The Impact of Teaching and Learning from Exploring the Representation and Etymology of Physical Terminology

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Abstract

This study proceeds to explore the representations and etymology of physical terminology in teaching and learning physics.

The study focuses on the concept of mechanics, such as moment of force, torque, momentum, free-fall, and so on, from three perspectives: (1) the literal meaning of physical terminology from students' point of view; (2) the etymology of physical terminology; (3) the impact of teaching and learning from the representation of physical terminology.

Text analysis and one-to-one interviews with high school students and teachers are used in this study. These interview questions are designed to probe students' understanding and applied to figure out key problems and effective cognitive conflict strategies to strengthen the development of professional teaching, clarify student's misunderstanding, and improve the context of physics textbooks.

1. Introduction

Physics is difficult to many students. Why? Physics appears difficult because it requires pupils to cope with a range of different forms of representation (experiments, graphs, mathematical symbols, verbal descriptions, etc.) simultaneously and to manage the transformation between these different representations [1]. Teachers should be able to see how their views are different from their students' views. Thus, they can begin to understand why students have difficulties in physics [4].

When studying physics concepts, the first representation that students encounter is the literal meaning of physical terminology. However, students, even teachers, seldom ask questions about the nomenclature of a physical term in the view of etymology. The study focuses on the concept of mechanics, such as moment of force, torque, momentum, free-fall, and so on.

2. Literal meaning of physical terminology: Moment

2.1 Playing a seesaw

Most children have the experience of playing seesaw in a playground and enjoy casting down and going up on a seesaw repeatedly. In addition, moving back or forth on a seesaw can make the effect that one can lift the other heavier player.

From physical point of view, seesaw is a good example of teaching the concept of lever. The distance from the fulcrum to the player's seat is called the lever arm. The lever arms and the player's weights both have effect on their balance. In other words, when one adult and one child play on a seesaw, the adult must sit near the fulcrum to keep the balance. The product of player's weight and the lever arm is defined as "torque".

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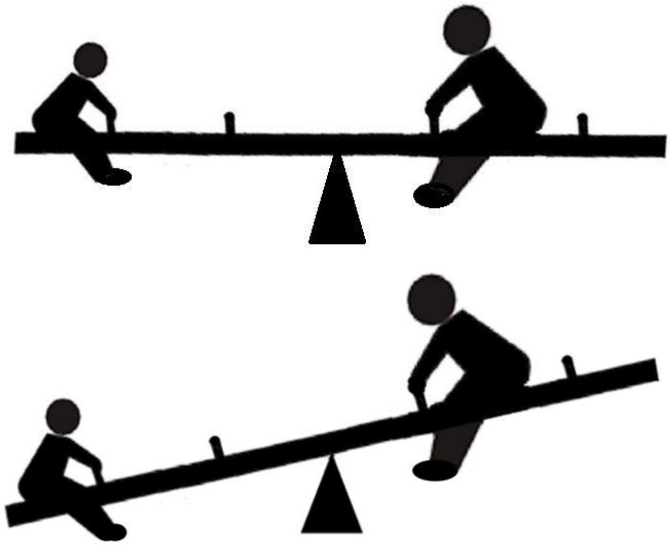

Fig.1 one adult and one child play on a seesaw

2.2 Torque, moment and momentum

The concept of torque was originated in the studies of Archimedes on levers about 2300 years ago. However, the term “torque” is an uncommon word in daily life and was not introduced into English scientific literature until the late 19th century.

Before the term torque was introduced, scientists called it “moment of force” or “moment of a force”, and it is usually shortened to “moment”. These terms about moment are still present in physics textbooks. In everyday English, “moment” is a general term to mean a very short period of time. It is hard for students to comprehend the meaning of “moment of force” or “moment”. Some students thus misunderstand the meaning of “moment of force” and regard it is a force acting in a very short period of time.

Further, more analogous physics terms bother students such as momentum, moment of momentum, electric dipole moment, and so on.

The term “momentum” is defined as the product of mass and velocity. I have no idea about why it is called “momentum” and what its relation with the moment (moment of force) is. In addition, I wonder why the representation of “momentum” is P. Likewise, why is the representation of “angular momentum” L?

2.3 The moment of force in Chinese

In Chinese world, the moment of force (torque) is translated to [li] [ju] (its pronunciation & the translated characters in Chinese are shown in Fig.2). Similarly, it is hard for students to comprehend why a rectangle is relevant to the moment of force.

2.4 The mathematical expression of torque

Archimedes did not write down the mathematical expression like the equation (1) in Fig.2. He did not define a proper noun as the product of distance and the weight. The work he did was using geometric reasoning to prove the relation between the distance and weight in his book entitled *On the Equilibrium of Planes*. The statement is in Propositions 6 and 7:“Magnitudes are in equilibrium at distances reciprocally proportional to their weights.”

