International Journal for Innovation Education and Research

ONLINE ISSN: 2411-2933 PRINT - ISSN: 2411-3123

Physical Preconception of Primary Education Pupils

Ljiljanka Kvesić PhD;Slavica Brkić PhD;Marina Zubac

Abstract

During their preschool age children discover natural phenomena in their environment. In their consciousness, they form the basic physical concepts based on experience. Their ideas can be right, but they can also be wrong because they take into consideration only what they see and thus, they come up with wrong ideas or misconceptions. At the very beginning of their primary education, teachers of class teaching directly witness their ideas related to basic physical concepts through various subjects: mathematics, natural sciences, art and physical education. Frequently, neither teachers nor their pupils consider these notions, thus their wrong ideas remain firmly rooted and present a barrier to the adoption of the correct physical ideas. Research of basic concepts related to motion, space and time was carried out as part of the workshop Class Teaching Course Open Days at the Faculty of Natural Sciences, Mathematics and Education of the University of Mostar. The sample consisted of pupils of primary education of Herzegovina-Neretva and West-Herzegovinian Cantons. It has shown that pupils have the correct ideas about many physical phenomena, but it has also shown the presence of intuitive ideas which are not in accordance with physical ideas and need to be corrected in time.

Keyword: physical ideas, intuitive ideas, research teaching, misconceptions, primary education.

Published Date: 5/31/2018 **Page.19-32** **Vol 6 No 05 2018**

Link: http://ijier.net/ijier/article/view/1027

Physical Preconception of Primary Education Pupils

Slavica Brkić PhD
Faculty of Science and Education
University of Mostar
slavica.brkic@fpmoz.sum.ba
0038763489163

Ljiljanka Kvesić PhD
Faculty of Science and Education
University of Mostar
ljiljanka.kvesic@fpmoz.sum.ba
0038763355021

Marina Zubac
Faculty of Science and Education
University of Mostar
marina.zubac@fpmoz.sum.ba
0038763512132

Abstract

During their preschool age children discover natural phenomena in their environment. In their consciousness, they form the basic physical concepts based on experience. Their ideas can be right, but they can also be wrong because they take into consideration only what they see and thus, they come up with wrong ideas or misconceptions. At the very beginning of their primary education, teachers of class teaching directly witness their ideas related to basic physical concepts through various subjects: mathematics, natural sciences, art and physical education. Frequently, neither teachers nor their pupils consider these notions, thus their wrong ideas remain firmly rooted and present a barrier to the adoption of the correct physical ideas. Research of basic concepts related to motion, space and time was carried out as part of the workshop Class Teaching Course Open Days at the Faculty of Natural Sciences, Mathematics and Education of the University of Mostar. The sample consisted of pupils of primary education of Herzegovina-Neretva and West-Herzegovinian Cantons. It has shown that pupils have the correct ideas about many physical phenomena, but it has also shown the presence of intuitive ideas which are not in accordance with physical ideas and need to be corrected in time.

Keywords: physical ideas, intuitive ideas, research teaching, misconceptions, primary education.

1. Introduction

Physics is a science which has the greatest impact on the development of technology and the major problem is that it is the least attractive school subject for pupils. Comprehensive research conducted in German schools showed that pupils find physics, out of all school subjects, the most difficult and the least attractive subject despite the fact that the German educational system as a whole is deemed to be the best in the world. Negative attitude towards physics is the greatest (30%), with chemistry at the second place (28%), followed by mathematics (26%) (Paar, V. 2001). In order to achieve progress in physics teaching, the right physical preconceptions should be formed long before introducing physics as a school subject. The teaching has to be motivating and the required knowledge could be integrated in such teaching subsequently. In this process teachers have to be able to answer fundamental pupils' questions at all times: Why do I have to learn this? What's the purpose of it? In this sense, the physics teaching should establish direct relation to the problems of real life. The issues of real world will encourage pupils' interest and motivation and cause their curiosity and scholarly interest, as they would study something relevant to their lives. Thereat, it is desirable for lessons to be formed as stories or experiments which are easy to remember. From the very beginning of primary education, the science teaching should be conducted in natural surroundings, by monitoring and measuring variables, but in the simplified version of nature as well, in classroom or laboratory, where the conditions could be controlled and variables could be measured. In this way pupils develop critical attitudes and experience that the science makes us understand the world that surrounds us. Such teaching requires excellent teachers who should be selected out of the population of the best students. Teaching physics through other school subjects in primary education requires high level of intellectual engagement both on the part of teachers and pupils, which cannot be achieved with typical lecture-based teaching.

