Good	57	20	4. Dimension Pj: 0,50 Rjx: 0,55
81	0,51	Easy	0,59	Very Good	54	17	
82	0,40	Avarege	0,59	Very Good	48	11	
83	0,42	Avarege	0,46	Very Good	41	12	
84	0,56	Easy	0,57	Very Good	56	20	
85	0,45	Avarege	0,65	Very Good	53	12	
6	0,71	Very Easy	0,54	Very Good	61	27	
12	0,71	Very Easy	0,51	Very Good	58	26	
33	0,64	Easy	0,52	Very Good	54	21	
37	0,44	Avarege	0,44	Very Good	42	14	
38	0,54	Easy	0,57	Very Good	50	24	
40	0,70	Very Easy	0,52	Very Good	57	24	5. Dimension Pj:0,63 Rjx: 0,52
44	0,61	Easy	0,52	Very Good	53	20	
45	0,73	Very Easy	0,43	Very Good	60	33	
29	0,44	Avarege	0,57	Very Good	47	11	
53	0,49	Avarege	0,56	Very Good	51	16	
56	0,65	Easy	0,40	Very Good	55	30	
63	0,70	Very Easy	0,57	Very Good	60	24	

70	0,70	Very Easy	0,56	Very Good	59	24
75	0,66	Easy	0,65	Very Good	62	21
76	0,68	Easy	0,51	Very Good	57	25

In Table 7, each dimension was assessed in itself and the results were found. The discrimination values of the questions in dimensions were found to be close to each other. When their difficulties were examined, it can be said that the dimension which compared musical instruments and the sound included more difficult questions. The easiest questions are in dimensions which include the concepts of sound propagation and sound properties which are the first and fifth dimensions.

One of the methods used to determine the reliability of the test is Kuder-Richardson approach (Günsakal, 2001). The method is based on determining whether all the items are consistent with each other and all the other questions (Gay, 1985; Ural & Kılıç, 2005). This method is a method developed with the view that each item is parallel with the other items and has the same average and variance with the other items. 1 point is used for the correct questions while 0 is used for the incorrect and unanswered ones. This method is used in tests the item difficulty indexes of which can be calculated, in tests the item difficulty of which cannot be calculated, KR-20 is used (Tanrıöğen, 2009). KR-20 formula is as follows.

$$KR_{20} = \frac{K}{K-1}\left[1 - \frac{\sum pq}{S_x^2}\right]$$

K = Number of test items

p = Item difficulty

q = 1- p

S_x^2 = Variance of the test

Table 8 gives the KR-20 values for the first and last version of SAT. This will inform us about the reliability of the test.

Table 8. Difficulty, discrimination and KR-20 values of SAT

	Total Item	N	Difficulty p	Discrimination rjx	KR-20
Pilot	85	234	0,55	0,57	0,92
Final	43	234	0,59	0,53	0,83

The analysis showed KR-20 value for the pilot test as 0,92. From the data obtained, the questions with discriminative values between 0,01 and 0,40 were eliminated and the actual test was prepared. KR-20 value of the actual test was found as 0,83. This value is sufficient for the reliability of achievement tests (Afacan, 2010; Gönen & Kocakaya, 2011; Köseoğlu et al., 2007; Sadleretl, 2010; Sesen & Tarhan, 2010; Saipanishetl, 2015). Analyses results show that this test is a reliable and valid test in measuring the related student achievement.

4. Conclusions

0,92 KR-20 value which is found as a result of the item analysis of 85 questions shows that the test can be administered. However, since there were too many questions and the questions with low discrimination values were eliminated, the number of items was reduced to 43. For the final test, KR-20 value was found as 0,83, average difficulty was found as 0,55 and average discrimination was found as 0,57. These values are sufficient for the reliability of the test. Assessment tools and developing assessment tools are important elements of education. Assessment tools have a great importance in terms of explaining education and finding the needs. With a well prepared assessment tool, the alternative concepts and levels of students can be found. Thus, assessment tools should be relevant, valid and reliable. We are of the opinion that this scale we developed is a wide assessment tool which includes concepts about propagation, velocity, frequency and intensity of sound, its association with musical instruments, sound energy and its use in daily life.