For college students, the mathematical expression of torque is vector form as equation (2) in Fig.2. Hence we can see that the distance (a vector) is in front of the weight (a vector). Students feel puzzled why the order is different from equation (1).Students also get quite confused with relation of torque (moment), momentum and angular momentum (moment of momentum) when they are learning rotational mechanics.

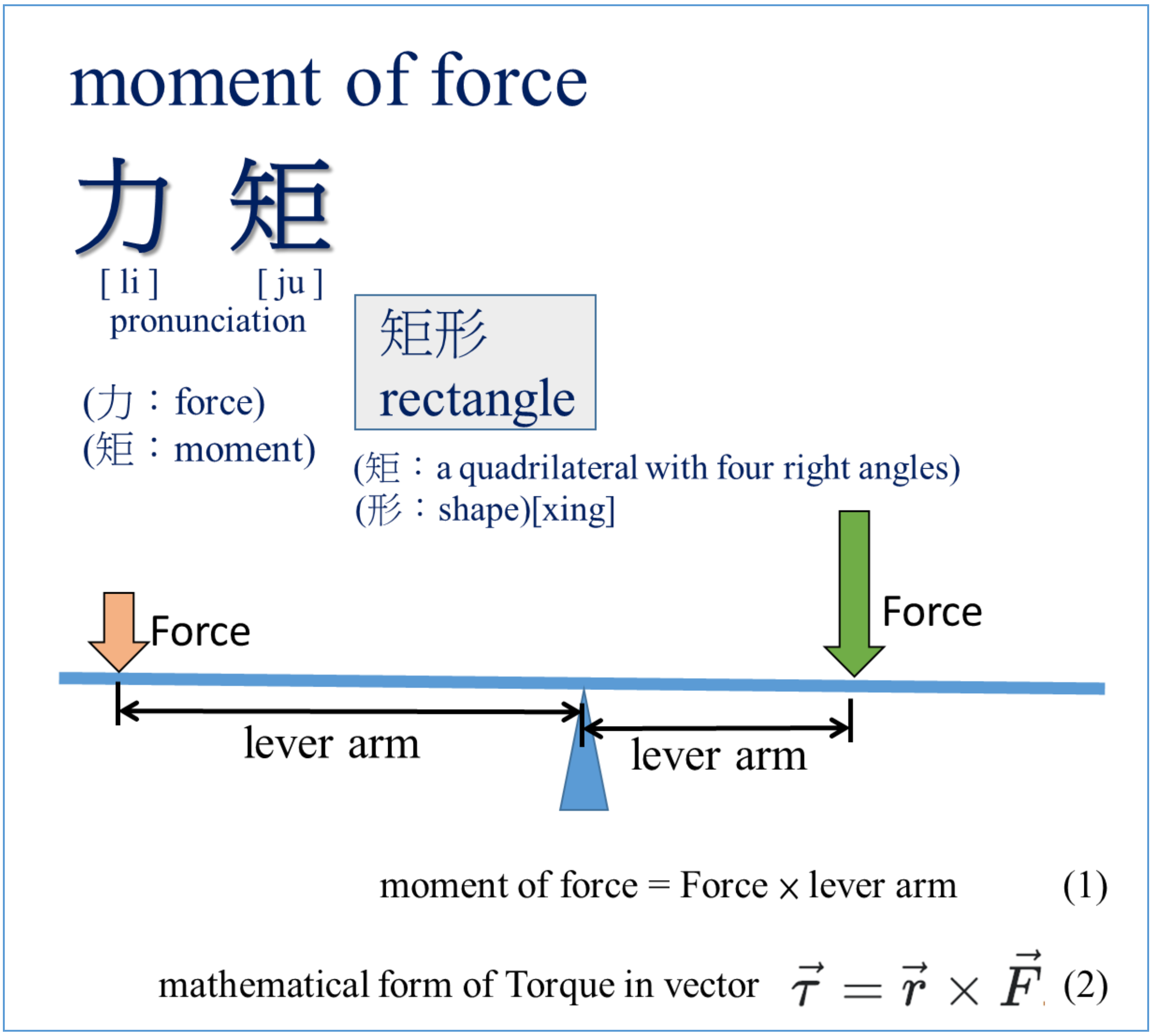

Fig.2 moment of force and its translated characters in Chinese

3. Literal meaning of physical terminology: Free-Fall

3.1 What is free-fall

There are three simple definitions of free fall in Merriam-Webster's Online Dictionary: (1) the state or condition of falling through the air toward the ground; (2) the condition of quickly becoming lower, less, or fewer; (3) a fast or continuing drop.

