

Introducing Concept of Equilibrium in Primary School Physics Class

Ivana BOGDANOVIĆ
University of Novi Sad

Abstract: We say that an object is in equilibrium if it does not accelerate. The conditions for keeping the body in equilibrium are that both, the net force and the net torque, acting on the object are zero. Although students are very familiar with equilibrium in their everyday life, they do not have the scientific knowledge about this concept and often misconceptions are formed. It is advisable that physics teachers help students in the formation and development of the scientific concept of equilibrium with the help of examples from everyday life with additional explanations, using simple experiments and new technologies. Selected everyday life examples, simple experiments and PhET simulations, as well as idea for creating multimedia quiz, will be presented in this paper. For example, teacher can take students to the playground and they can learn about equilibrium experimenting on the seesaw. Similarly, students can use ruler and paperclips to make balance and carry out different simple experiments. Moreover, students can try to keep body in equilibrium by changing the intensity or direction of the forces acting on it. There is also available PhET simulation for inquiry Balance. Presented ideas of teaching students about equilibrium can help in detecting students' misconceptions, as well as in formation scientific concept of equilibrium.

Keywords: Concept Formation, Equilibrium, Physics, Primary School

Introduction

Students often think that physics is difficult, abstract and uninteresting and are not able to see connection between basic concepts of this science and world around them. With the use of different approaches to teaching one can impact students' physics performance, as well as their motivation for learning (Sağlam, 2010; Zouhor, Bogdanović, Skuban & Pavkov-Hrvojević, 2017). Therefore, physics teachers should find the way to help students in realizing stated connection in order to change students' opinion about physics and help them to better acquire physics contents. For instance, practical work has positive impact on students' physics performance (Lee & Sulaiman, 2018). In the Republic of Serbia, Physics is introduced as a separate school subject in sixth grade of primary school (11-12 year old students). According to the curriculum for seventh grade physics (determined by the Ministry of Education, Science and Technological Development of the Republic of Serbia), basic knowledge of equilibrium should be mastered in this grade. After learning about two forces acting on a body in the same direction, students learn about concept and types of equilibrium, lever, torque and balance and its application. Students are familiar with equilibrium in everyday life but lack of scientific knowledge and formation of misconceptions are problems that are present. One of possible solutions for these problems can be using examples from everyday life with additional explanations, using simple experiments and new technologies in teaching.

Concept of Equilibrium

We say that an object is in equilibrium if it does not accelerate. The conditions for keeping the body in equilibrium are that both, the net force and the net torque, acting on the object are zero. Torque (moment of force) is the rotational equivalent of linear force, it is the tendency of a force to rotate the body to which it is applied. The magnitude of the torque, with respect to an axis of rotation, is equal to the force times the lever arm with respect to that axis (perpendicular distance from the axis of rotation to the line of action of the force). The direction of the torque is given by the right hand rule. There are three types of equilibrium: stable, unstable, and

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neutral. The type of equilibrium depends on the position of body's center of gravity relative to the base of support. Stable equilibrium can be defined as a state of equilibrium of a body which, when subjected to a slight displacement tends to return to its original position. For example, equilibrium of a pendulum hanging directly downward from its point of support. Unstable equilibrium is a state of equilibrium of a body which, when subjected to a slight displacement departs further from the original position. For example, a pendulum standing directly upward from its point of support. Neutral equilibrium is a state of equilibrium of a body which, when subjected to a slight displacement has no tendency to return to its original position nor to depart further from its original position. The example of this type of equilibrium is pendulum supported in its center of gravity.

The educational standards (describing what students should know and be able to do) that should be met related to concept of equilibrium in primary school (seventh grade) are given for intermediate and advanced level (proposed by the Ministry of Education of the Republic of Serbia).

Intermediate level:

-The student can recognize when the lever is in state of equilibrium and can apply the equilibrium conditions. Example: if two people are on a seesaw, the student knows to recognize the ratio of distances from the point of support if the ratio of their masses is given.