Possible alternative concepts in questions asked to students were found by making use of our previous studies (Bolat & Sözen, 2009; Sözen, 2009; Sözen & Bolat, 2011; Sözen & Bolat, 2014). The developed scale was

helpful in finding the alternative concepts of students. These alternative concepts are shown in Table 9 according to dimensions.

Table 9. Alternative concepts in SAT according to dimensions

Dimension	Alternative Concept
1. Dimension Sound propagition	The ability of sound to carry material while moving in air The ability of sound moving the material ahead while moving Not being able to think that sound propagates with vibration Not being able to think that a material environment is required for the formation of sound Not being able to associate between frequency and compaction and expansion of particles Not being able to think that the resonance of the sound that forms when the environment changes will be different Not being able to think that sound can propagate in space
2. Dimension Velocity of sound	Thinking that sound propagates faster in space Thinking that velocity of sound is influenced by electricity conductivity and transparency Thinking that velocity of sound changes with the length of the material that forms the sound Thinking that the source of sound can influence the greatness of energy (intensity) can influence the pitch of sound Not being able to associate the velocity of sound with the frequency of particles that form the sound Thinking that the velocity does not change when sound moves from an environment to another Thinking that velocity changes when sound reverberates
3. Dimension Sound energy	Thinking that sound cannot turn into another energy Not being aware of technological devices made by using the energy of sound Confusing sound energy with echo
4. Dimension Musical instrument & Sound	Not being able to associate between the length of musical instrument and string and the pitch of sound and notes Not being able to think that the length, type, thickness and strain of string can influence the frequency of sound Not being able to think what can be done to increase the intensity of sound in musical instruments Not being able to associate between the amount of matter and high pitch and low pitch sound
5. Dimension Property of sound	Not being able to associate between the intensity of sound and amplitude Not being able to associate between frequency and vibration Not being able to find out the properties that influence the frequency of sound Not being able to find out the properties that influence the amplitude of sound Not being able to associate between wave graphs and pitch of sound and weakness and intensity Not being able to think that intensity of sound will increase as temperature increases Not being able to associate between the frequency and amplitude of sounds the wave graphs of which are given Not being able to associate between high pitch and intensity Not being able to identify what sound noise is Not being able to associate between sound properties and units Confusing sound level unit decibels and frequency unit Hertz

The data in Table 9 shows that SAT is a very practicable test in terms of finding out many alternative concepts of students. Thus, as well as finding out students' achievements, their alternative concepts will also be found out.

5. Suggestions

– This test can be administered to students studying their last year at secondary school. The scale can be developed by the addition of extra concepts about sound up to 12th grade. For example, mechanical wave property of sound and the properties of mechanical waves can be included in the scale. At the same time, questions which include questions about the concepts of types of waves and cross-sectional and longitudinal waves can be asked.

– This test can be used as data collection tool for studies in this field.

– The reliability of the test can be tested by administrating the test on different samples.

– This test gives us ideas about students' achievement and their possible alternative concepts. However, multiple choice tests do not allow us the possibility to find out the misconceptions of students thoroughly. Thus, using teaching methods about these subjects and further studies will increase the validity and reliability of the data obtained.

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Appendix

Sound Diagnostic Test

School:

Grade:

Sex: Female 

Male

Age:

1) In which of the following environments do sound waves propagate faster?

a) Sea water b) Air c) Aluminium wire √ d) River water

2) Which of the following statements about the amplitude and intensity of sound is true?

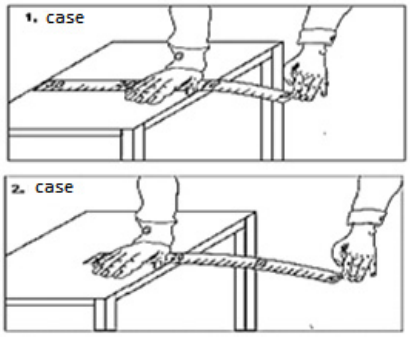
a) As the amplitude of sound increases, so does the intensity of sound. √

b) As the amplitude of sound decreases, intensity of sound increases.

c) When the amplitude of sound increases, intensity of sound remains constant.

d) There is no association between the amplitude of sound and the intensity of sound.