In these definitions, the meaning of fall is obvious. However, the meaning of “free” is not found. According to Wikipedia (The Free Encyclopedia), free fall in Newtonian physics is any motion of a body where gravity is the only force acting upon it. Oxford Dictionaries give the meaning “downward movement under the force gravity only”. The above two definitions fit the physics textbooks but did not tell us the meaning of free.

According to Merriam-Webster, first known use of free fall in 1919 was originated in parachutists and in rocketry. Apart from free-fall, there are free-body diagram, free charge, free energy, and so on, both in chemistry and physics.

Here is a good question teachers and students may ask: why is the free-fall “free”?

3.2 Meaning of FREE in English

According to Merriam-Webster's Online Dictionary, this word “free” has many meanings: not costing any money, not held as a slave or prisoner, not physically held by something.

Free is a common word that everyone knows it, but most students do not understand the meaning of free when it is used in science terminology.

3.3 Meaning of FREE in Chinese

In Chinese world, free is translated to [zi] [you] or [main] [fei](its pronunciation and the translated characters in Chinese are shown in Fig.3). The former [zi] [you] is usually misunderstood by students as “not limited or controlled”. Therefore, they fail to grasp the meaning of free-fall. As far as we know, a free-falling body is not out of control; otherwise, it is under the control of the gravity, not free.

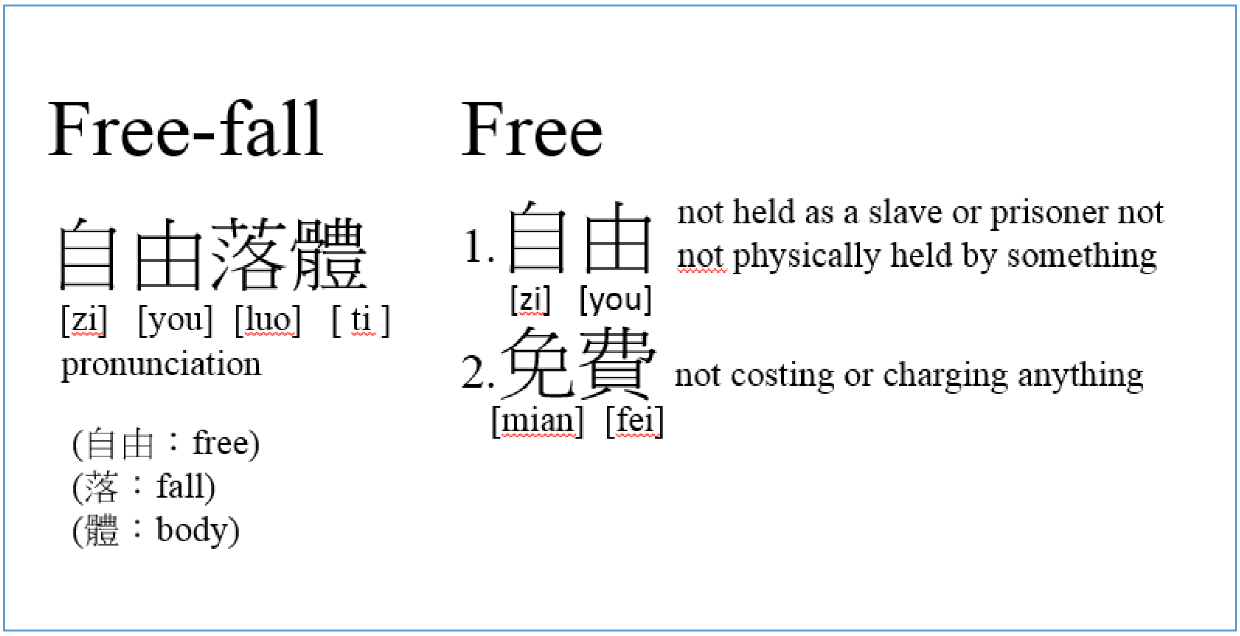

Fig.3 Free-fall in Chinese

4. Conclusion

The term “moment” and “free” both are common words in daily life, but are often incomprehensible when they are used as physical terminology. On the other hand, the term “torque” is an uncommon word that students can scarcely understand from its literal meaning. Thus, these physical terminology seldom keep in students’ mind.

To teach these concepts, teachers must help students to contend with different representations such as experiments, formulas and calculations, graphs, and conceptual explanations at the same time.

Although some questions raised in this paper remain unanswered, this study provides a new approach to explore the etymology of physical terminology and will thus inspire teaching and learning in physics.

Acknowledgments

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