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Knowledge levels of prospective science and physics teachers on basic concepts on sound (sample for Samsun city)

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Abstract

The study has been focused on the basis of determining the knowledge levels of prospective Science and Physics teachers on basic concepts on sound. The design of the research is a case study. The sampling consists of 92 students studying in Science and Physics teaching departments in the Faculty of Education at Ondokuzmayıs University in the academic year of 2007/2008. Data were collected from by the means questionnaires. The data were analyzed both qualitatively and quantitatively. It was determined that the knowledge levels of prospective teachers on basic concepts were low and misconceptions were rather high. The results of study were interpreted comparing other studies in literature.

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Keywords: Case study; primary school curriculums; sound; concept; knowledge levels.

1. Introduction

Primary education is the most important step of our education system. The role that the child will likely take in the future in his school life is mostly formed during the primary education of educational system. Therefore, this level of education has been called as basic training as in many countries. The other educational steps are based on primary education. The researchers have been mostly focusing on primary education in recent years.

It has been observed that examining of educational programmes and textbooks, usage of techniques and methods are emphasized in this study (Tytler, 2001; Aikenhead, 1996; McComas & Almazroa, 1998; Matthews, 1997; Lakin and Wellington, 1994; Hodson, 1992; Meriç, 2003, Altun, 2004; Özsevgeç, 2006; Çepni et. al., 2003).

Blosser (1987) defines the concepts as units of thought and during childhood, concepts and the words named for concepts are learnt, then concepts are classified and relationships between them are found. New concepts and knowledge are produced by using these concepts. This learning lasts whole life. Misconception is defined as supernatural events, destiny, luck and unfounded belief without fear elements. It has been observed that researchers made a lot of studies to enlighten these subjects and to determine the knowledge levels and misconceptions of the
students (Abimola, 1988; Eaton et. al., 1984; Stead & Osborne, 1980; Shipstone, 1984; Engel & Driver, 1985; Clement, 1982; McDermott, 1984; Sere, 1985; Novick & Nussbaum, 1981; Miller et al. 1985; Meheut et. al., 1985; Driver & Ericson, 1983; Gilbert & Watts, 1983; Akgün vd, 2005; Korkmaz & Kaptan, 2003).

In the study in the field of training carried out by Pearlsall at al. (1997), it was shown that although the best teachers showed their best performances, the students were unsuccessful mostly in understanding the central concepts in Science, and had problems in comprehending, and those graduated from the best schools had also the same problems. Accordingly, conceptual difficulties are the expected parts of learning and misconceptions are the efforts of students in order to develop sense about natural events and objects.

When we searched the studies related to sound, it attracted our attention that there are not many researches concerning this subject in Turkey. But, some studies concerning this subject were carried out abroad, even if not enough, compared to other research bases. In these studies, there are not only researches in order to find out the most basic knowledge of the students related to sound (Linder and Ericson, 1989; Maurines, 1992; Hrepic, 2004) but there are also researches in order to find out misunderstandings of the students (Linder, 1992; 1993; Merino, 1998; Beaty, 2000; Wittmann, 1998; 2002). Apart from the studies mentioned above, there were also studies aimed to find out the differences between students centered method and traditional method (Barman et al, 1996).

When we examined the Primary School Science and Technology curriculums, we have observed that a lot of concepts related to sound and its features were mentioned from fourth to eighth grade. Therefore, researches were highly interested in the sound knowledge levels of prospective teachers to work in Primary and Secondary schools. This study is based on determining the knowledge levels of Science and Physics teachers related to some concepts about sound. Besides, the study aimed to answer the questions whether the knowledge levels of prospective teachers related to some concepts about sound show any differences according to variables such as their fields, mother’s education, father’s education and sexes or not.

