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After Teaching, Perceptions of B&C Class High School Students in Concepts of Friction Force

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Abstract: This paper presents the ideas/perceptions of B&C class high school students in concepts and laws of the force of friction. All the students had been taught the unit of friction in Class A with traditional teaching methods during the previous school years from the Class A Natural Sciences school textbook "Physics of General Education". The sample of the research consisted of 224 students from the region of Epirus. The analysis of the answers led to the creation of three categories: a) answers in accordance with the scientifically accepted ones, b) alternative answers, and c) others. The comparison of the results with the equivalent bibliographical ones on students' ideas/perceptions shows that the findings are in line with those of other researches. From the processing of the answers given by the students it becomes clear that a large number of students have not understood the concepts related to the force of friction and the particularly stable and durable character of their alternative perceptions emerges.

Key words: B&C class, high school students, friction force

1. Introduction

Students' ideas are deeply-rooted because they are enhanced by their daily experiences and senses. Students' approach to the interpretation of natural phenomena is performed with the help of their experiences. Some of the ideas that children use about the physical world are so entrenched that they cannot be uprooted by teaching. Therefore, while some children may be able to apply scientific ideas to exam problems, they fail to apply them in an out-of-school situation so as to interpret some phenomena. Children's ideas can remain not only after teaching, but also after adulthood (Kokkotas P. V., 2001).

Research on the power of friction in secondary education is limited. In their research (Stead et al., 1981; Koukoutsak et al., 2004) there were students who identified friction with reaction force. In addition, they associated friction with movement "if there is no movement there is no friction". They even connected friction with rubbing. The students believed that the force of friction is related to energy and especially to heat. Finally, they expressed the force of friction as if it were an object (friction does this and that, or tries to do something, etc.)

Different research that was carried out (Halloun N. D., 1985; Black et al., 1993; Caldas et al., 1995) showed that students rarely recognize "friction" as a force. Therefore, the property of slowing down or accelerating the motion of a body by its action is seldom recognized in the force of friction. What most students believe is that the force of friction decelerates some movement because it has human properties (anthropocentric view in science).

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Furthermore, research (Viennot, 2001) reveals many elements in relation to the perception students have concerning the natural origin of frictional force or the correct positioning of the friction force vector to the various problems so that there are no misinterpretations mainly on the identification of the force that expresses the reaction to the action of the friction force (Newton’s 3rd axiom).

In a study by (Koukoutsaki et al., 2004) students were unable to apply Newton’s first law when a horizontal force F is exerted on a stationary body, or they reported that the static friction is greater than F and even reported that no other force is exerted except F. They also believed that in order to move a body horizontally, they had to exert a horizontal force greater than the weight of the body.

In their research (Evangelopoulou & Micha, 2011) the most important alternative ideas mentioned, in a body that we exert force on, are a) if it is stationary it remains stationary because the friction is greater than the external force, b) if it performs a linear smooth motion, then it is not rubbed, that is, they are unable to use Newton’s first law in both cases. Even in the case of a body (passive) mounted on another (motor) which receives a force F and remains stationary with respect to the motor , they do not draw the friction force at all or draw it in the opposite direction from the F force.

2. Research Methodology

This paper presents the results from the empirical research carried out on 224 Class B high school students in Spring 2012 in the prefectures of Thesprotia and Ioannina. Regarding sex, 51.8% were female students while 48.2% were male students. The sampling method used is simple random sampling. The close-ended questionnaire was used for data collection and the data analysis was performed with the statistical program SPSS 16.0.

The questions asked are mostly related to simple phenomena and situations of everyday life and not questions that would constitute a sterile testing of students’ knowledge.

The aim of this paper is to explore students’ alternative ideas about friction (static and sliding), the laws of friction and its origin.

The questions were multiple choice and explored students’ ideas (the questions are in the appendix) more specifically: In the first and fifth question, whether the friction force is a force that always resists any movement of the body in which it is exerted. The second and third question investigate the factors on which the sliding friction does not depend (contact surface area and speed).