Advanced level:

- The student is familiar with the facts about the net force acting on a body that is at rest or moving evenly: when two collinear forces of opposite directions act on a body, the body will be in a state of equilibrium only when those forces are of the same intensity. The student knows that under this condition the body is at rest (static balance) or moves evenly in a straight line (dynamic balance). From the fact that the body is in equilibrium, the student is also able to conclude what is the ratio of the two collinear forces that act on it. (It should not be expected for student to know how a body will behave if more than two forces act on it, or if non-collinear forces act.)

- The student understands the lever equilibrium conditions, knows that the lever is in equilibrium when the equality of the moments of force with respect to the support point is achieved, knows which force gives the highest or the lowest moment of force relative to the support point and knows how to calculate the intensity of moment of force in the case of forces that are normal to the lever arm. The student knows what is the relationship of forces acting on a body at rest (in a state of static equilibrium) or body moving evenly (in a state of dynamic equilibrium). The student independently performs experiments, asks questions and gives answers, draws conclusions.

Suggestions for Teaching Concept of Equilibrium

Every Day Life Examples

Students would be very interested in having physics class at the playground. Seesaw is very suitable for learning about equilibrium. Students can experiment and try to conclude when the seesaw is in equilibrium. The concept of torque can be introduced to students and they can discuss about the types of equilibrium. The discussion about equilibrium while standing on one leg; walking; riding a bike and similar can be interesting to students.

The teacher can prepare instructional sheets with assignments that would be very interesting for trying and can provoke constructive discussion among students. This way students can inquiry physics of balance and weight shift. (1) Each student should get instructed to fold arms across chest, try to keep feet flat on the floor and back straight while trying to get up from a chair. Can one get up from a chair without leaning forward? In order to rise from a chair one must bring his/hers center of gravity over legs. (2) While standing, one should bend and hold his/hers toes (with slightly bent knees) and try to jump backward and forward. Why can one jump only backward? (3) Can someone move his/hers left leg while his/hers right side (right foot and shoulder) is against a wall?

Simple Experiments

It is shown that students who independently perform experiments better acquire physics knowledge (Cvjetičanin, Obadović & Rančić, 2015) and simple experiments are widely available since it is possible to select experiments for which low cost materials are needed and which require simple procedures.

Students can use ruler and paperclips to make lever (and use it like balance) and carry out different simple experiments. Students can inquiry what happens when (1) changing number of paperclips at each side of balance for given distance from axis of rotation and (2) changing distance from axis of rotation for given number of paperclips at each side of balance. Besides, students can try to keep body in equilibrium by changing the intensity or direction of the forces acting on it.

With round box and marble students can inquiry types of balance. Box and marble should be placed like it is shown in Figure 1. Students can observe marble's tendency to move when it is subjected to a slight displacement.

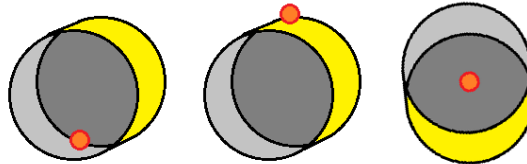


Figure 1. Examples of stable, unstable, and neutral equilibrium

Another interesting assignment for students can be to look up on the Internet and build their own Da Vinci popsicle stick bridge at class or for homework.

Toys in Physics Teaching

According to Güémez, Fiolhais and Fiolhais (2009) toys can provide amusing way to teach physics to both students and popular audiences. A long time ago balancing toys, like balancing man, were found to be useful when discussing equilibrium (Turner, 1987), another often described balancing toy is balancing bird (Fort, Llebot, Saurina & Sunol, 1998).

The teacher can use the balancing bird to get students motivated for learning and to explain center of gravity. The balancing bird can balance on finger, pencil, the edge of desk and similar, because its center of gravity is beneath the tip of its beak (Figure 2).



Figure 2. Balancing eagle

Besides, students can design their own balancing toy (bird, ballerina...) for homework.