2. Interactive teaching

We are forced to make radical changes in physics teaching due to the character of contemporary physics and extraordinary quick development of science and technology. Successful education of physics at school is one of the most challenging issues facing modern education in the world. Teachers' responsibility is not to merely transfer knowledge but to develop a certain way of thinking, an understanding of basic concepts, as well as practical application of knowledge in problem situations.

"The anticipated knowledge cannot be poured in by a funnel; required attitudes cannot simply be glued on; experience belonging to others is not helpful. Experience is the result of an individual's activity. This activity must be real, realistic and life-concerning one, an activity directly contacting its surroundings. Teacher's ideas are just teacher's ideas, and pupils need to build their own ideas. No thought, no idea ... is possible to be transposed from one person to another as a conception ... An individual starts thinking when they directly deal with a problem, when they search for and find their own solution", (Dewey, J. 2009).

Standard oral tests, lecture or traditional tests cannot detect whether a pupil has really mastered knowledge that is in accordance with fundamental concepts of physics. Tests have shown that formal learning is not satisfactory and the solution is sought in the intellectual activation of pupils through interactive teaching.

Types of questions and problems that students face are of essential importance in all forms of interactive teaching. The issues that are important for understanding physical concepts are emphasized. Research has shown that students have firm ideas and explanations for some phenomena, which are significantly different from scientific explanations. These wrong ideas are called misconceptions (Helm, 1980) and it is important that teachers identify them promptly (Driver, 1985). The easiest way to detect and recognize them is through tests. Conceptual tests contain qualitative questions whose aim is to identify, recognize, and correct pupils' misconceptions. The results of the same test done by the pupils of fourth and fifth grade of primary education (ages 10 and 11) and the pupils of ninth grade of elementary school[1] (age 15) did not show a significant difference, which is a consequence of formal learning of physics. In order to develop scientific creativity and cope with new problem situations, it is necessary to set new educational goals to be pursued: pupils need to acquire the ability to deal with new problem tasks, to adopt previously unknown concepts, and to create new ones. These educational goals differ from the traditional ones in which the teachers were content with the reproduction of the material and the understanding of matter. Teaching and learning of physics requires a high level of pupils' intellectual involvement, and this is not achieved in typical lecture-based teaching. Contemporary education trends move the boundaries of education towards active learning. Active learning is a process of changes in the educational system that involves higher cognitive processes. The lowest educational goal is factual knowledge, which is not irrelevant as pupils need to know the basic concepts and definitions without which they cannot move forward. Higher educational goals include understanding, application of the learned, analysis, synthesis and evaluation. To achieve these goals, a greater interaction between pupils and teachers is needed; and it takes place in so-called interactive teaching. Interactive methods of work require much greater teacher's engagement and most of them would not readily accept it, and it is also difficult for pupils to get accustomed to the new method. Some of the pupils, once taught to get ready-made knowledge, are not interested in high quality learning. However, most pupils accept new methods as they feel as active participants of teaching where they can freely express their attitudes even though they might be wrong.

2.1 Physical Misconceptions

Apart from school and school education pupils also possess numerous and various kinds of knowledge. Experience has taught them that winters are colder than summers; that the Sun always rises on one side, and sets on the other side of the horizon; that objects thrown upwards always fall back to the ground. In the 1980s, it was revealed that pupils had certain ideas about many physical concepts and conceptual relations about physical phenomena that mostly did not correspond to the correct physical ideas (Driver, R. 1973). These wrong intuitive ideas are spontaneously developed by all pupils regardless of their background, upbringing or previous education, and they present a serious obstacle to learning physics. The research concerning intuitive ideas had no effect on the teaching until the work of R. Driver and L. Viennot in the 1980s (Driver, R. 1973, Viennot, L. 1979). Thereafter, there was a whole series of the investigations of wrong ideas which were called misconceptions. Traditional forms of teaching ignore the existence of misconceptions; they deal with the ready-made knowledge, trying to convey it to their pupils.