2. Method

The design of the study is a case study. The population of study consists of the first grade students in Science teaching department and the fifth grade students in Physics teaching department in Samsun. In this study, randomly chosen subject method is used. Participants are 92 prospective teachers studying in Physics and Science departments in the Faculty of Education at Ondokuzmayıs University in the academic year of 2007/2008. 42 of the participants is male and 50 of them is female. Data collecting means was developed by the researchers through scanning the literature and compatible with Science and Technology programmes (M.E.B., 2006; Hrepic, 2004; Wittmann, 2002). Developed data collecting means was checked by field experts, field educators and experienced teachers. In this study, 25 multiple choice questions (among these questions, explanations related to the velocity of sound in questions 1, 2 and 3 were requested) and 3 prearranged questions about how the sound is propagation were asked. Questions involve basic concepts concerning sound such as vibration, wave, transmission, velocity, loudness, intensity and isolation. Obtained data were analyzed question by question. The data analyzed by SPSS 14.0 programme on computer were interpreted by the help of the results of Chi-Square and frequency and percentage distribution. Significance level was accepted as .05. But, qualitative data were analyzed through document analysis method.

3. Finding

Multiple choice questions assigned in the study are grouped as in Table 1 according to the basic concepts related to sound chosen by us.

| Group no | Concepts                     | Questions |
|----------|------------------------------|-----------|
| Group 1  | Feature of sound, wave and vibration | 6, 10, 13, 17, 18, 19, 21 |
| Group 2  | Velocity of sound            | 1, 2, 3, 4, 11, 14, 19, 20, 22, 24 |
| Group 3  | Loudness and intensity of sound | 5, 8, 9, 25 |
| Group 4  | Isolation of sound and usage in daily life | 7, 12, 15, 16, 23 |

The frequencies of the participants’ responses to the classified multiple choice questions are shown in table
Table 2. Frequencies of the students’ responses to the questions according to the choices

| Group 1 Questions | A  | B  | C  | D  | E  |
|-------------------|----|----|----|----|----|
| Question 6        | 8.7% | 13% | 23.9% | 15.2% | 2.2%* |
| Question 10       | 2.2% | 2.2% | 9.8% | 81.5%* | 4.3% |
| Question 11       | 2.2% | 73.9%* | 12% | 5.4% | 6.5% |
| Question 13       | 5.4% | 10.9% | 19.6% | 8.7% | 53.3%* |
| Question 17       | 0% | 0% | 1.1% | 14.1% | 84.8%* |
| Question 18       | 4.3% | 54.3%* | 32.6%* | 5.4% | 0% |
| Question 20       | 8.7% | 15.2% | 21.7% | 10.9% | 37%* |
| Question 21       | 4.3% | 65.2%* | 2.2% | 19.6% | 5.4% |

| Group 2 Questions | A  | B  | C  | D  | E  |
|-------------------|----|----|----|----|----|
| Question 1        | 37.1%* | 0% | 44.5% | 14.1% | 2.2% |
| Question 2        | 6.5% | 50.2% | 40%* | 0% | 3.3% |
| Question 3        | 19.6% | 0% | 19.6% | 45.7%* | 14.1% |
| Question 4        | 13% | 2.2% | 8.7% | 51.1% | 21.7%* |
| Question 14       | 22.8% | 29.3% | 26.1% | 13%* | 5.4% |
| Question 19       | 13%* | 64.1% | 15.2% | 2.2% | 2.2% |
| Question 22       | 15.2% | 8.7% | 57.6%* | 1.1% | 13% |
| Question 24       | 31.5%* | 22.8% | 2.2% | 2.2% | 39.1% |

| Group 3 Questions | A  | B  | C  | D  | E  |
|-------------------|----|----|----|----|----|
| Question 5        | 10.9% | 32.6%* | 22.8% | 14.1% | 17.4% |
| Question 8        | 3.3% | 32.6% | 23.9% | 14.1%* | 23.9% |
| Question 9        | 32.6% | 4.3% | 38%* | 4.3% | 17.4% |
| Question 25       | 10.9%* | 39.1% | 30.4% | 2.2% | 9.8% |

| Group 4 Questions | A  | B  | C  | D  | E  |
|-------------------|----|----|----|----|----|
| Question 7        | 0% | 1.1% | 93.5%* | 0% | 5.4% |
| Question 12       | 3.3% | 2.2% | 51.1% | 31.5%* | 0% |
| Question 15       | 2.2% | 42.2%* | 14.1% | 14.1% | 26.1% |
| Question 16       | 9.8% | 5.4% | 48.9%* | 26.1% | 9.8% |
| Question 23       | 19.6% | 27.2%* | 21.7% | 22.8% | 6.5% |

*Correct answer

On examining table 2, it is obvious that frequencies of correct answers of the students to some questions in the groups are rather low, but in some groups of questions they are high.