3) Efe places a 30 cm long ruler on the edge of a table in two different ways.



Efe, who presses the ruler on the table in either way, stretches the end of the ruler which is not on the table with his other hand and then lets loose. As a result of this process, he realizes that the sound that comes out with the first situation is deeper than the first situation.

According to this, with which of the following does Efe explain as the reason for deeper sound?

a) With the increase in the amplitude of sound

b) With the increase in the frequency of sound √

c) With the decrease in the amplitude of sound

d) With the decrease in the frequency of sound

4) In an environment, which of the following quantities of the environment is the velocity of sound propagated directly associated with?

I. Transparency

II. Heat

III. Electric conductivity

a) Only II √ b) Only I

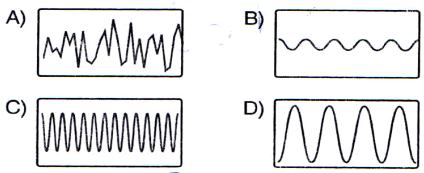
c) Only III d) I and II

5) The string K makes 15 vibrations in a period of t, while the string L makes 15 vibrations in a period of 3t and the string M makes 30 vibrations in a period of 5t.

According to this information, which of the following gives the correct order of frequencies from the smallest to the biggest?

a) K,L,M b) M,L,K c) L,K,M d) L,M,K √

6) Which of the following gives the wave graphic of the sound that comes out when concrete breaker is working?



7) Which of the following comments is correct according to flutes of different sizes?

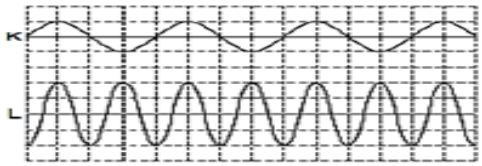
a) It is made to carry easily

b) The long flute gives out a deep sound √

c) The shortest one gives out the highest sound.

d) The sound that comes out from a flute cannot be acquired from other flutes.

8) The sound waves of K and L are as follows.



Which of the following is correct in terms of the K and L sounds being low pitched-high pitched and intense-weak when compared with each other?

	Low-High		İnense -Weak	
a)	L	K	K	L
b)	K	L	L	K
c)	L	K	L	K
d)	K	L	K	L

9) I. While following the development of the unborn baby

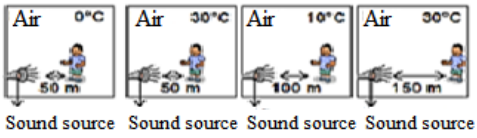
II. While finding out the place of a shoal in the sea?

III. While breaking a kidney stone

Which of the above makes use of the energy of sound waves?

a) Only III b) Only I

c) I and II d) I, II and III √



10) An observer tries to hear sound in different situations as in the figures without changing the intensity of sound.

Thus, which of the following question/s can the observer answer?

I- Does the velocity of sound propagation change with temperature?

II- Does the intensity of sound increase as one moves away from the sound?

III- Does the intensity of sound decrease in terms of different environments?

a) I, II and III b) I and II

c) Only III d) Only I

11) Which of the following affects the velocity of the propagation of sound in a material?

I. The length of the matter

II. The magnitude of the intensity of the sound source

III. Deepness or weakness of the sound

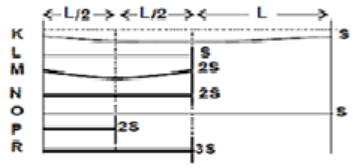
IV. The distance between the particles of the material in which sound propagates

V. High or low temperature of the environment in which sound propagates

a) I, IV, V b) III, V

c) III, IV, V d) IV, V √

12) The frequencies of the sounds of strings with different sections (S) and same type and length (L) which are held from both ends are also different. Which of the strings in figures should a student who wants to prove this conclusion use?



a) K and O b) M and P

c) L, N and R d) K, M and R

13) How do the air particles move when the sound passes from air?

a) They stay motionlessly where they are.

b) They generally move to the direction where the sound comes from (away from the source)

c) Air particles just act in vibrations √

d) They can move in any direction

14) We cannot hear the sound of ambulance passing by soon after. Which of the statement/s can explain this?