---

[1] Nine-year elementary education (five+four) is effective in Bosnia and Herzegovina

There are two types of misconceptions:

- Preconceptions
- Alternative ideas

Preconceptions. Preconceptions are wrong intuitive ideas that a pupil has before learning physics. Most pupils are not aware of their preconceptions and feel that their thinking is correct because it can easily be backed up with examples from everyday life. They came up as a need to explain the phenomena of the world in which they live without taking into account things that cannot be seen. Some of these ideas are very similar to the ideas we find in the history of physics, and in some periods they were accepted as valid. Their attraction lies in their simplicity and intuitive comprehensibility.

Alternative ideas. Alternative ideas are a mixture of intuitive ideas and formal physical learning. It is difficult to replace once created and accepted misconception with the correct physical idea.

Putting an emphasis on interactivity, today's teaching tends to confront misconceptions. Misconceptions are stubborn and it is important that teachers recognize them and try to eliminate them.

The easiest way of discovering pupils' misconceptions is through tests. If preconceptions are removed on time, then further physical laws, even harder physical laws will become easier to pupils, they will be adopted faster and, most importantly, pupils will understand them in the true sense of the word. The implementation of the test does not require any additional material resources, does not take much time, and the test results and analysis could contribute to the improvement of teaching. In order to be productive for teaching aims, the questions in the test should neither be trivial, nor too difficult; they should not be tricky questions, and it is good if the answers offered have some common typical reasoning errors. A new teaching method called peer instruction was introduced at introductory physics courses at Harvard University in 1991 (Mazur, E. 1997). In this method the classical lectures were replaced with short segments of lectures followed by a conceptual question related to the main topic of that part of the lecture. Students would give their answers and discuss them afterwards. The optimal range of correct answers was 35-70%, and then students would discuss the answers. If there were less than 35% of correct answers, it meant that students had failed to understand the given problem, and in such a case it was necessary to study the problem in more detail and explain it, and then to repeat the evaluation using another test. If there were more than 70% of correct answers, the questions were deemed as having been too easy (Mazur, E. 1997).

3. Research

Short tests present the easiest way of identifying pupils' misconceptions and preconceptions. In a very short time, teachers receive the follow-up information about the matter they are checking. The results of checking determine the course of future teaching; tests reveal which parts of the matter are the most difficult to pupils, in other words, which conceptions are not adopted correctly. Teachers should spend more time on such issues, as the matter once learned incorrectly is more difficult to correct subsequently. Pupils' misconceptions and preconceptions related to basic physical conceptions were examined at the Open Doors Day of the Classroom Teaching Studies in March in the academic year 2016/17 at the Faculty of Natural Sciences, Mathematics and Education of the University of Mostar, Bosnia and Herzegovina. Pupils learn about some fundamental conceptual physical conceptions within the curriculum of mathematics and science, thus our tests partly related to already covered matter and partly to things not learned in class but familiar to pupils, and they had certain ideas about them which might be correct or wrong.

3.1 Test and Test Results Analysis

Pupils did closed type picture test. They had to find the right answer to the multiple choice questions. We will mention some multiple choice questions from the test and their results. The same test was given to the pupils of ninth grade of elementary school after they had gone through the first cycle of physics teaching, and the results were compared. Another sample group consisted of 120 pupils.

Test results show that pupils have no problems with the sense of quantity and numbers. The concept 'number sense' was used for the first time by Tobias Dantzing in 1954 in his book Number, the Language of Science. The author thinks that we were born with that sense and that a child in his early age can recognize the difference between two groups if we deduce or add one element to them. The questions related to quantity were the easiest for both groups of respondents, so they are not mentioned here.

3.1.1 Examples from the Test

1 - In Figure 1, there are three boys. Which of them can run the fastest?

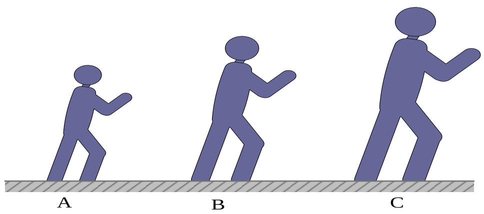

Figure 1.