When the responses obtained separately from prospective Physics and Science teachers to all multiple choice questions according to Chi-Square analysis on .05 significance level were compared, it was observed that there was a significant difference in favor of Physics teachers in the first and second questions 0.005, in the third question 0.025, in the fifth and sixteenth questions 0.004, in the eighth and twenty-third questions 0.001, in the nineteenth question 0.029, in the twenty-second question 0.018, and in the twenty-fourth question 0.002 significance levels.

On analyzing the data obtained from students participated in the research according to Chi-Square results on .05 significance level, no significant difference was found between sex, mother’s education and father’s education.

Table 3. The responses of university students the the questions: “In which medium does sound spread faster? Why did you give this answer?” and frequencies of these answers (N: 92 participants)

| Choice (frequency) | Sample answers | Quantitative | Qualitative |
|--------------------|----------------|--------------|-------------|
| A* (37%) Solid     | Correct explanations (Frequency) | Incorrect explanations (Frequency) |
|                   | When molecules are closer, vibration is easier* (38.2%) | Since density is high, sound is fast (8.8%) |
|                   | Since molecules are close together* (26.4%) | Other (26.6%) |
| C (44.5%) Gas      | Since the distance between molecules is far, sound is fast 34.1 | Since gas molecules are faster, sound is fast 17.1 |
|                   | Since density is low, sound is fast 4.9 | Since no obstacles, sound is faster 7.3 |
|                   | Since no obstacles, sound is faster 2.4 | Other 29.3 |
| D (14.1%) Airless medium | Students without any explanations 46.2 | Students without any explanations 38.5 |
| E (2.2%) Equal in all of them | Since the space is distant between molecules 7.7 | Students without any explanations 38.5 |
|                   | In space, more sound propagates 7.7 | Students without any explanations 38.5 |
|                   | Students without any explanations 50 | Students without any explanations 50 |
|                   | The number of those who left totally blank 100 | The number of those who left totally blank 100 |

* Correct answer
On examining the table above, when compared the qualitative and quantitative analysis of the first question in multiple choice related to velocity of the sound, although 37% of the participants gave the correct answer, it was observed that only 26.1% of them gave correct explanations qualitatively.

Table 4. The responses and frequencies of these responses to the question: “Person A is speaking. Explain how person B hears the sound of person A by using your drawings.” (N: 92 participants)

| Alternative answers given to questions. | Frequency |
|----------------------------------------|-----------|
| Arrives by propagating through waves*   | 41,3      |
| Only by means of vibrations *           | 4,3       |
| Arrives both through wave and vibration*| 6,5       |
| Explaining biologically                | 17,4      |
| Explaining by drawing arrows           | 18,5      |
| Other                                  | 3,3       |
| Students left totally blank             | 8,7       |

* Correct answer

When analyzed the question “Person A is speaking. Explain how person B hears the sound of person A by using your drawings.” qualitatively; those who gave the correct answers were grouped in three categories. This consists of 52% of the participants.

Table 5: Frequency data of the responses to the question: ‘How does the velocity of sound change depending on distance between particles in elements where the sizes of particles (in volume and mass) is same but the distance among the particles is different and why did you give this answer,’ (N: 92 participants)

| Quantitative Choice (Frequency) | Sample answers | Qualitative | % |
|---------------------------------|----------------|-------------|---|
| A                               | Since medium is same |              | 16,7 |
|                                 | Intensity is high, velocity is same | | 16,7 |
| Both are equal                  | Depends on not the structure of the wall but on frequency and wavelength | | 16,7 |
| B                               | Students without any explanations | | 50 |
| Material a is faster than material b | If the distance among molecules far, it is fast. | | 50 |
|                                 | Since there are few obstacles, sound is fast. | | 10,9 |
|                                 | Other | | 8,7 |
|                                 | Students without any explanations | | 30,4 |
| C*  | Correct explanations (frequency) | Incorrect explanations (frequency) |
| Material a is slower than material b | If the distance among molecules is short, sound is fast* (32,4%) | As the density increases sound speeds up (14,7%) |
| | If the space among molecules is small, vibration is high and sound is fast* (26,9%) | Other (26%) |
| E  | Students without any explanations | 100 |
| (2,2%) | I have no idea | |
| (11, 1%) | Number of those who totally left blank | 100 |