I. We cannot hear the sound of objects which is disappearing and can not see.

II. Sound energy has transformed into other energy.

III. The amplitude of the sound has gradually shrunk.

a) Only I b) II and III √

c) I, II and III d) I and II

15) Which of the following is not a proof that sound is not a kind of energy?

a) A plane crash causing vibrations in the glasses of houses

b) The light of the lightening coming first followed by sound √

c) Breaking kidney stones with sound waves

d) Scattering of the objects around due to an explosion

16) Ali: We cannot hear the sound of each vibrating object.

Ferhat: The number of vibrations in a unit of time is called frequency.

Ömer: Sound is caused by a vibration.

Which of the above information about sound is incorrect?

a) Ali

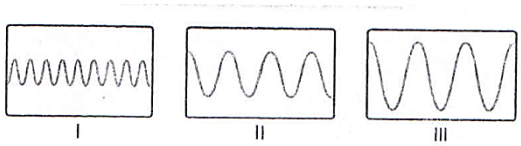
b) Ferhat and Ömer

c) All of them

d) None of them √

17)

	K	L	M
Frequency (Hz)	1000	750	1500
Intense (dB)	40	60	10



Which of the following gives a correct matching of K,L,M sounds the frequency and intensity values of which are given and wave graphics of I,II,III?

a) K:I L:II M:III

b) K:II L:I M:III

c) K:II L:III M:I √

d) K:III L:I M:II

18) The frequency of sound waves are associated with ……

a) Highness of the sound √

b) Intensity of the sound

c) Highness and intensity of the sound

d) The temperature in the environment

19) Merve: Amplitude and frequency are two features that help us define sound.

Kuzey: Particles which transmit the energy of sound make a movement of oscillation.

Nilay: For a vibrating object to produce sound, the object should be within a physical environment.

Which of the above information about sound is correct?

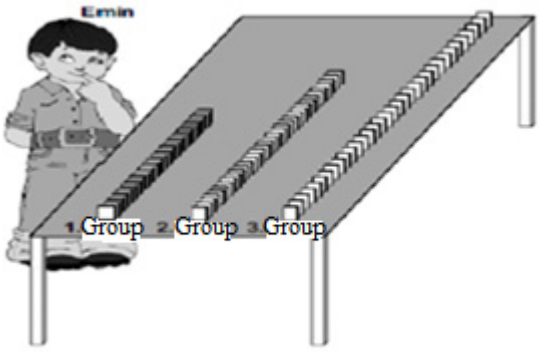
a) Nilay

b) Kuzey and Merve

c) Kuzey

d) Kuzey, Nilay, Merve √

20) Emin, who makes a modelling for information about sound, makes 3 groups of 100 from 300 dominos. He lines the dominos in the first group with an interval of 1 cm, the dominos in the first group with an interval of 1,5 cm, the dominos in the first group with an interval of 2 cm as in the figure.



Emin, who applies the same driving force to the first domino in three groups, records the period until the last domino falls in the following table.

Emin's Measurement results

Grup	Geçen süre
1. Group	2 Second
2. Group	2,5 Second
3. Group	3 Second

According to this table, for which information did Emin prepare a modelling?

a) Sound propagates at solids the fastest, followed by liquids and gases.

b) Even if the intensity of sound increases, its velocity of propagation does not change.

c) Sound is an energy and it can be turned into another energy

d) The energy of sound grows as it comes closer to the source

21) Jet planes causing the windows of houses to shake while flying low.