PhET Simulations

Technology significantly effects contemporary education (Odadžić, Miljanović, Mandić, Pribičević & Županec, 2017). If computer is available for teaching and learning, PhET simulations can be used for introducing a new topic, formation of concepts, mastering skills, reinforcing ideas, and providing final review and reflection (Wieman, Adams, Loeblein & Perkins, 2010).

PhET (Physics Education Technology) Project was created by Nobel Laureate Carl Wieman, in 2002. It is realized at the University of Colorado. Within this project, free interactive math and science simulations are created. These simulations cover a wide range of topics in different sciences (STEM topics: physics, chemistry, biology, Earth science and mathematics). Free PhET simulations are available at website <https://phet.colorado.edu/> and, with the help of them, students can learn by exploring (as in virtual laboratory).

When learning concept of equilibrium one can address next simulations:

- Forces and Motion – Basics (Figure 3), available at <https://phet.colorado.edu/en/simulation/forces-and-motion-basics>, and
- Balancing Act (Figure 3), available at <https://phet.colorado.edu/en/simulation/balancing-act>.

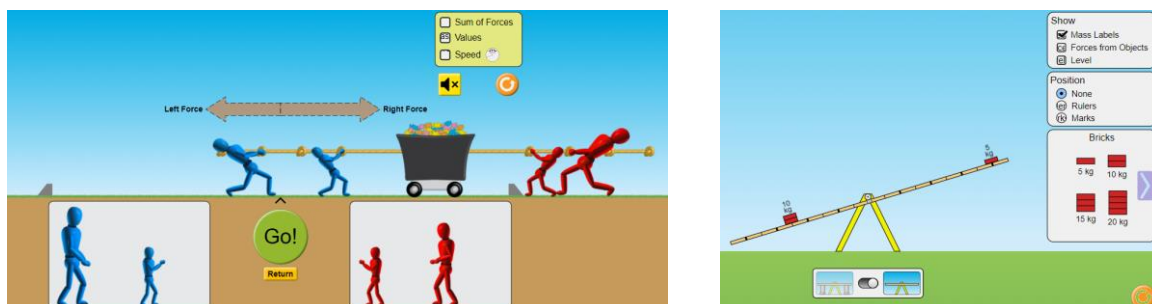


Figure 3. Examples of PhET simulations: forces and motion – basics (left) and balancing act (right)

Multimedia Quiz

Quiz can be prepared without the use of new technologies, but students are used to technology in their every day life and they can find interesting playing multimedia quiz in physics class. During participation in quiz, students develop competitive spirit, but also the cooperation of members within a team is encouraged (Tatić-Janevski & Radosavljević, 2002).

For creating multimedia quiz one can use Microsoft Office PowerPoint, as well as different online tools. For instance, free online platform Kahoot which “makes learning inclusive, fun and engaging.” Kahoot is very simple to create and play (<https://kahoot.com/company/>). Different time limit can be set for each answer. When playing Kahoot, questions (with related images or videos) and answer options are displayed on the large screen while smartphones can be used for answering. Students can compete individually or in teams. Kahoot makes answering questions fun; after each question correct answers award quiz points, so students get feedback instantly.

Conclusion

Students are familiar with equilibrium in their everyday life but they do not have the scientific knowledge about this concept and often misconceptions are formed. The teacher should assist students in creating a full understanding of a concept. Concepts formation and development should be encouraged instead of memorizing definition of a term. It can be suggested to implement various teaching strategies in school practice in order to keep students engaged and motivated for learning. Selected everyday life examples, simple experiments and PhET simulations, as well as idea for creating multimedia quiz can be implemented in teaching about equilibrium. Besides, presented ideas of teaching students about equilibrium can help in detecting students' misconceptions, as well as in formation scientific concept of equilibrium.

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Author Information

Ivana Bogdanović

University of Novi Sad

Faculty of Sciences Trg Dositeja Obradovića 4, Novi Sad

21000, Serbia

Contact e-mail: ivana.bogdanovic@df.uns.ac.rs