* Correct Answer

If you examine the table above and compare the qualitative and quantitative analysis of the second multiple question related to the velocity of the sound, although 40,2% of the participants gave correct answers quantitatively, only 23,9% of them gave correct explanations qualitatively.
Table 6: Frequency data of the responses to the question; ‘How does the velocity of sound change depending on distance among particulars in elements where the size of particulars (in volume and mass) is different but the distance among the particulars is same and Why did you give this answer?’ (N: 92 participants)

| Quantitative | Qualitative |
|--------------|-------------|
| Choice (frequency) | Sample answers | % |
| A (19,6%) | Does not affect by mass | 50 |
| Velocity of sound is equal in both. | Other | 16,6 |
| | Those without any explanations | 33,3 |
| C (19,6%) | If the molecules are big sound is fast | 16,6 |
| Material a is faster than material b | Other | 16,6 |
| | Those without any explanations | 66,7 |
| D* (43,7%) | Correct explanations (frequency) | Incorrect explanations (frequency) |
| Material a is slower than material b | If the mass is big, sound is slow* (38,1%) | Other (16,6%) |
| | If the density is low sound is faster* (9,5%) | Those without any explanations (33,4%) |
| | If the mass is big, vibration is less, sound is heard more slowly* (2,4%) | |
| E (14,1%) | Those without any explanations | 100 |
| I have no idea | |
| (1,1 %) | Those who left totally blank | 100 |

* Correct answer

If you examine the table above and compare the qualitative and quantitative analysis of the third multiple question related to the velocity of the sound, although 45,7 % of the participants gave correct answers quantitatively, only 15,8 % of them gave correct explanations qualitatively.

Table 7: The answers and the frequencies of these answers to the question; ‘Where will the dust particle be when the loudspeakers are stopped, while they are producing sound for a while? and Draw the place of the dust particle on the diagram?’ (N: 92 participants)

| Alternative answers | % |
|---------------------|---|
| It makes vibration motion, does not change its place * | 1,1 |
| It stays in the same place * | 7,6 |
| It approaches the girl | 63 |
| It scatters | 5,4 |
| Other | 4,6 |
| Students who left totally blank | 15,2 |

* Correct answer

When the question on table 7 ‘Where will the dust particle be when the loudspeakers are stopped, while they are producing sound for a while? and Draw the place of the dust particle on the diagram?’ is analyzed qualitatively, those who gave correct answers were classified into three categories. This consists of % 8,8 of the participants.

Table 8: The answers and the frequencies of these answers to the question; ‘How is the motion of the candle flame when the loudspeakers are stopped, while they are producing sound for a while? and Draw the place of the candle flame on the diagram?’ (N: 92 participants)

| Alternative answers | % |
|---------------------|---|
| It stays in the same place, does not move* | 7,6 |
| Those who answered: it makes vibration motion in right/left* | 4,4 |
| Those who answered: it approaches the girl | 76,1 |
| Other | 1 |
| Students who left totally blank | 10,9 |

* Correct answer

When the question on table 8 ‘How is the motion of the candle flame when the loudspeakers are stopped, while they are producing sound for a while? and Draw the place of the candle flame on the diagram?’ is analyzed qualitatively, those who gave correct answers were classified into three categories. This consists of % 12 of the participants.
4. Results and Discussion

Students’ correct and wrong answers to multiple choice questions which were separated into groups by us and conducted in the research are shown in Table 2. The following misconceptions and insufficient knowledge of the students were determined by means of wrong answers.