Opera singers breaking glass,

Breaking of kidney stones with sound technology

Which property of sound are the above mentioned things associated with?

a) Velocity b) Timbre c) Energy √ d) Height

22) When your mother tells you to "turn the volume of the radio down", in fact she means …….

a) Reduce the frequency of sound waves

b) Increase the frequency of sound waves

c) Reduce the amplitude of sound waves √

d) Increase the amplitude of sound waves

23)

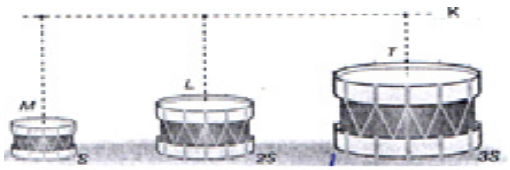
İmage 1 İmage 2 İmage 3

Which of the following figures is a proof that sounds is a type of energy.

a) Only I b) I and III

c) I and II √ d) I, II and III

24)



The surface areas of the drums made from materials of equal tightness and identical material are as in the figures above. A stone from K surface is dropped on the drums.

Which one shows the ordering of the frequencies of sound obtained from M,L,T drums from the biggest to the smallest?

a) T,L,M b) L,M,T c) M,L,T √ d) L,T,M

25)

According to the K and L sound wave graphics in the same time zone, which features of K and L sounds are absolutely different?

a) Amplitude b) Frequency √ c) Intense d) Velocity in air

26) The type of the material it is made from

Length of the string

Thickness of the string

Tightness of the string

How many of the above affect the frequency of the sound that comes from a string?

a) One b) Two c) Three d) Four √

27) Performers who play string instruments make different tunes and notes by pressing the different points of their instruments.

Which of the following can explain why performers press the different points of the strings?

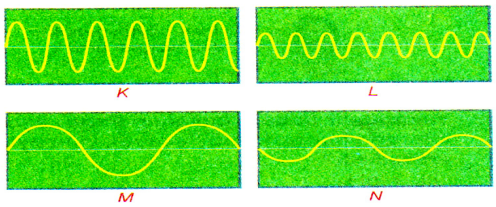
a) To change the length of the string √

b) To change the tightness of the string

c) To change the temperature of the string

d) To change the vibration intensity of the string

28) For which of the following graphics below, the frequency of the sound made for the source of sound is high and low pitched?



a)K b) L √ c) M d) N

29) Which of the following definitions is correct for a thin, nice sound that does not disturb the ear?

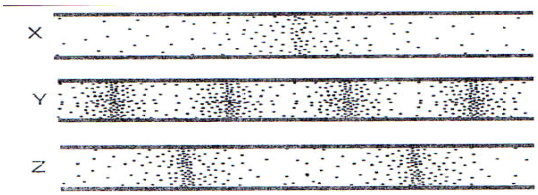
a) High frequency, high amplitude

b) High frequency, low amplitude √

c) Low frequency, low amplitude

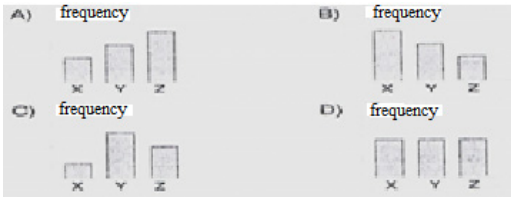
d) Low frequency, high amplitude

30)



The transmission of X,Y,Z sounds in one second by air particles in identical air section is given as in the figure.

Which of the following column chart shows the frequency of these sounds?



31) Efe, who presses the point K on the top string of the guitar, taps the same string with his right hand as in the figure and listens to the sound that comes out.

Efe wants to decrease the highness and intensity of the sound. Thus, which of the L and M points of the same string should he press and how should he tap this string with his right hand?

	Left hand	Rigt hand
a)	M point	faster
b)	M point	slower
c)	L point	faster
d)	L point	slower

32)

The particle models of a matter in its three states are shown.

Which of the following is correct about the sound's velocity of propagation in these matters?