Table 1. Distribution of answers in Test number 1

A(%)		B(%)		C(%)		X(%) Without answer	
4^{th} and 5^{th} grade	9^{th} grade	4^{th} and 5^{th} grade	9^{th} grade	4^{th} and 5^{th} grade	9^{th} grade	4^{th} and 5^{th} grade	9^{th} grade
26,38	13,33	20,83	33,33	52,78	53,33	0	0

When asking this question, we thought that all the pupils will choose C answer. The tallest boy has the greatest strength and therefore he can run the fastest. Pupils' answers were based on their experience, and so a younger brother could be faster than the older one. We can see that the distribution of answers is equal for both groups of respondents although the pupils of the ninth grade learned about mechanical work and the force within the frame of physics curriculum (Šindler, G. and Valić, B. 1997).

2 - Three hills are shown in Figure 2. Which hill is the most difficult to climb to the top?

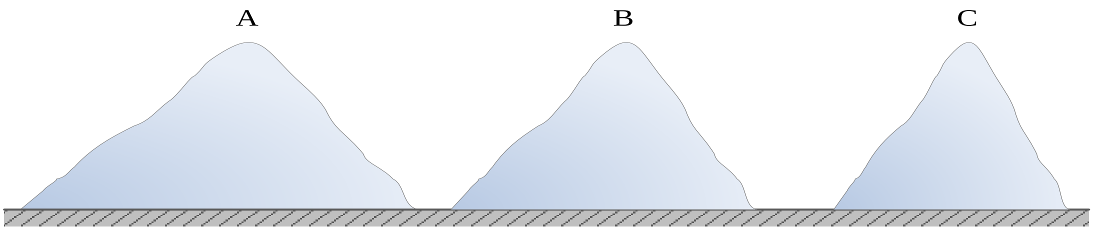

Figure 2.

Table 2. Distribution of answers in Test number 2

A(%)		B(%)		C(%) Correct answer		X(%) No answer	
4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade
4,17	6,67	5,56	0	90,28	93,33	0	0

The answers to the second question confirm that the pupils' answers were based on their experience. Although pupils do not know the golden rule of mechanics, they know that the steeper a slope is, the harder it is to climb. There are more than 90% of correct answers, this meaning that the question was too easy for the pupils.

3 - There is a tree-lined road in Figure 3. Are all the trees of the same height?

Figure 3.

Table 3. Distribution of answers in Test number 3

YES(%) Correct answer		NO(%)		X(%) No answer	
4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade
36,11	60,00	63,89	33,33	0	6,67

4. There is a boy in front of the school in Figure 4. Which drawing is correct?

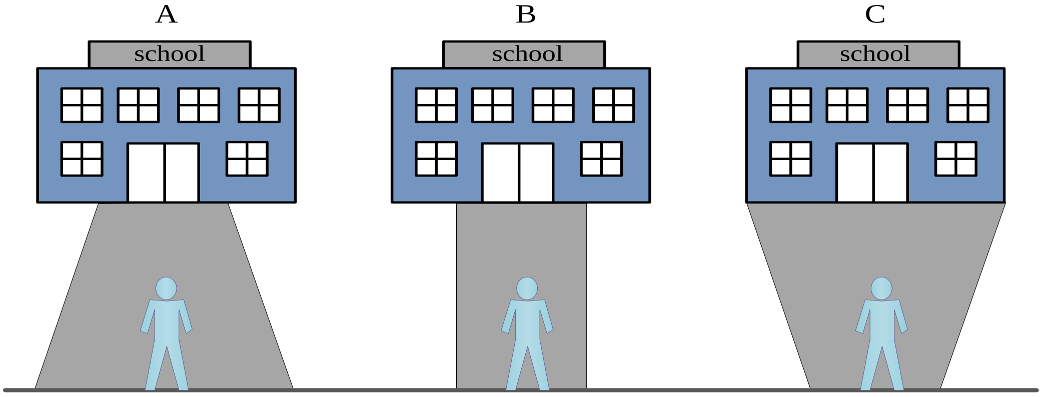

Figure 4.