Group 1: (Wave and vibration features of sound)
- Students do not know that;
- Sound is a longitudinal wave
- Sound waves form pressure alteration.
- Sound is a kind of energy
- Students think that;
- Sound is transmitted by reflection and absorption
- While the sound is being transmitted, the air molecules in front of the sound stay motionless or air molecules move in the direction of that sound propagates
- While the sound is passing from one medium to another, its wavelength does not change
- Sound does not diffuse in solid
- Sound formed in one medium cannot be heard in another medium
- Sound can be generated in airless medium

Group 2: (sound velocity)
- Students think that;
- When molecules are close together, sound propagates more slowly
- They cannot establish the relationship between the density of the medium and the velocity of sound
- When the energy of the sound source is high, the speed of the sound increases
- The frequency of the sound affects the velocity of the sound
- Sound velocity is low in solid
- As the density increases, the velocity of the sound increases, too
- Sound can be generated in airless medium and the velocity is faster than that in the air
- Heat does not affect the velocity of the sound

Group 3: (Pitch and intensity of sound)
- Students cannot establish the relationship;
- Between the frequency of the sound, wave length and its period,
- Between the frequency of the sound and the thickness and thinness of the sound,
- Between the intensity of the sound and amplitude.
- They do not know that;
- Pitch of sound means the same as sound frequency
- They do not think that;
- Intensity of the sound and height of the sound express the same meaning.

Group 4: (Sound Isolation and Usage in daily life)
- Students think that;
- Iron can be used in the isolation of the sound
- It was determined that they do not know;
- the tools which are made utilizing the physics of sound
- the materials which are used in the isolation of the sound
- what kind of materials can be used in decorating the places such as cinemas and theatres
- The data obtained from prearranged questions used in the research are shown in table 3, table 4, table 5, table 6, table 7 and table 8. When these tables were studied, it was determined that participants’ misconceptions and insufficient knowledge were as mentioned below.
- These were determined as follows;
- Sound is fast in solid, as it is denser
- Sound is faster in gas, as the distance among molecules is distant
• Sound is faster in gases, as gas molecules are faster
• Sound is faster in gases, as the density is low
• Sound is faster in gases, as there are not any obstacles
• Gas is faster in airless medium, as there are not any obstacles
• In space, more sound diffuses
• The velocity of sound is same in all mediums, but the intensity alters
• If the distance among molecules is distant, the velocity of the sound is higher
• In the case of the sizes of molecules (in volume and mass) are same, but the distance among particles is different, the velocity of the sound depends on the frequency and wave length.
• While sound is being generated, the air particles will move in the direction of the sound propagates
• In addition, it was determined that they did not know that;
• Sound diffuses through vibration and waves
• Sound is a vibration but what vibration means

   Analyzed of participants responses has been observed that the misconceptions and insufficient knowledge obtained in grouped multiple choice questions show similarities with those obtained in prearranged questions. Especially, it has been observed that students’ misconceptions and insufficient knowledge related to velocity of sound and sound wave and sound vibration features exposed quite distinct in prearranged questions compared to multiple choice questions.

   In the study, our students’ having insufficient knowledge related to the point that sound is transmitted by vibration, that is; it is transferred by energy transfer from one molecule to the other along a medium shows similarities with the results that Linder (1992) and Barman et al (1996) obtained from their studies. Besides, according to the results of their studies, students’ thinking that the velocity of sound can be obstructed by the medium it is moving through, the density of the medium molecules will increase this obstacle and as there are no obstacles in airless medium, the sound will be high and their not knowing that how the heat affects the velocity of the sound overlaps with the study of Linder (1993).

   It is consistent with the results obtained from Hrepic’s (1998) study that in our findings, students think that sound can be slowed down by obstacles, sound cannot be generated in solids, and the speed of sound in dense media will be faster. Their not being able to determine the relationship between the intensity and amplitude of the sound is consistent with the results of Merions’ (1998) study. It overlaps with the results obtained from Beaty’s (2000) study, that students think that as the density increases, the sound speed will also increase, sound propagates in the spaces among the substances rather than in substance itself and substances, too, move together with waves. It shows some similarities with the results Witmann et. al. obtained in his study in 2001 that students have some difficulties in defining the motion of candle flame and dust particles.

   In addition to these, in our study it has been pointed out that students do not know that sound waves are pressure alteration, what the word ‘vibration’ means and the materials used in sound isolation. It was found out that students thought that iron could be used in the isolation of sound, sound formed in one medium cannot be heard in another medium and sound could be transmitted through absorption and reflection. In addition, their not being able to establish the relationship between the frequency of sound, its wave length and its period and between the frequency of sound and thickness and thinness of sound is one of the other obtained results.

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