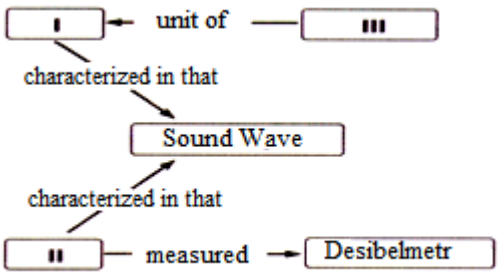
a) II>I>III √

b) I>II>III

c) III>II>I

d) I>III>II

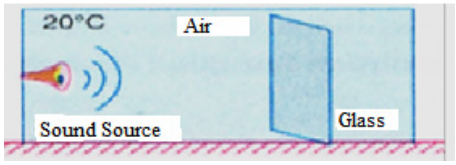
33)



How can the gaps in the concept map above be filled?

	I	II	III
a)	Frequency	Volume	Decibel
b)	Volume	Frequency	Decibel
c)	Frekans	Volume	Hertz √
d)	Energy	Frequency	Hertz

34)



Sound energy can be broken with glass as in the figure.

In order to prevent the glass from breaking;

I. The temperature of the environment should be reduced,

II. The glass should be approached to the source of the sound,

III. The air of the environment should be emptied.

Which of the following procedures should be followed?

a) I and II b) I and III

c) Only III √ d) Only I

35) (……) Sound waves can pass from air to water

(……) Sound waves can pass from solid to air

(…...) The velocity of sound which changes its state also changes

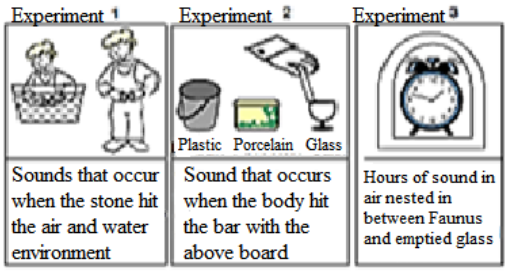
(…...) The velocity of sound which is reflected from the Wall changes

When T is written at the beginning of the sentences which contain True information and F is written at the beginning of the sentences which contain false information, which of the following T and F ordering will be correct?

a) T, T, T, F √ b) T, T, F, T

c) T, F, T, F d) F, F, T, T

36)



Which of the following judgements can the above experiments 1, 2 and 3 be tested with?

I- If the sources of sound are different, sounds produced from each one will be different.

II- If the environments are changes without changing the source of the sound,

III- the sounds one hears will be different. III- Sound will not propagate in space..

	Experiement 1	Experiement 2	Experiement 3
a)	I	II	III
b)	II	I	III
c)	III	II	I
d)	I	III	II

37) What is the most important feature of a sound that can cause harm in our ear?

a) It has a big amplitude. √

b) It has a small amplitude.

c) It has a low frequency.

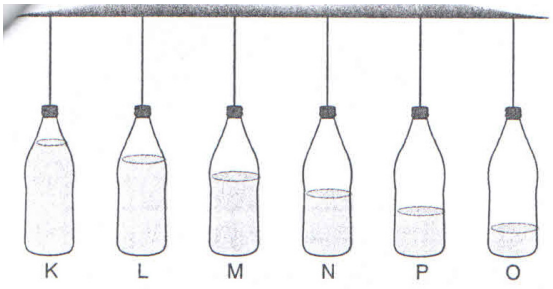
d) It has very big frequency.

38) When the intensity of sound in the source of the sound is increased, ……(I) of the sound wave also increases, however, ……(II) does not change.

Which of the following should be used to fill in the gaps in a suitable way?

	I	II
a)	Amplitude	Frequency √
b)	Frequency	Amplitude
c)	Frequency	Velocity
d)	Velocity	Amplitude

39)



Some sounds are produced by hitting with wooden sticks to identical bottles above prepared by putting different amounts of water. Answer the following questions according to these explanations.

Which bottle will give the highest sound?

a) K b) M c) P d) O √

40) Which bottle will give the lowest sound?

a) K √ b) L c) P d) O

41) When hit with the stick, which bottle will vibrate least in a unit of time?

a) K √ b) N c) P d) O

42) Which of the following bottles will give the highest sound?

a) L b)M c) N d) P √

43) Which of the following ordering from the highest to the lowest is incorrect?

a) P,N,K b) M,L,K c) O,L,K √ d) M,N,L