In the fourth question the relationship that exists between the power the student uses to push the desk and the static friction that resists the movement. In the sixth question whether they are able to interpret the nature of the force of friction on a microscopic level.

In the seventh question, apart from the nature of the force of friction, it is investigated whether friction is a single force exerted on a point or it is a component force.

In the eighth question if the students know that the measure of static friction is a variable measure up to a maximum value of Ts (max).

In the last question, it is investigated whether the students have understood that the force of friction is a classical force like all the others that appear in nature and that it must satisfy all the laws of nature.

3. Results and Discussion

The direction of the friction force vector may differ from case to case and sometimes it can assist the movement of the body (as in the case of human gait or in the case of rolling a roller on a ramp, bicycle), while other times it can resist it, as in the case of a body trying to slide or sliding on a surface (Ohanian, 1991). This does not seem to be known to the students, since in the first question they give the correct answer to only 37.5%. The other answers suggest that the friction force vector always has a certain direction which has nothing to do with the problem.

In the second question, students cannot distinguish between simple factors that affect the measure of the friction force vector and those that do not, such as the area of the interface, its speed of movement, or the horizontal force exerted on the body. 51.7% answers this question correctly.

The third question is answered correctly by 58.9% of the students. Obviously, many students cannot recognize that the force of friction is, on a macroscopic scale, independent of the area of the surface in contact, as well as the speed at which the body moves relative to the plane (Ohanian, 1991).

Also, in the fourth question 42% of the students answer correctly 23.2% answered that the horizontal force should be greater than the weight, while 17.9% are of the opinion that the force should generally be greater than the static friction and 16.9% greater than that exerted from the box to the man.

For friction to occur, the body must move or tend to move relative to another body it is in contact with (Bowden & Tabor, 1973). The correct answer to the fifth question is given by the students at a rate of 38.8%. A large number of 42.4% of students are of the opinion that the force of friction can exist even if there is not even a tendency to move and therefore to remove surfaces that are in contact with each other. While 18.8% of children believe that the friction appears only when there is body movement.

Then, only 8.5% correctly answer the sixth question. The small percentage is due to the fact that students have never been taught a corresponding lesson on the cause of friction on the interface of the two bodies in their Physics lesson (Ringl Ein et al., 2004), thus being unable to distinguish the correlation between friction force and electrostatic bonds (correlation forces). A remarkable percentage of students 60.7% answer that the force of friction exists to play the role of reaction, based on Newton’s third law, to the moving force that maintains the motion of the body. This is another one of the alternative ideas the students have embraced and carry with them as university students (Karaog l th & others, 2011). At this point another difficulty of the students is revealed, the difficulty to recognize the action-reaction pairs in nature (Viennot, 2001; Viennot, 2003). Finally, 30.8% believe that friction occurs because the surfaces have irregularities and rub against each other.

Only 39.3% of students answer the seventh question correctly for the same reason as the previous question. So, many of the students do not even know where the friction force is exerted and do not recognize that the vector with which the force is manifested represents the component of many forces at the individual points of contact of the rubbed surfaces. While 21.4% answer that the friction force is exerted on a single point. Another 23.7% believe that it is exercised in the center of mass. Finally, 15.6% of the students are of the opinion that the friction vector depicts the recommended force exerted on the two points that come in contact locally, i.e., on one point of the surface and on the other part of the body that touch each other.

28.1% of the students answer the eighth question correctly. 33.9% answer zero because the friction is exerted only on the moving bodies, while 21% found that it is greater than 100 N after the power exerted fails to move the body. Finally, 17% less than 100 N. From the above responses, it is shown that students fail to understand that, when we exert a horizontal force on a body that remains stationary, then the power exercise is not less than the value of static friction at that moment, but equal to it since the body is balanced according to Newton's first law.

Finally, the ninth question proves that many students cannot understand that the force of friction is a classic force like all the others that appear in nature and that it must satisfy all the laws of nature, since only 29% of students answer correctly. Another 42.9% answer that the friction is slippery and is exerted to the left. While 28.1% answer that no friction force is exerted on it since it does not tend to move in relation to the wagon.