Table 4. Distribution of answers in Test number 4

A(%) Correct answer		B(%)		C(%)		X(%) No answer	
4^{th} and 5^{th} grade	9^{th} grade	4^{th} and 5^{th} grade	9^{th} grade	4^{th} and 5^{th} grade	9^{th} grade	4^{th} and 5^{th} grade	9^{th} grade
54,17	60,00	34,72	6,67	11,11	20,00	0	1,33

Both in Test number 3 and 4, the correct answer is A. There is a road in both pictures which seems to be narrower in the distance. Primary education pupils learn about space, movement and time through various school subjects. Within the school subject of Science and society in the first grade of primary school they learn distinction between closer and further, left and right, above and under (Markovac, J. and Zorić, V., 2015). If a photo of landscape is shown to children, all of them will know that the tree is closer than the house, the house is closer than the hill, and the hill is closer than the cloud, and the cloud is closer than the Sun. A teacher should discuss the photo of landscape to see how they explain the fact that the hill is further than the house. Whether their answer is: "Well, we know it's further" or their answer is: "Because hills are big and it seems to be small to us because it is far away"? The question is not in a familiar context, it confuses pupils, which is the consequence of formal adoption of knowledge, which is shown by their answers.

5 - There are three cubes made of different materials in Figure 5. Which cube is the heaviest?

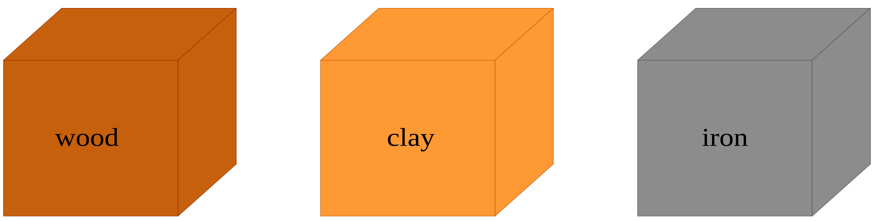

Figure 5.

Table 5. Distribution of answers in Test number 5

A(%)		B(%)		C(%) Correct answer		X(%) No answer	
4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade
2,78	0	2,78	0	88,89	93,33	5,56	6,63

6 - In Figure 6, there are three bottles, each containing a liter of oil, water and alcohol, respectively. Do they weigh equally?

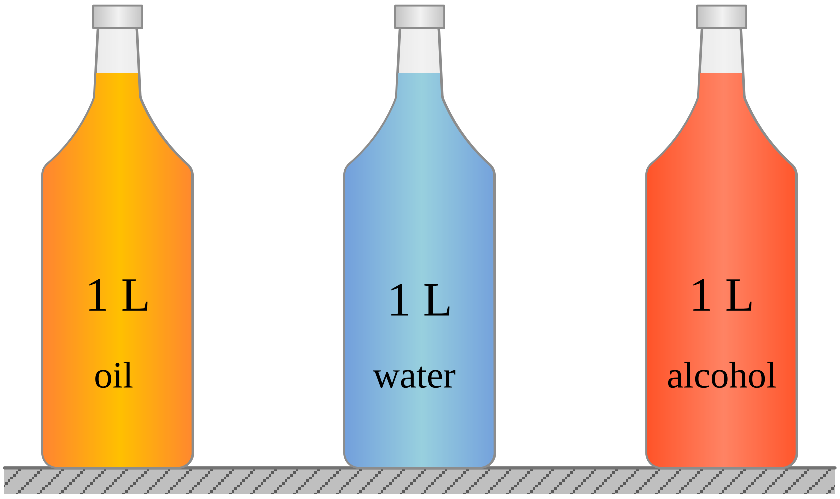

Figure 6.

Table 6. Distribution of answers in Test number 6

YES(%)		NO(%) Correct answer		X(%) No answer	
4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade
43,05	46,67	31,94	33,33	25	20

Questions 5 and 6 are almost identical but for the pupils they seemed different. The confusing term is the ‘liter’. This exceptionally allowed unit measure for volume is taught in mathematics in fourth grade of primary education (Markovac, J., Zorić, V.2015). All the children know that an iron cube of the same size is heavier than a wooden cube, but the question whether a liter of oil is heavier than a liter of water has been confusing pupils for generations.

7 - Figure 7 shows three containers of water, each having three holes. Which drawing is correct?

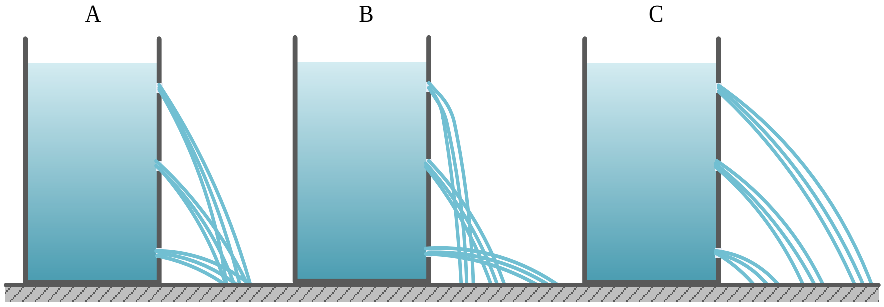

Figure 7.