4. Conclusions

Summarizing the results we come up with some findings about children's perceptions of the force of friction and whether their teaching at school has altered them.

An alternative student idea recorded for friction force has to do with the direction of the friction force vector. From the percentages of the respective answers it is found that the students believe that friction is a force which always resists the movement of the body in which it is exerted. Students must therefore realize that the force of friction is a kind of "passive force" which means that it adapts in response to active action (Arons, 1992).

Students also do not know the nature of the force of friction on a microscopic level. Most students believe that the friction force exists because the surfaces that rub against each other have irregularities and so one surface prevents the other from moving. In other words, they do not know that the frictional forces are of a molecular nature and, for this reason, in the interpenetration regions of the anomalies the surface molecules are very close, so strong attractive forces of cohesion and coherence are developed. In other words, numerous "cold" welds occur which impede the relative movement of the two bodies. Thus, when one body slides on another, the frictional force is essentially related to the breaking of thousands of welds, which are constantly rebuilt, as new random contacts are created during the sliding of the body (Garofalakis et al., 1999).

Students' next alternative idea has to do with the factors on which the measure of its vector depends (Stead et al., 1981). Although students have been taught the empirical law of friction force, they believe that the measure of the friction vector depends on both the body's contact area with the plane and the speed at which the body moves.

Moreover, students do not seem to understand that the force of friction is actually exerted along the entire surface between all the points that come in contact and not just on one point (the center of mass of the body or a point on the surface).

An alternative idea also refers to the fact that the frictional force also appears when there is no movement or tendency to move.

In addition, students do not know which bodies are involved in the phenomenon of friction force. They believe that force is applied to a single body at a time and find it difficult to identify the body to which the reaction to this force is applied, based on Newton's third axiom. They also believe that the force of friction is the reaction to the moving force each time (Viennot, 2001).

Many students believe that the static friction force is constant and that, if we practice a horizontal force on a body that remains stationary, the force we exert is less than the static friction value at that time.

A major misconception and teaching goal is to make students understand that the static friction the floor exerts onto a body has no fixed measure, but can fluctuate from zero to a maximum level (Dosis et al., 2007). They also believe that in order to move a body we must exert a horizontal force greater than its weight (Evangelopoulou et al., 2010).

Finally, students do not recognize "friction" as a force that obeys Newton's axioms as normal forces do and, therefore, it sometimes slows down the body movement but it can also accelerate it (Caldas et al., 1995; Besson et al., 2010).

The results and conclusions of this research largely coincide with those of previous research such as those mentioned in the introduction.

For all of the aforementioned, teachers should understand that students coming to the classroom have formed an opinion about natural phenomena and the concepts involved in them through their daily lives. Thus, it should not be taken for granted that students can easily accept the conceptual changes on the issues of friction and more specifically in the traditional way of teaching, thus simply displacing their previous perceptions (Besson et al., 2007).

The learning process does not take place in a social vacuum. The school textbook with the projects and activities it includes, however appropriate, are not enough to build the knowledge sought. The role of teachers, whom Fullan (2001) describes as "agents of change", is also crucial, because they are the ones who usually apply it in practice, in the learning environment, and its effectiveness depends on the way they will transfer change to educational practice. Only changes that take into account the teachers themselves seem to have a chance of success, because they are the ones who will implement the new positions of Teaching Science related to the Natural Sciences, teaching with the new books.

The continuous training of teachers in teaching and learning concepts of Natural Sciences is a prerequisite for the organization of appropriate teaching interventions and activities that they propose with the aim of gradually reconstructing, correcting, expanding and supplementing the initial perceptions of students.

The multiple representation of scientific knowledge helps in this purpose because it brings about the development of students' physical intuition around phenomena. Research in the teaching of Physics has shown an inability to transmit information and knowledge from the teacher or the textbook to the student and has led to the formulation of new learning theories dominated by the constructive one that supports the active involvement of the student in building knowledge from the existing perceptions he/she has (Driver, Oldham, 1986). According to Arons (1992), it is not enough to instill laws and rules in the minds of students through oral presentation, because they can memorize and repeat the laws orally but when they are forced to use them to predict the evolution of a natural phenomenon or describe what happens in real physical states they return to their original primary perceptions.