Table 7. Distribution of answers in Test number 7

A(%)		B(%) Correct answer		C(%)		X(%) No answer	
4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade
44,44	40,00	8,33	33,33	33,33	26,67	13,89	0

Preconceptions are connected to intuitive ideas and experience and it is not unusual that the seventh question has the least correct answers. The answers given by primary education pupils are incorrect but logical regarding the fact that they do not consider the things they do not feel or do not know, namely hydrostatic pressure. They have 8.33% of correct answers. Here we can see that ninth grade pupils also have more incorrect than correct answers although they learned about pressure in physics in eighth grade (Šindler, G. and Valić, B., 1997).

8 - There is a magnet in Figure 8. If it is moved closer to the table, it will attract

A. nails.

B. pieces of paper.

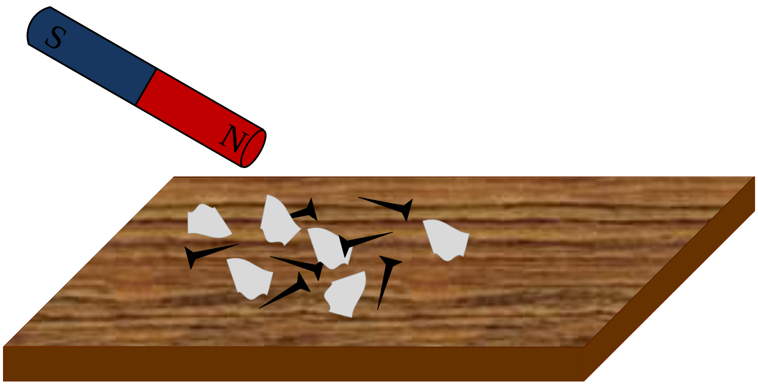

Figure 8.

Table 8. Distribution of answers in Test number 8

A(%) Correct answer		B(%)		X(%) No answer	
4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade
98,61	53,33	0	6,67	1,39	40

The basic conceptions related to magnetism are learned within the school subject Science and society in fourth grade of elementary school (Jelić,T., Brkić, S., 2015). The eighth question was too easy for the pupils of fourth and fifth grade of elementary school whereas it was not the case with ninth grade pupils. We think that it is the result of traditional teaching and overloaded curriculum, which obviously led them to confuse electricity and magnetism. 40% of pupils failed to answer at all, which points to fear of wrong answer.

9 - Figure 9 shows an enlightened apple and its shadow. Which drawing is correct?

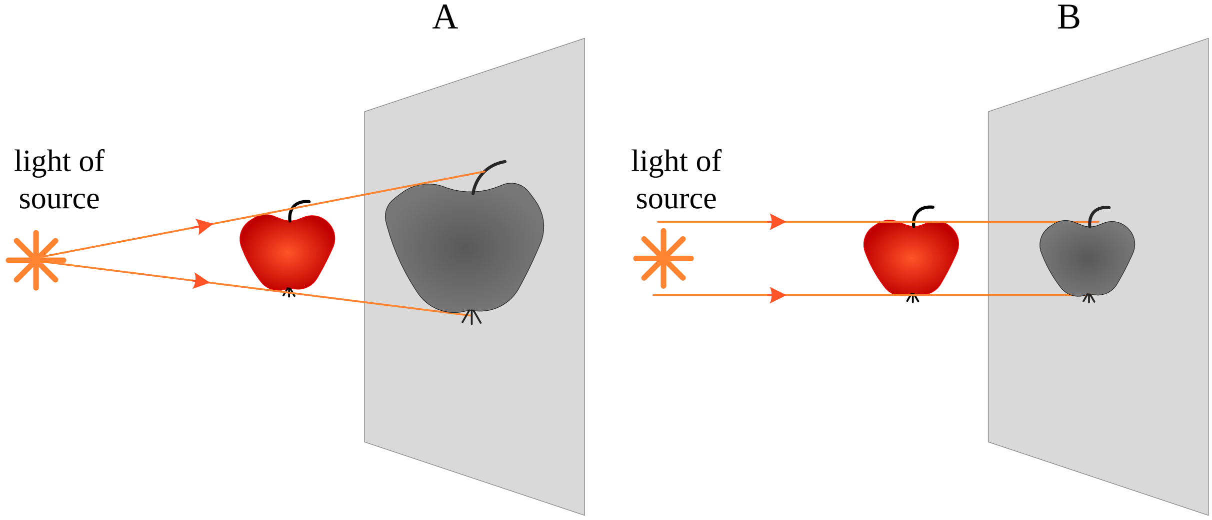

Figure 9.

Table 9. Distribution of answers in Test number 9

A(%) Correct answer		B(%)		X(%) No answer	
4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade
56,94	33,33	43,06	33,33	0	33,33

Again, the primary education pupils have more correct answers to the ninth question although the ninth grade pupils learned basic laws of geometric optics. The first geometric optics law says that the light dispersion is linear, and the consequence of their badly adopted knowledge is the implication that it disperses in parallel lines.

10. Where is it easier to lift a stone?
    a. In the water.
    b. In the air.

Table 10. Distribution of answers in Test number 10

Water (%) Correct answer		Air (%)		X(%) No answer	
4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade
43,06	53,33	55,56	33,33	1,39	13,33

11. Where is it easier to swim?
    a. In the pool.
    b. In the sea.

Table 11. Distribution of answers in Test number 11

A(%)		B(%) Correct answer		X(%) No answer	
4th and 5th grade	9th grade	4th and 5th grade	9th grade	4th and 5th grade	9th grade
16,67	13,33	80,56	60,00	2,78	26,67

Tests 10 and 11 are the same for those who are familiar with lift force. For those who are not, the answers are based on their experience. Primary education pupils have less correct answers to question 10 as they obviously never tried to lift a stone in water, but they know that it's easier to walk on a dry path than on a muddy one. Primary education pupils have more correct answers to question 11 than the elementary school ninth class pupils who, burdened by teaching, fail to connect their knowledge with real life.

The results of our test showed that the answers of primary education pupils are based on experience, which does not always lead to the correct answer. Primary education pupils have more correct answers than the ninth grade pupils to the questions from the curriculum of the first cycle of physics, which is a consequence of traditional teaching. Traditional teaching tests factual knowledge as the lowest form of knowledge or pupils are required to complete a sentence. Such way of communication fails to encourage creative thinking and does not lead to high quality learning.

Educational research in physics has shown that interactive teaching of physics is much more efficient than lecture–based teaching, especially in development of conceptual understanding. It can also be noticed that another group had more unanswered questions, with fear of tests or wrong answer being a possible cause. Figure 10 shows the total distribution of the correct answers of primary education pupils and elementary education pupils.

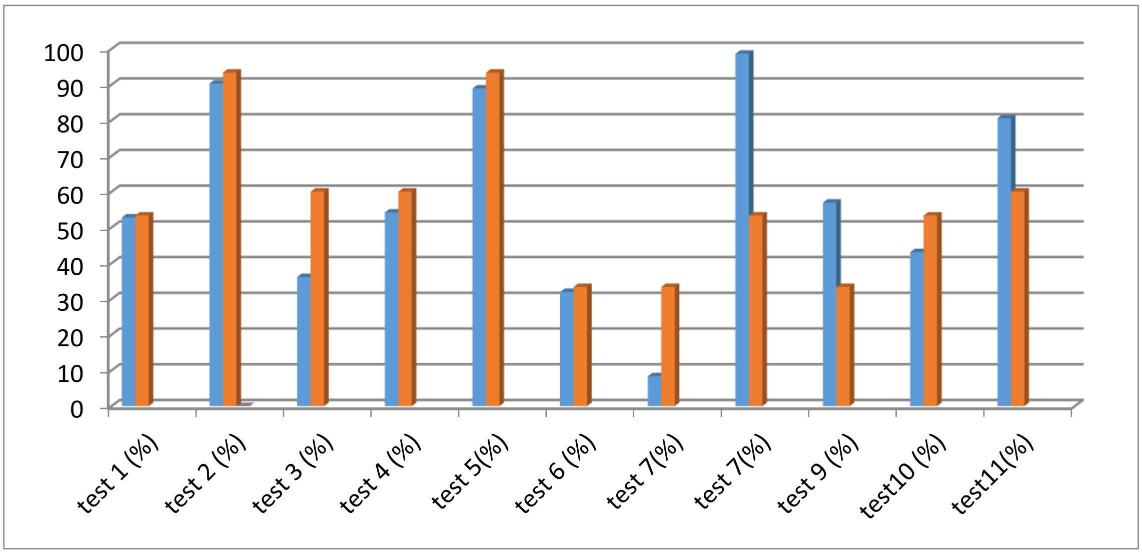

Figure 10. The distribution of the correct answers of primary education pupils (blue column-left) and elementary education pupils (red column-right).