In conclusion, it is reasonable for someone to assume that the teaching of the force of friction must be done after a targeted teaching and with a clearly defined and studied method (Theodoropoulos et al., 1997), so that many of the previous perceptions are revised and the scientific ones are consolidated (Besson & Vienot, 2004). Only in this way can the correct understanding of the concept of friction force be gradually cultivated, which plays such a big role in our daily activities as sometimes we try to get rid of it and sometimes it is necessary for us.

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Appendix Research Questions

Q1: Many of your classmates believe that the force of friction always has a direction opposite to the direction of motion of the body on which it acts. How would you describe this sentence?

A**) Correct**

B**) Wrong**

C**) Sometimes correct and sometimes wrong.**

Q2: Two bodies in the shape of a cube **A** and **B,** are exactly the same (in dimensions and mass). Body A moves with speed υ while body B moves with speed 2υ. Which body do you think the greatest friction is exerted on?

1) **A.**

2) **B.**

3) **equal measure in both.**

Q3: Two bodies of parallel shape **A** and **B** are exactly the same (in dimensions and mass) and are in the same horizontal plane. In bodies A and B the same horizontal force F is exerted in order to move them to the right. Body A rests on the horizontal plane with its large seat while B rests with its small seat. Which body do you think will move more easily? (that is, on which body will greater friction be exerted?)

1) **A.**

2**) B.**

3**) It makes no difference.**

Q4: A man exerting a horizontal force pushes a stationary box, in the shape of a parallelepiped, and finally manages to move it. This is because the force exerted by the man on the box is:

A) Larger than that carried by the box to the man

B) Greater than the body weight.

C) Greater than the static friction of the gearbox.

D) Greater than the maximum static friction exerted on the body by the floor.

Q5: When does a friction force appear on a body?

A) It occurs even when the body is not moving.

B) It occurs only when there is movement of the body in relation to a surface on which the body moves.

C) It occurs when the body moves towards a surface or tends to move towards it.

Q6: A body moves in a horizontal plane with velocity υ, friction being the only force exerted. The friction force exists because:

A) in the areas of interpenetration of the anomalies, the molecules of the contact surfaces are very close, in which case strong attractive forces are developed, i.e., electrostatic bonds are developed.

B) the surface and the body have imperfections and so the close points are rubbed against each other.

C) It is the reaction to the driving force that keeps the body in motion (due to the 3rd) Newton's law).

Q7: The friction force is represented by a vector which is parallel to the surface on which the body we are studying is located and has a point of application of a point of contact of the body and the surface. This vector illustrates:

A) The frictional force exerted by the surface on the center of mass of the body

B) The force exerted at this point only

C) The recommended force exerted by the surface at all points of contact with the body

D) The recommended force exerted on the two points that come in contact locally, on one point of the surface and on one point of the body that touch each other.

Q8: Wanting to move a heavy object, which is in a horizontal plane, we exert a constant horizontal force of 100 N. But the body remains motionless. How much do you think the measure of static friction exerted on the body can be?

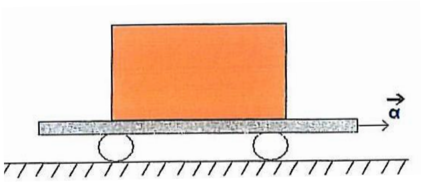
A. Zero because the friction is exerted only on the moving bodies.

B. Less than 100 N, since the static friction has a ceiling.

Γ. Exactly 100 N, after the body balances.

Δ. Greater than 100 N, since the force we exert fails to move the body.

Q9: In the adjacent figure you see a box lying motionless on a wagon moving at a constant acceleration **a.** What do you think about the direction of the friction force exerted on the box?



A) No friction force is exerted on it as it does not tend to move in relation to the wagon

B) A sliding friction force is exerted in a left direction, i.e., opposite to the motion.

C) A static friction force is exerted to the right to satisfy Newton's 2nd axiom