4. Conclusion

Children discover basic physical phenomena in their earliest age. Through various school subjects, primary education teachers should find out whether their ideas are correct. Wrong ideas or misconceptions are difficult to identify during traditional way of working. Research and successful teaching practice showed that the research approach to teaching enables teachers in the best way to recognize, and pupils to adopt conceptual base which is essential for their further education. Conceptual tests present the fastest and easiest way for teachers to get feedback information on understanding physical concepts. Those tests turn the pupils' attention to important things, their knowledge is being corrected, changed and extended, and the result is long-lasting memory and ability to apply acquired knowledge to new situations. Good results present satisfaction to both pupils and teachers whereas bad results point to the need of changing work methods. Traditional teaching is deeply rooted work method and it may go through numerous radical

changes in order to reach better results; the solution is moving from traditional towards interactive.
The results of our test that was done by both primary education pupils and elementary education pupils are similar. It is notable that primary education pupils' knowledge is based on their experience, and they do not consider things they do not see. The same questions posed a dilemma for pupils notwithstanding the fact that the second group pupils worked on certain matters during physics teaching. It could be noticed that the elementary education pupils have less correct answers to the questions concerning the matter which is a part of their curriculum. The reason might lie in too extensive educational material and formal physical teaching. More frequent use of tests reduces the test fear; and more unanswered questions were given by the pupils of the second group which just points to the fear of failure.
Physics is nature, physics is in butterfly's flight, in birdsong, in rainbow and in mirage; physics is first learned in mathematics and science, which is important to be recognized by primary education teachers. Laws of physics are the base of our functioning. "There is no escape. There is physics all around you" [16].

5. References

[1] Dantzing, T., Number, the Language of Science, Free press, New York, 1954.

[2] Devlin, K., Mathematics Gene, Naklada Algoritam, Zagreb, 2008.

[3] J. Dewey, "Democracy and Education: An Introduction to the Philosophy of Education Paperback" – December 20, 2009.

[4] Driver, R., "Student's conception and the learning of science". PhD Thesis, 1973.

[5] H. Helm, "Misconceptions in physics amongst South African students", Physics Education, 15,92-105, 1980.

[6] Jelić,T., S. Brkić, Our Homelands, Textbook for fourth grade of elementary school", Naklada Alfa, Mostar, 2015.

[7] Krsnik, R., Contemporary Ideas in Physics Teaching Methodology, Školska knjiga, Zagreb, 2008.

[8] Markovac, J., V. Zorić, "Mathematics 1, Working material for first grade of nine-year elementary school", Naklada Alfa, Mostar, 2015.

[9]Markovac, J., V. Zorić, Mathematics 4, Textbook for fourth grade of nine-year elementary school, Naklada Alfa, Mostar, 2015.

[10] E. Mazur, "Peer Instruction, A User´s Manual-Concepts", New Jersey, Prentice Hall, 1999.

[11] V. Paar, “Teaching of Physics at School and Introduction of The Concept of Mass”, ZBORNIK_2001.doc

[12]M.Planinić, “The Most Important Results of Educational Research in Physics“, Faculty of Natural Sciences and Mathematics, Department of Physics, Zagreb, 2005.

[13]M. Planinić, “Interactive Ways of Teaching Physics”, Faculty of Natural Sciences and Mathematics, Department of Physics, Zagreb, https://bib.irb.hr/datoteka/402534.Planinic_uvodno_

[14] Šindler, G. and B. Valić, Physics Textbook for eighth grade of elementary school, Školska knjiga Zagreb, 1997.

[15] L. Viennot, “Spontaneous reasoning in elementary dynamics”, European Journal of Science Education, 1. 203-221, 1979.

[16] http://fizika.beep.com/